Effects of three different mouthwashes on the surface characteristics of nickel-titanium and Stainless steel archwires in orthodontics

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Abstract

Introduction: Patients are recommended regular using of mouthwashes to control dental caries or periodontal diseases since orthodontic treatment may have detrimental effects on the tooth structures. However, chemical agents may potentially damage metal components of orthodontic appliances. The aim of this study was to evaluate the influence of three mouthwashes on the surface characteristics of nickel–titanium (NiTi) and Stainless steel (SS) arch wires. **Methods and Materials:** 15 pieces of 0.016 inch NiTi and 15 pieces of 0.016-inch SS wires were randomly assigned into 5 groups including 2 controls (as-received and artificial saliva) and 3 experimental groups. The samples in all groups were stored in artificial saliva in an incubator at 37˚C for one month, after that, the test groups were immersed in Chlorhexidine 0.12%, Hydrogen peroxide 0.12% and Persica mouth washes for 30 min, 1.5 h and 1.5 h, respectively. Then, the samples were washed by distilled water and returned to artificial saliva for more than two months. Surface topography changes and the number of corrosion holes were characterized via a scanning electron microscope (SEM).Two way ANOVA and Tukey tests were used to compare groups. **Results:** SEM photographs of the present study showed significant corrosion rate among "as- received" group and Persica ($p=0.04$), Chlorhexidine ($p=0.02$), and artificial saliva group ($p=0.008$) in NiTi wires, but there was no significant difference in the surface topography between any of the groups in SS wires. **Conclusion:** Alterations in surface of NiTi wires were significantly more than SS wires. Although not significant, 0.12% Chlorhexidine and Peroxide showed higher pitting view on SS and NiTi wires, respectively compared to other mouthwashes.

Keywords: Mouthwashes, Nickel-titanium, Orthodontics, Stainless steel.

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Introduction

As we know, nickel-titanium and stainless steel wires are widely used in orthodontic practice. Since most people do not follow a satisfactory oral hygiene regime during treatment, orthodontic treatment may have detrimental effects on tooth structures or periodontium. For this reason, using different mouthwashes to control dental caries or periodontal disease is recommended to patients. However, chemical agents may be potentially damaging to metal components of orthodontic appliances (1, 2).

Chlorhexidine is an agent with antibacterial properties, which is widely used in clinical dentistry, and has a special affinity for oral structures. The effect of Chlorhexidine in inhibiting plaque formation and reducing bacteria in the oral cavity, including streptococci, is well established in the literature (3).

Persica is another mouthwash that is widely used in the Middle East and proven to have antibacterial effects on cariogenic bacteria (4); the effects of this mouthwash have been investigated in the UK, USA and the Middle East (5-7).

Hydrogen peroxide (H202) is an effective bactericidal agent that catalyzes salivary peroxidase to form products with antibacterial properties (8, 9). It has been proven that even low levels of H202, either directly or by adding H202-generating systems, would be the most effective approach for inhibiting acid production and growth of streptococci(1).

Although orthodontic alloys show resistance against corrosion in various solutions as a result of the thin passive oxide film on their surface, this protective layer is susceptible to some chemical disruption (10-12).

The corrosion of orthodontic appliances in the oral environment has concerned clinicians about two principle issues: absorption of corrosion products in the body with local or systemic effects and the effect of corrosion on metal parts with regard to friction. Corrosion can adversely affect tooth movement because of the induced pitting and porosity on the surface of metal parts, which consequently increase the friction between the wire and the bracket slot. The friction behavior between an orthodontic wire and brackets can affect surface topography and vice versa (13). According to our knowledge, there has not been any studies on the effect of different mouthwashes (Except fluoride mouthwashes and Chlorhexidine) on surface topography of orthodontic archwires, therefore the purpose of the present study was to evaluate the effects of the three mouthwashes on surface characteristics of nickel–titanium NiTi and stainless steel (SS) wires.

Materials and Methods

1. Pre-processing: consisted of removal of noise and improving the images. In this phase, we used an air filter (smoothing) on the image to reduce sensitivity of the instrument to fine details in later phases. Since these particles had more brightness compared to the other parts of the image, a filter planar (Binarization) was used to identify them. Then, the areas identified were expanded by a morphology operator (dilation). Finally, these areas were replaced with average points of surrounding areas (figure1).
2. Hole nomination: In the second phase, hole candidates by morphological operators hat-top and hat-bottom, were identified (figure2).
3. Calculation of confidence factor of each hole: confidence factor was calculated for each hole based on the brightness values of the boundary of each hole and its surrounding area. The possibility that the candidate area is detected as a hole increases with higher confidence factor.

$$confidence = \left(\frac{mean(bound)}{mean(in)} \times \frac{mean(bound)}{mean(out)}\right)\left(\frac{\min(bound)}{\min(in)} \times \frac{\min(bound)}{\min(out)} \times \frac{\min(out)}{\min(in)}\right)$$

4. Hole detection: based on reliability values, real holes were identified among candidate holes. The rate of cavity area and their number was measured in five regions of each sample (figure3).
5. Measuring cavities: In this process nine parameter values W1, W2, W3, T1, T2, T3, R1, R2, R3 were determined for each image.

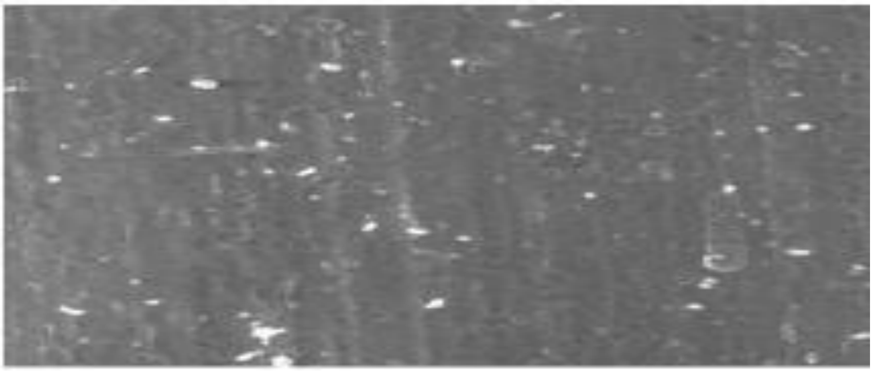

Figure 1. Pre-processing applied on a sample image :(A) The original image.

Figure 1(B). Detected noise particles

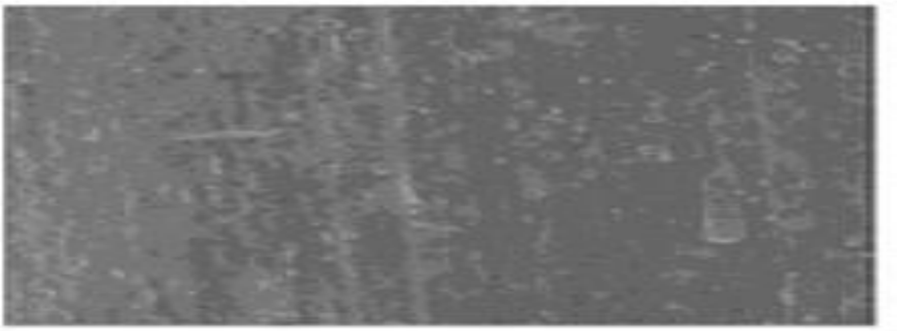

Figure 1(C). Removing noise particles from the image

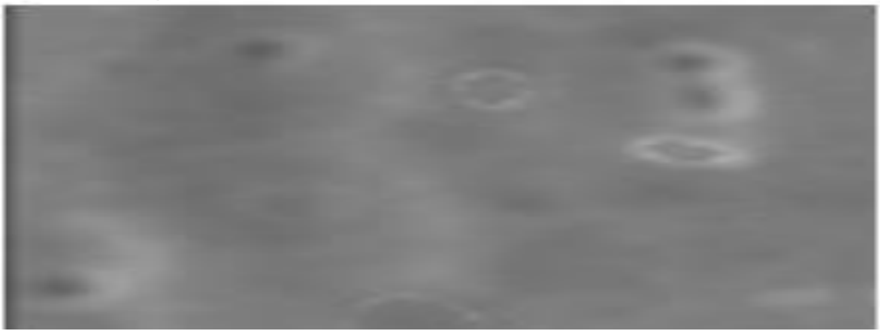

Figure 2. Nominate holes part of the sample image: (A) an improved image.

Figure2(B). Internal surface of hole from conversion of thehat – bottom

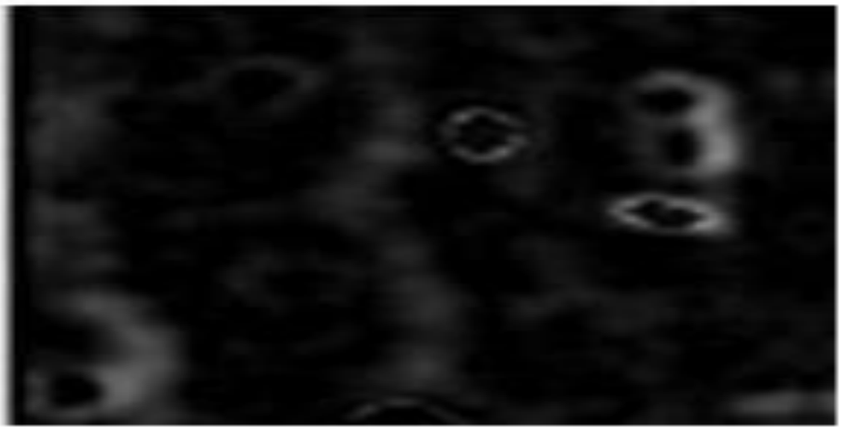

Figure2(C). External hole borders from conversion of the hat-top

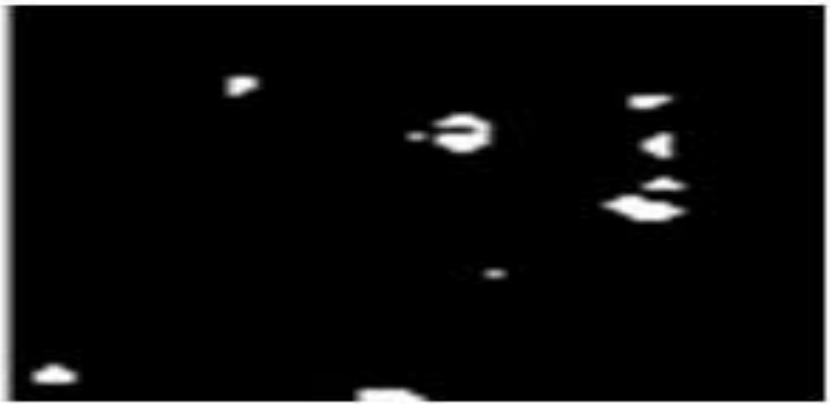

Figure 2(D). Holes have been nominated

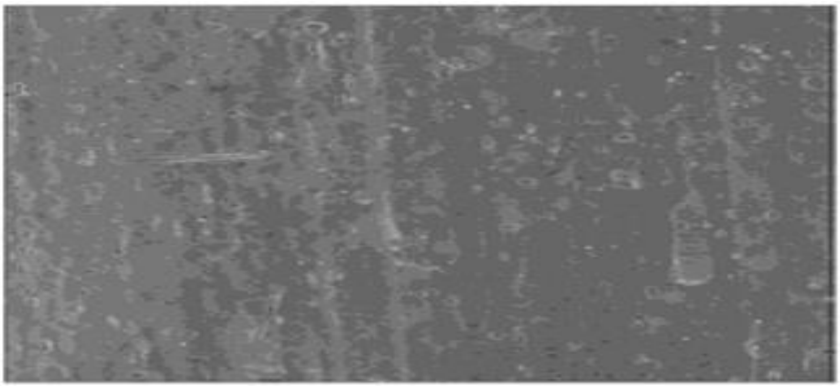

Figure 3. Identified holes for a sample image: (A) an improved image.

Figure 3(B). Identified holes Tables

Results

The effects of Chlorhexidine, hydrogen peroxide and Persica on topography properties of NiTi and SS wires were compared with 2 control groups. The mean values of corrosion percentage and hole count of NiTi and SS wires in different mouthwashes and artificial saliva are shown in Table 1.

Comparison pairs of corrosion percentage of NiTi wires (Table 2) showed that There was significant difference between Persica and as-received (P=0.049) and Chlorhexidine and as-received (p=0.20) arch wires.

Aspect of hole numbers in NiTi wires, there were no significant difference between none of the groups (P-value>0.05) but it is interesting that in this wire is highest corrosive appearance was in as-received group.

Comparison of the number of cavities and corrosion percentage of SS wires in pairs are shown in Table 3. In this type wire, Chlorhexidine was dominant media for corrosive effect but non-significant (P-value>0.05)

Table1. The mean of corrosion percentage in NiTi and SS wires

Mouthwash	**corrosion percentage Mean±SD**		**Number of holes**	
	NiTi	SS	NiTi	SS
Persica	6.18±0.91	3.07±0.978	6.6±0.848	4.4±0.282
Chlorhexidine	5.40±0.75	5.30±4.330	9.7±3.252	5.4±1.97
Peroxide	6.35±1.076	3.33±1.101	6.6±1.97	4.8±3.11
Artificial saliva	4.48±0.418	2.03±0.908	6.6±0.848	4.2±0.565
As-recieved	9.22±0.308	4.100±0.250	11.9±2.121	4.6±1.97

SD: Standard Deviation

Table 2. A comparison between different mouthwashes and control groups in NiTi wires

MOUTHWA(I)	**MOUTHWA(J)**	**corrosion percentage**		**Number of holes**	
		Mean Difference(I-J)	**Sig. (p-value)**	**Mean Difference(I-J)**	**Sig. (p-value)**
Persica	Chlorhexidine	0.78	0.82	-3.100	0.586
	peroxide	-0.16	0.99	0.0000	1.000
	artificial saliva	1.70	0.29	0.0000	1.000
	as-received	-3.04	0.049*	-5.3000	0.201
Chlorhexidine	Persica	-0.78	0.82	3.1000	0.586
	peroxide	-0.95	0.72	3.10	0.58
	artificial saliva	0.91	0.74	3.10	0.58
	as-received	-3.82	0.020*	-2.20	0.80
Peroxide	Persica	0.16	0.99	0.00	1.00
	Chlorhexidine	0.95	0.72	-3.10	0.58
	artificial saliva	1.87	0.23	0.00	1.00
	as-received	-2.87	0.06	-5.30	0.20
As-received	Persica	3.04	0.049*	5.30	2.20
	Chlorhexidine	3.82	0.020*	5.30	5.30
	peroxide	2.87	0.060	0.201	0.80
	artificial saliva	4.74	0.008*	0201	0.20
artificial saliva	Persica	-1.70	0.29	0.00	1.0
	Chlorhexidine	-0.91	0.74	-3.10	0.58
	peroxide	-1.87	0.23	0.00	1.00
	as-received	-4.74	0.008*	-5.30	0.20

Table3. A comparison between different mouthwashes and control groups in SS wires

MOUTHWA(I)	MOUTHWA(J)	corrosion percentage		Number of holes	
		Mean Difference(I-J)	**sig**	**Mean Difference(I-J)**	**sig**
Persica	Chlorhexidine	-2.22	.817	-1.00	0.980
	peroxide	-0.25	1.00	-0.400	0.999
	artificial saliva	1.04	0.98	0.200	1.000
	as-received	-1.02	0.98	-0.200	1.000
Chlorhexidine	Persica	2.22	0.81	1.00	0.980
	peroxide	1.97	0.86	0.60	0.997
	artificial saliva	3.26	0.57	1.20	0.963
	as-received	1.20	0.97	0.800	1.000
peroxide	Persica	.25	1.0	0.40	0.999
	Chlorhexidine	-1.97	0.86	-0.60	0.997
	artificial saliva	1.29	0.96	0.60	0.997
	as-received	-0.76	0.99	0.20	1.000
as-received	Persica	1.02	0.98	0.20	1.000
	Chlorhexidine	-1.20	0.97	-0.80	0.991
	peroxide	0.76	0.99	-0.200	1.000
	artificial saliva	2.06	0.85	0.40	0.999
Artificial saliva	Persica	-1.04	0.98	-0.20	1.000
	Chlorhexidine	-3.26	0.57	-1.20	0.963
	peroxide	-1.29	0.96	-0.60	0.997
	as-received	-2.06	0.85	-0.40	0.999

Discussion

Orthodontic treatment involves the application of dental arch wires and attachments for tooth movement. Since the appliances are present in the mouth and exposed to altered biological conditions, orthodontic patients are more prone to gingivitis and enamel decalcification; Therefore, to reduce these potential risks, mouthwash application along with brushing is important. On the other hand, we must be aware of the effects of the mouthwash on the various components of the orthodontic appliances.

The alloy used in orthodontic wires (nickel-titanium and stainless steel) have a high resistance to corrosion that relates to the protective layer on its surface. Protective layer of NiTi and stainless steel wires are titanium oxide and chromium oxide, respectively. Yet this protective layer is susceptible to both mechanical and chemical disruption (16).

Overall, according to the obtained results of this study, the rate of corrosion was higher in NiTi wires than SS wires. Moreover, NiTi wires, soaked in Chlorhexidine or Peroxide or Persica, had no significant difference in corrosive behavior compared to the artificial saliva group. Corrosion percentage in our results were consistent with the results of Bundy K (17) and Rondelli G (18) that showed Orthodontic wires in various solutions such as Ringer, artificial saliva and NaCl had a high resistance to corrosion (19). In these solutions, the corrosion resistance of titanium alloys is higher than that of stainless steels alloys from the viewpoint of film breakdown (19).

In NiTi wires, high corrosion percentage was seen in peroxide mouthwash compared to as received group. The destruction of the protective layer of NiTi wire due to low PH (3.6) can lead to increased penetration of hydrogen peroxide. Also, hydrogen peroxide can lead to release of high amounts of OH radicals in metal surface, which can play an important role in the destruction of the surface layers of NiTi wire (20). Previous studieshave stated that in an acidic environment, the corrosion predisposition of certain metals especially titanium, is increased (16, 21).

In this study, it was observed that as-received wires had highest surface defects. Surface defects and roughness produced during the manufacturing processes has been reported in some investigation(s) (22).

These are prominences created during wire manufacturing that seems to be worn wire immersion in mouthwashes.

The degree of stainless steel corrosion in different mouthwashes such as EDTA, chlorhexidine (0.2%), and NaCl (5.25%) was assessed by the Dartar Oztan et al. and its result showed that there was corrosion in stainless steel files, especially pitting corrosion, in chlorhexidine solution (23). Hosseinzadeh Nik et al showed chlorhexidine-containing mouth rinses may be prescribed as non-destructive prophylactic agents (24). The surface of ORJ brackets showed significant changes under a light microscope indicating the staining of these brackets in acidic artificial saliva. This corrosion results in the release of corrosion products into the oral cavity. (25)In this regard, conflicting results may be due to differences in the type of material used in the researches and the application duration of mouthwashes. According to our study, while with no significance, the highest amount of corrosion was observed in stainless steel wires immersed in Chlorhexidine solution and peroxide and Chlorhexidine have more detrimental effects on NiTi and Stainless steel wires respectively. Intergranular corrosion is also observed on the surface of these brackets that can lead to staining of SS brackets followed by their weakening and eventual fracture.(26)

Conclusion

Based on our results, the following points expressed:

1. Alterations in surface of NiTi wires were significantly more than SS wires.
2. Although not significant, 0.12% Chlorhexidine and Peroxide showed higher pitting view on SS and NiTi wires respectively, compared to other mouthwashes.
3. The mouthwashes should be prescribed according to the orthodontic materials used to reduce side effects of some mouthwashes.

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