Evaluating the Effect of Different Mouthwashes on the Titanium and Nickel Ions Released from Ordinary and Blue NiTi Archwires (An In-vitro Study)

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Abstract

Objectives: This studywas carried out to evaluate the effect of alcohol present in mouthwash on the Ni and Ti ions release from ordinary andblue NiTiarchwire.

Materials and Methods: Sixty specimens of 2cm length from 0.017×0.025 inch maxillary Flexy and Blue Flexy NiTi archwire (30 per each archwires) were immersed in 15 ml. distilled water, alcoholic and alcohol-free Corsodyl mouthwashes (10 per immersing media for each archwire) for one and half hour. After that, Ni and Ti ions released in mouthwashes and distilled waterwere measured using atomic absorption spectrophotometer. Unpaired sample t-test and one way ANOVA test were used for comparison between the archwire types and among different immersion media.

Results: Regarding Ni ion, the release of this ion washigher significantly in distilled water followed by alcohol-free Chlorhexidine while the least amount released in alcoholic Chlorhexidine. For Ti ion, the higher amount of Ti ion was released significantly from alcoholic Chlorhexidine followed by alcohol-free Chlorhexidine and the least amount was released in distilled waterin both types of archwires.Both ions were released significantly more from conventional NiTi archwire in all mouthwashes.

Conclusions: Ions released from the tested archwires appear to be low with blue NiTi archwire. Ni ion was released more with alcohol-free mouthwash and just the opposite forTiion.

Key words: *NiTi archwire, mouthwash, ion release, orthodontics.*

Introduction

In early 1970s George AndreasenintroducedNickel Titanium orthodontic archwires (1). Unitek Corporation developed the NiTi alloy for clinical use with the trade name Nitinol® in 1972.The composition of this alloy was 55% of nickel and 45% titanium in an equiatomic structure(2).

Due to their excellent mechanical properties having shape memory, high spring back, wide working range, applying light continuous force and most importantly is super-elasticity, so these alloys are widely used in early stages of orthodontic treatment i.e. leveling and alignment(3,4)also being strong and resilient make these alloys beneficial in reducing number of orthodontic arch wires during treatment and thus the frequency of orthodontic appointments(5).

In an attempt to reduce the release of nickel ion and improve the corrosion resistance, recentlyOrthometric Company from Brazil manufactured the Flexy Blue-NiTi archwire. This archwire was treated by oxidation under high temperature to enhance aforementioned properties and produce by smooth and more homogeneous surface in comparison with the conventional NiTi archwire. The surface was treated by the oxidation that change the color of the wire to blue hence the name is given.

One of the most important aspects in successful orthodontic treatment is maintaining good oral health[(6)].yet suboptimal levels of oral hygiene will lead to plaque accumulation that results in demineralization, white spot lesions and dental caries[(7)].Orthodontists prescribe mouthwashes as prophylactic agents to prevent plaque accumulation during treatment but they may have certain adverse effects due to their chemical compositionssuch as corrosion and discoloration of stainless steel and Nickel Titanium alloys [(8)].

Due to their prolonged broad spectrum antibacterial activity and plaque inhibitory potential, Chlorhexidine mouthwashes is considered as the "gold standard" antibacterial mouth agents [(9)].Many researches studiesthe effect of Chlorhexidinemouthwash on orthodontic wires [(9-12)].Up to the author's knowledge, there is no study assessing the concentration of Ni and Ti ions released from blue NiTi archwires after immersion in alcoholic and alcohol-free Chlorhexidine mouthwash, so this study as carried out.

Materials and Methods

Two types of NiTiarchwires namely; FlexyNiTi and Flexy BlueNiTi (Orthometric Company, Marília, Brazil) with a gauge of 0.017×0.025 inch were chosen to be immersed in two types of mouthwash (Alcoholic and non-alcoholic Corsodyl from GlaskoSimthKline Co., Brentford, U.K.) in addition to the distilled water as a control media.

A 2-cm length piece from the straight posterior portion of the maxillary archwire was cut using archwire cutter. Thirty specimens from each type of archwire were then immersed in glass tube containing15 ml of one of the immersing media(ten for each media) and incubated at 37°C for 1.5 h.Before commencing the experiment, the pH of each mouthwash and the distilled water was measured using pH meter(pH meter, Sartorius 2010, pp 25, Switzerland).

After incubation,the immersion solution was measured with atomic absorption spectrophotometer (Shimadzu AA-7000, Japan)to determine the concentrations ofNickel and Titanium ions in part per million.

Statistical Analyses

Data were analyzed using SPSS program version 25. Descriptive statistics included means, standard deviations, minimum and maximum values while the inferential statistics included independent sample t-testand one way ANOVA then Post-hoc Tukey's test. Probability value was set at 5%.

Results

Descriptive statistics and effect of different mouthwashes on the Ni and Ti ions release from both types NiTi archwires were presented in tables 1 and 2 respectively. The general pattern of Ni ion released appeared to be higher significantly in distilled water followed by non-alcoholic Chlorhexidine while the least amount released in alcoholic Chlorhexidine. This can be applied for both conventional and Blue NiTi archwires.

Regarding Ti ions the scenario as somewhat different. The higher amount of Ni ion was released significantly from alcoholic Chlorhexidine followed by non-alcoholic Chlorhexidine and the least amount was released in distilled water. Again this pattern was applied in both archwires

Comparing Ni and Ti ions released from the two types of NiTi archwires in different mouth washes were presented in Table 3. Generally, both ions were released significantly more from conventional

NiTi archwire in all mouthwashes except for Ti ions released in distilled water which showed non-significant difference.

Table 1: Descriptive statistics and effect of different mouthwashes on the Ni and Ti ions released from different NiTi archwires

Ions	Archwires	Media	Descriptive statistics				Media difference	
			Mean	S.D.	Min.	Max.	F-test	p-value
Ni	Flexy NiTi	D.W.	0.414	0.004	0.410	0.420	2095.717	0.000
		Alcoholic CHX	0.289	0.005	0.281	0.300		
		Non-alcoholic CHX	0.328	0.004	0.320	0.331		
	Blue Flexy NiTi	D.W.	0.359	0.013	0.343	0.377	529.218	0.000
		Alcoholic CHX	0.207	0.011	0.198	0.232		
		Non-alcoholic CHX	0.311	0.009	0.300	0.324		
Ti	Flexy NiTi	D.W.	0.210	0.006	0.201	0.220	4113.258	0.000
		Alcoholic CHX	0.395	0.005	0.389	0.401		
		Non-alcoholic CHX	0.290	0.002	0.288	0.294		
	Blue Flexy NiTi	D.W.	0.207	0.005	0.200	0.212	1709.863	0.000
		Alcoholic CHX	0.378	0.009	0.356	0.388		
		Non-alcoholic CHX	0.261	0.005	0.254	0.268		

Table 2: Post hoc multiple comparisons among different mouthwashes

Ions	Archwires	Media		Mean difference	p-value
Ni	Flexy NiTi	D.W.	Alcoholic CHX	0.125	0.000
			Non-alcoholic CHX	0.086	0.000
		Alcoholic CHX	Non-alcoholic CHX	-0.039	0.000
	Blue Flexy NiTi	D.W.	Alcoholic CHX	0.152	0.000
			Non-alcoholic CHX	0.048	0.000
		Alcoholic CHX	Non-alcoholic CHX	-0.105	0.000
Ti	Flexy NiTi	D.W.	Alcoholic CHX	-0.185	0.000
			Non-alcoholic CHX	-0.080	0.000
		Alcoholic CHX	Non-alcoholic CHX	0.105	0.000
	Blue Flexy NiTi	D.W.	Alcoholic CHX	-0.170	0.000
			Non-alcoholic CHX	-0.054	0.000
		Alcoholic CHX	Non-alcoholic CHX	0.117	0.000

Table 3: Mean values, standard deviations and comparison of Ni and Ti ions released from different NiTi archwires immersed in various mouthwashes

Ions	Media	Archwires	Descriptive statistics		Wire difference	
			Mean	S.D.	t-test	p-value
Ni	D.W.	Flexy NiTi	0.414	0.004	13.034	0.000
		Blue Flexy NiTi	0.359	0.013		
	Alcoholic CHX	Flexy NiTi	0.289	0.005	22.279	0.000
		Blue Flexy NiTi	0.207	0.011		
	Non-alcoholic CHX	Flexy NiTi	0.328	0.004	5.614	0.000
		Blue Flexy NiTi	0.311	0.009		
Ti	D.W.	Flexy NiTi	0.210	0.006	1.334	0.199
		Blue Flexy NiTi	0.207	0.005		
	Alcoholic CHX	Flexy NiTi	0.395	0.005	5.295	0.000
		Blue Flexy NiTi	0.378	0.009		
	Non-alcoholic CHX	Flexy NiTi	0.290	0.002	17.707	0.000
		Blue Flexy NiTi	0.261	0.005		

Discussion

After bonding fixed orthodontic appliance, orthodontists demonstrated the correct method of teeth brushing in the presence of the appliance with prescription of appropriate anti-microbial mouthwash to maintain good level of oral hygiene hence decreasing the risk of plaque accumulation and dental caries development [11].

Mouthwash containing Chlorhexidine Digluconate is considered as the gold standard that had wide range anti-microbial activity. Basically, it comes in two forms either alcohol-free or alcoholic form. The latter differs from the first one by containing 7% ethanol. Ethanol causes initial burning sensation, bringing an unpleasant taste and dryness of the mouthby damaging almost all types of bacteria in mouth – both the bad and good bacteria. One the other hand, alcohol-free mouthwash may not completely clear mouth from bacteria, but selectively targeting more bad bacteria than good creating a desirable balance to avoid further side effects or bad breath[13].

Generally, orthodontic metal alloys are at a risk of corrosion and ions release when subjected in oral environment. This can be determined mainly by the chemical and mechanical factors. NiTi alloys characterized by good corrosion stability provided by the passive protective layer of titanium oxide (TiO_2) and a small amount of nickel oxide (NiO)[12,14].

One of the methods used to improve the properties of NiTi alloy is oxidation under high temperature to produce light (sky) blue color form.At higher oxidation temperatures, oxygen will diffuse into the surface layer of the alloy then titanium will migrate from the NiTi alloy bulk toward the outersurface easily; consequently, the oxide layer on the alloys' surface becomesthicker and increases with increasing oxidation temperature and time, so this gives the blue NiTi archwire additional protective layer against the corrosion attack[14].

This is the first study in the world that addresses the effect of different mouthwashes (alcoholic and alcohol-free types) on the Ni and Ti ions released from blue NiTi archwire. Archwires were immersed in the selected media for one and half hours at attempt tosimulate the accumulative three monthsuse of chlorhexidine mouthwash for one minute daily [9].

Reviewing tables 1 and 2, the amount of released Ni ion appeared to be higher significantly in distilled water followed by non-alcoholic Chlorhexidine and the least amount was released in alcoholic Chlorhexidine. The pattern is applied for both conventional and Blue NiTi archwires. This could be explained by the absence of ions in the composition of distilled water making it a violent solvent. The corrosion of metals in water is influenced by the oxygen content, the level of pH, water temperature, and immersion time. The pH of distilled water was 7, so the acidity is not the matter that leads to corrosion. Yet the of lack of minerals in its contents is the major issue, so distilled water acts like a magnet that absorb ions from NiTi alloys and this comes in agreement with previous findings[15-18].

Both types of mouthwashes had almost the same pH (alcoholic=5.30, alcohol-free= 5.36) which is considered as acidic environment that attacks the protective titanium oxide leading to Ni leaks out that appears significantly more with non-alcoholic mouthwash[19].Moreover, alcohol (ethanol) with chemical formula CH_3-CH_2-OH contained in mouthwash may bind to the TiO_2 layer leading to leak out of Ti more with alcoholic mouthwash. Yamaguchi et al. [20] found that alcoholic solvents reduced the thickness of the protective oxide layer and affecting its structure.

Comparing ions released from conventional and blue NiTi revealed that Ni and Ti ions were released (leak out) significantly more from conventional NiTi archwire and in all immersion media even with the presenceof the protective oxide layer (Table 3). Blue NiTi archwire had thicker oxide layer that reduced the amount of ions released, so the amount of ions release were less.

Conclusions

Ions released from the tested archwires appear to be low with blue NiTi archwire. Ni ion was released more with alcohol-free mouthwash and just the opposite for Ni ion

Ethical Clearance: The Research Ethical Committee at scientific research by ethical approval of both MOH and MOHSER in Iraq

Conflict of Interest: None

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