ORIGINAL ARTICLE

Evaluation of mechanical properties of NiTi orthodontic wire after immersion in three different mouthwashes

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Introduction: Since orthodontic therapy may have detrimental effects to the tooth structures or periodontium, practitioners recommend their patients to use different mouth washes. These chemical agents may be potentially damaging to metal components of orthodontic appliances. The aim of the present study was to evaluate the effect of three common mouthwashes on mechanical properties of NiTi orthodontic wires.

Materials and Methods: 27 pieces of 0.016inch Niti wires were randomly assigned into 9 groups including 3 control and 6 experimental groups. After the first month of immersion in artificial saliva, the wires in 3 groups were immersed in Chlorhexidine, Persica and Hydrogene Peroxide for 30min, 1.5h and 1.5h respectively. The control groups included as-received wires, wires immersed only in artificial saliva and Saliva + tooth brush. Mechanical properties of the wires were evaluated by three point deflection test. Two way ANOVA and Tukey tests were used to compare groups.

Results: Persica caused significantly lower force in 2 and 3 mm deflection during loading compared to Peroxide, chlorhexidine and “as received”. Chlorhexidine also significantly reduced the loading force during 3mm deflection in comparison to saliva control. In 2 mm deflection during unloading Persica significantly reduced unloading force in comparison to all groups including: chlorhexidine, peroxide, saliva control and “as received”. It is also seen that chlorhexidine caused lower force compared to saliva control. Then, NiTi wires in 3 groups underwent 3200 tooth brushing cycles and were compared with each other and with 2 control groups (saliva + brushing and "as received") by Tukey test. The results showed that only in 3mm loading deflection there was significant difference between Persica and Peroxide, and also between peroxide and as received wires.

Conclusion: Persica was the most effective mouthwash on mechanical properties of NITI wires.

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Introduction

Dental Plaque elimination is challenging during orthodontic treatment, especially in adolescents[1-2]. Many studies have reported progression of hyperplasic gingivitis during 1-2 months after bonding the fixed appliances[2]. Orthodontic treatment with fixed appliances changes oral environment, and dental plaque accumulation accentuates around the bands and brackets.[4]Alterations in oral micro flora and limited access to teeth surfaces result in gingivitis and decalcifications around fixed appliances, therefore, in order to prevent these side effects oral irrigation with different mouthwashes have been suggested in addition to mechanical tooth brushing. [5-8]

In many orthodontic patients fluoride mouthwash is routinely prescribed [8], but many studies also recommend other chemical substances for plaque control in these patients as well. [9-10]

Chlorhexidine is one of the most common mouthwashes whichare used effectively as a routine mouthwash in periodontal and orthodontic patients. This mouthwash inhibits plaque formation and acidogenicbacteries and indirectly can reduce dental caries. [11-13]

Persica is an herbal antibacterial agent that could be an alternative for chlorhexidine. The effects of this mouthwash have been investigated in UK, USA and Middle East. [14-16] Results of different studies have shown improved gingival health and lower carriage rate of cariogenic bacteria when compared with the pre-treatment values. [17]

Hydrogen peroxide is another antimicrobial agent that is especially effective on anaerobic bacteria with 1.5% and 3% concentrations. It has been proven that Hydrogen peroxide can markedly reduce the amount of plaque formation and significantly retard the gingivitis development. [18-20]

Prescribing oral mouthwashes are usually necessary in orthodontic patients, but the main concern is their side effects on orthodontic attachments and wires that are made from different metal alloys. These mouthwashes can affect superficial and mechanical properties of metallic parts of orthodontic appliances. Thus, important question is how far do these mouthwashes influence the orthodontic appliances and how serious are these changes?

Since, there is no published study about evaluating mechanical effects of different mouthwashes (except fluoride mouthwashes) on mechanical propertiesof NiTi wires; therefore the aim of the present study was to evaluate the effects of these mouthwashes (Chlorhexidine, Persica, Hydrogen peroxide) on mechanical properties (loading-unloading curve) of NiTi wires.

Material & Methods

In this in-vitro study the effects of three types of mouthwashes including Chlorhexidinegluconate 0.12 %(0.12% Chlorhexidinegluconate in a base containing water, 11.6% alcohol, glycerin), PH = 5.5 (ShardaruLabratories, Tehran, Iran), Hydrogen peroxide 1.5 % PH = 3.6(Nanosil, kimiafamLabratories, Tehran, Iran), Persica PH= 5.7(containing extract of *SalvadoraPersica* (meswak), mint and yarrow extract) from Poursina Pharmaceutical Laboratories, Iran with main ingredient as tannen, flavonid, calcium, fluoride, chloride and essence) were studied on mechanical properties of 0.016 inch NiTi wires (OrthotechnologyInc). In our study, each group included 3 samples of 30 millimeters of 0.016 inch NiTi wire (straight part of preformed wire was used for all groups) and comprised of 3 control and 6 test groups as followed:

Control groups:

Group 1(saliva control): samples were stored in artificial saliva for 3 months

Group2(saliva + brushing control): samples were stored in artificial saliva for 3 months and 3200 times tooth brushing was performed to simulate oral environment.

Group 3(As received control): samples were stored in room temperature without any manipulation

Test groups:

Group 4: samples were stored in chlorhexidine (0.12%) for 30 minutes (equivalent to 4 weeks daily oral rinsing, 1 minute for each rinsing).

Group 5:samples were stored in chlorhexidine for 30 minutes (equivalent to 4 weeks daily oral rinsing, 1 minute for each rinsing) and 3200 times tooth brushing was performed.

Group 6:samples were stored in Hydrogen peroxide for 90 minutes (equivalent to 3 months daily oral rinsing, 1 minute for each rinsing).

Group 7: samples were stored in Hydrogen peroxide for 90 minutes (equivalent to 3 months daily oral rinsing, 1 minute for each rinsing) and 3200 times tooth brushing was performed.

Group8: samples were stored in Persica for 90 minutes (equivalent to 3 months daily oral rinsing, 1 minute for each rinsing).

Group 9: samples were stored in Persica for 90 minutes (equivalent to 3 months daily oral rinsing, 1 minute for each rinsing) and 3200 times tooth brushing was performed.

After marking groups, saliva- brush groups placed under the brushing and all groups except group 3 were placed in artificial saliva in incubator with 37 degree of centigrade for 1 month. Then group 4 and 5 were placed in chlorhexidine for 30 minutes, group 6 and 7 placed in Hydrogen peroxide for 90 minutes, group 8 and 9 placed in Persica for 90 minutes. After 1 month these groups were taken out from mouthwash plates and then rinsed with distilled water and returned to artificial saliva for 2 more months. Then the wires were used for testing mechanical properties (three-point bending test).

Toothbrushing process:

In order to simulate toothbrushing process similar to mouth condition, abrasion was performed by a piston-action brushing machine under a standardized load in order to simulate abrasive forces in the oral environment. This device consisted of 8 heads to hold toothbrushes connected to a camshaft driven by a motor/gearbox system and a control unit. A toothbrush with soft nylon bristles (Jordan toothbrush) was fitted into each head, and the specimen block was mounted inthe opposing of specimen holder. Thirty two hundred strokes (equivalent to 3 months brushing)[21] were performed on each specimen at a speed of 235 strokes (complete forward and reverse movement) per minute, with a load of 280 g [22], using 5 mL of toothpaste slurry containing toothpaste and deionized water in a ratio of 1:3).[23]

Three-point bending test:

A three-point bending test was conducted using the universal testing machine (Zwick 250, Germany). In order to simulate oral condition, the wires placed in a dental arch containing brackets adhered on central and canine teeth. The machine adjustments included: deflection range 3 mm, cross head speed: 1 mm/min. preload adjusted to 0.25 N. The samples were unloaded at the same crosshead speed for 3 mm. The forces were registered in 1 mm, 2mm, 3 mm of deflections in loading, furthermore in 2 mm, and 1mm of deflections in unloading. Mean values of forces for 3 pieces of NiTi wires in each group were calculated and data was analyzed by two-way ANOVA and Tukey test.

Results

In this study, we evaluated effects of three mouthwashes (Chlorhexidine, Hydrogen peroxide and Persica) on mechanical properties of Niti wires in comparison with 3 control groups (wires stored in artificial saliva, wires stored in artificial saliva plus brushing and wires “as received” in room temperature). In Table 1 the mean values of recorded force in 1mm, 2mm and 3mm loading ,and 2 mm, 1 mm unloading is demonstrated.
Loading –unloading forces of NiTi wires stored in 3 mouthwashes (groups 4, 6, 8) were compared with control group 1 (saliva) and “as received” (group 3) by Tukey test (Table 2)

In 2 mm deflection during loading, there was significant difference between Persica and Peroxide and Persica and “as received” wires.

In 3 mm deflection during loading there was significant differences betweenPersica and Chlorhexidine, Persica and “as received”, Chlorhexidine and saliva control, and between saliva control and “as received” wires.

In 2 mm deflection during unloading there was significant difference between Persica and all groups including: Chlorhexidine, peroxide, saliva control and “as received”, and also between chlorhexidine and saliva control.

Then, NiTi wires which were stored in 3 mouthwashes underwent 3200 tooth brushing cycles (groups 5, 7, 9) were compared with each other and with control group 2 (saliva + brushing control) and as group 3 (“as received “control) by Tukey test. (Table 3)

The results showed that only in 3mm deflection during loading there was significant difference between Persica and Peroxide, and also between peroxide and as received wires.

Table 1: loading-unloading(L – UN) forces of NITI wires in different groups.
S =saliva
B = brushing

	L1	L2	L3	UL2	UL1
Chlorhex(S)	3.24 ± 0.14	4.42 ± 0.05	7.23 ± 0.05	1.80 ± 0.06	1.24 ± 0.01
Peroxide(S)	2.61 ± 1.80	4.80 ± 1.18	6.23 ± 1.38	1.59 ± 0.13	1.05 ± 0.15
Persica(S)	1.23 ± 0.10	2.31 ± 0.11	4.73 ± 0.23	0.00 ± 0.00	0.00 ± 0.00
Control(S)	1.50 ± 0.36	3.73 ± 0.25	4.76 ± 0.20	1.44 ± 0.12	3.20 ± 4.41
Chlorhex(S + B)	3.40 ± 0.36	4.51 ± 0.24	5.70 ± 0.26	1.70 ± 0.13	1.16 ± 0 .15
Peroxide(S+B)	2.78 ± 0.78	3.99 ± 0.88	4.38 ± 1.4	0.62 ± 1.01	0.60 ± 0.72
Persica(S+B)	2.67 ± 0.94	4.25 ± 0.39	6.97 ± 0.18	1.80 ± 0.17	1.24 ± 0.18
Control(S+B)	2.20 ± 0.47	3.96 ± 0.15	5.26 ± 0.23	1.47 ± 0.08	0.87 ± 0.11
As recieved	2.55 ± 1.00	4.66 ± 1.34	7.40 ± 1.04	1.60 ± 0.13	1.14 ± 0.13

Table 2: Pairwise comparison of mouthwashes and control groups ((S) control and As received) in different loading-unloading (L-UN) deflections.
*Significant Difference

		L1		L2		L3		UL2		UL1	
		Mean Diff	**P value**	**Mean Diff**	**P value**	**Mean Diff**	**P vale**	**Mean Diff**	**P value**	**Mean Diff**	**P value**
Persica	**chlorhexidin**	-2.01	0.14	-2.11	0.06	-2.496	.020*	-1.80	.000*	-1.24	0.933
	peroxide	-1.38	0.422	-2.48	.025*	-1.5	0.211	-1.59	.000*	-1.05	0.963
	(S)Control	-0.27	0.996	-1.42	0.277	-0.03	1	-1.4467	.000*	-3.20	0.338
	As recieved	-1.32	0.465	-2.34	.034*	-2.66	0.013*	-1.60	.000*	-1.14	0.950
Chlorhexidin	**peroxide**	0.62	0.921	-0.37	0.977	0.99	0.561	0.20	.199	.196	1.000
	(S) control	1.74	0.232	0.69	0.832	2.46	0.022*	0.35	.014*	-1.96	0.745
	As recieved	0.69	0.891	-0.23	0.996	-0.17	0.999	0.20	.210	.103	1.000
Hydeogen Peroxide	**(S) control**	1.11	0.611	1.06	0.525	1.47	0.227	0.15	0.447	-2.15	0.678
	As recieved	0.06	1	0.14	0.99	-1.16	0.421	-.003	1.000	-0.09	1.000
Control(s)	**As recieved**	-1.05	0.66	-0.92	0.64	-2.63	0.015*	-0.15	0.427	2.06	0.710

Table 3:Pairwise comparison of mouthwashes and control groups after tooth brushing simulationin different loading-unloading deflections. *Significant Difference

		L1		L2		L3		UL2		UL1	
		Mean Diff	P value	Mean Diff	P value	Mean Diff	P vale	Mean Diff	P value	Mean Diff	P value
Persica	chlorhexidin	-0.73	0.760	-0.26	0.992	1.27	.371	0.10	0.999	0.08	0.998
	peroxide	-0.11	1.000	0.26	0.991	2.59	.020*	1.17	0.069	0.64	0.238
	(S)Control	0.46	0.938	0.29	0.988	1.71	.152	0.32	0.910	0.36	0.710
	As recieved	0.12	1.000	-0.40	0.962	-0.42	.966	0.20	0.983	0.09	0.997
Chlorhexidin	peroxide	0.62	0.847	0.52	0.906	1.31	.346	1.078	0.103	0.56	0.345
	(S) control	1.20	0.359	0.55	0.893	0.43	.963	0.22	0.975	0.28	0.851
	As recieved	0.85	0.653	-.014	0.999	-1.70	.156	0.10	0.999	0.01	1.000
Hydeogen Peroxide	(S) control	0.57	0.878	0.02	1.000	-0.88	.687	-0.85	0.243	-0.27	0.861
	As recieved	0.23	0.995	-0.67	0.808	-3.01	.008*	-0.97	0.153	-0.54	0.371
Control(s)	As recieved	-0.34	0.978	-0.69	0.789	-2.13	.058	-0.12	0.997	-0.26	0.876

Discussion

Good oral hygiene is an essential part of a successful orthodontic treatment. Dentists may prescribe special mouthwashes in risky patients which are not able to maintain perfect oral hygiene such as surgical patients in maxillomandibular fixation period), uncooperative patients (especially teenagers) or patients with previous periodontal problems. This mouthwash might be fluoride compounds, Chlorhexidine, hydrogen peroxide or Persica.There are several studies about positive effects of these mouthwashes on plaque indices and periodontal health. [24-26]
But to our knowledge few attentions have been paid to negative effects of these mouthwashes on mechanical properties of orthodontic wires which are the most common active part of orthodontic appliances.

In some studies, the effects of fluoride compounds on brackets and wires (especially Niti wires) have been evaluated.[27-29], but there is no published study about the effects of hydrogen peroxide and chlorhexidine and Persica on mechanical properties of NiTi wires. Therefore this study was planned to evaluate the effects of three routine mouthwashes on mechanical properties of Nit wires. The results of this study can help the clinicians to choose the proper mouthwash during orthodontic treatment.

Siiriläand Könöneninvestigated the risk of corrosion of titanium abutments by the accidental or unauthorized use of preventive fluorides. They found that an amino fluoride toothpaste with low ionizable fluoride content (0.125%) used in brushing natural teeth does not cause deterioration of the titaniumabutments. Carefully controlled use of fluoride gel (F 1.25%) and varnish (F 2.25%) is likewise not dangerous. The mechanical abrasion caused by toothbrush bristles appears to be the main deteriorating factor for the titanium surface. [30]

Wataha et al measured the susceptibility of several types of nickel-based alloys to brushing abrasion relative to gold- and palladium-based alloys. They concluded that although nickel-based alloys have many excellent mechanical properties, Ni-Cr-Be alloys may be prone to degradation from brushing. [31]

In support of Wataha's study, we concluded that brushing can affect loading and unloading forces of NiTi wires in different deflections in comparison with control group (group 3).

Persica is an herbal mouthwash which is considered to control gingival diseases and dental caries .[14-17] Nowadays herbal compounds are attractive for many patients and even dentists, because they are considered to be harmless. In orthodontics there are considerations about deterious effects of mouthwashes on mechanical properties of orthodontic appliances, but there is no published documented study about this. According to this study, Persia reduced loading and unloading forces in all deflections in comparison with control groups (group 1 and 3) that in some deflections, reduction of forces was significant. This negative effect seems to be related to its composition.Salvadorapersica is an alcoholic extract that contains carbohydrates and glycosides, terpenes, alkaloids ,chlorides ,sulfur, vitamin C, large amounts of fluoride and silica, small amounts of tannins, saponins, flavonoids and sterols.[32]

A probable reason for reduction of loading/unloading forces in NiTi wires may be due to large amounts of fluoride application. Walker et al concluded topical fluoride agents could decrease the functional unloading mechanical properties of NiTi wires and contribute to prolonged orthodontic treatment. [33]

Also, Persica contains chloride ions which are effective in destruction of protecting layer of active-passive alloys. Soluble chemical elements like chloride can disrupt the superficial layer of the alloy that will cause severe corrosion so-called "stress corrosion cracking". This phenomenon may be true about NiTi wires. [34]

We also found a significant reduction in loading force of NiTi wires in 3mm deflection in hydrogen peroxide mouthwash in comparison with control group (saliva-brushing). It seems that brushing is one of the effective factors in modifying mechanical properties of the wire, in addition, when hydrogen peroxide was added to brushing, the loading force decreased significantly. The reason may be the destruction of protective layer of NiTi wire as a result of low PH (PH=3/6) along with scratches from bristle of brush that will increase the depth of hydrogen peroxide penetration in maximum deflection (3mm). In addition, hydrogen peroxide can produce free radicals of OH^- which may destroy the superficial layers of the NiTi wire and therefore affect it's mechanical characteristics. [34]

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Conclusions:

Among Persica, Chlorhexidine and Hydrogen peroxide, Persica reduced the loading- unloading forces of NiTi wires in most deflections. Therefore Persica had the most unfavorable effects on mechanical properties of Niti wires.

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