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Evaluation of the effects of three different mouthwashes on the force decay of orthodontic chains

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ABSTRACT

Background: Elastomeric chains are commonly used in orthodontics. Force decay in these materials poses clinical problems. The aim of this study was to evaluate the effects of three different mouthwashes on the force decay of orthodontic chains.

Materials and Methods: In this experimental study, elastomeric chains with two different configurations were divided into eight groups (two control and six test groups). After 10 s of prestretching up to 100% of their initial length, the chains were stretched for 25 mm on jig pins and then immersed in artificial saliva, persica, chlorhexidine 0.2% and sodium fluoride 0.05% mouthwashes. Ten cycles of thermocycling between 5°C and 55°C were conducted daily during the test period. In order to reach a 200-g initial force, seven loop closed chains, and five-loop short chains were selected. Forces were recorded by digital force gauge (Lutron) at initial, 24 h, 1, 2, 3 and 4 weeks for all groups. The amount of force loss was compared among different mouthwashes and times using one-way analysis of variance (*post-hoc*, Tukey, $\alpha = 0.05$).

Results: About 20% of the force decay occurred during the first 24 h, but after that and up to the 4th week the rate of force loss was gradual and steady. After 4 weeks, persica and chlorhexidine caused the lowest and the highest percentage of force loss, respectively. These two mouthwashes showed statistically significant differences at all points of time ($P < 0.05$).

Conclusion: Within the limitations of this study, during the orthodontic treatment, persica is preferred to chlorhexidine for oral health control.

Key Words: Elastomeric chain, force decay, mouthwash

INTRODUCTION

Elastomeric products are used as ligatures and chains in order to apply retraction forces to the teeth.[1] Since 1960s, elastomeric chains have entered orthodontic treatment[2] and for some applications, have replaced elastic appliances. The latter are made of latex, and the patient has to replace them daily. In addition, orthodontists prefer elastomeric ligatures to stainless steel wire ligatures.[1] Not only have the elastomeric chains the ability to return to their original shape after some deformation, but also they are easy to use, relatively hygienic, economical and do not need patient compliance.[2]

In spite of this acceptability, there has always been a concern about force degradation in these elastomeric materials. This has led to an increasing interest toward self-ligating brackets that eliminates the need for elastomeric ligatures. One of the most important reasons of plastic deformation and force decay of elastomeric modules is their sensitivity to the changes in intraoral environment that arise from a number of factors including different foods

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and beverages and other materials that enter the oral cavity.[3,4] Mouthwashes have been used for centuries for medicinal and cosmetic purposes, but it is only in recent years that the rationale behind the use of chemical ingredients has been subject to scientific research and clinical trials. Today's dentists are practicing in an era where the patients are more concerned about both their oral health and their overall medical wellbeing. Thus, in the midst of growing evidence of the connection between oral health and whole body health, herbal medicines with their "naturally occurring" active ingredients offer a gentle and enduring way for restoration of health by the most trustworthy and least harmful way.[5] Recently, the use of herbal mouthwashes such as persica is increasing. Persica is prepared from *Salvadora persica* extract. It has been shown that using this herbal medicine or its extract would support periodontal health, and reduces the accumulation of microbial plaques,[6] and bleeding during brushing,[7,8] and controls gingivitis and periodontal diseases.[7-9] The aim of this study was to evaluate the effects of three different mouthwashes on the force decay of orthodontic chains.

MATERIALS AND METHODS

In this study, elastomeric chains were used to simulate retraction of canine into premolar extraction space. Clear elastomeric chains (Dentaurum, Germany) in two configurations of short- and closed-connector were stored in plastic packages at room temperature (22-24°C) until the beginning of the study.[4,10] Each piece of short- and closed-connector chains included five and seven loops, respectively. An extra half loop at each end was reserved to compensate for the probable damage caused by prestretching and to facilitate performing the test.

The chains were prestretched to 100% of their initial length for 10 s. A jig with two posts secured on it with screws was designed [Figure 1]. The distance between the posts was fixed at 25 mm to simulate the distance between the first molar hook and distal wings of the canine bracket.[11,12] Each piece of chain was stretched between two posts. In this way, a constant force was exerted on elastomeric chain during the test period.

One hundred and twenty pieces of chains were divided into two control and six experimental groups of 15 as follows:

- Control group 1: Short-connector chains in artificial saliva.
- Control group 2: Closed-connector chains in artificial saliva.
- Experimental group 1: Short-connector chains in chlorhexidine 0.2% mouthwash.
- Experimental group 2: Closed-connector chains in chlorhexidine 0. 2% mouthwash.
- Experimental group 3: Short-connector chains in persica mouthwash.
- Experimental group 4: Closed-connector chains in persica mouthwash.
- Experimental group 5: Short-connector chains in 0.05% sodium fluoride mouthwash.
- Experimental group 6: Closed-connector chains in 0.05% sodium fluoride mouthwash.

Six pieces of chains (three short- and three closed-connectors) were mounted on the posts in the same manner, and their remained forces were measured. This was a time 0 and air group. All groups (except time 0) underwent thermocycling: Ten 30-s cycles/day in 5 and 55°C with 30-s for transition.[13] The chains were placed in their planned mouthwashes for 1 min/day to simulate the application of mouthwash by the patient. Then, the chains were rinsed by distilled water and returned to artificial saliva. The effects of the following three mouthwashes on the force loss were evaluated: Chlorhexidine 0.2% (Shahdaru Laboratories, Tehran, Iran) with 0.2% chlorhexidine digluconate and 13.65% ethanol (V/V), persica (Poursina Pharmaceutical Laboratories, Tehran, Iran) containing extract of *S. persica* (meswak), mint and yarrow extract with main ingredient as tannen, flavonid, calcium, fluoride, chloride and essence and Oral-B sodium fluoride 0.05% mouthwash (Procter and Gamble, Weybridge, United Kingdom) containing water, glycerin, alcohol, aroma, methyl paraben,

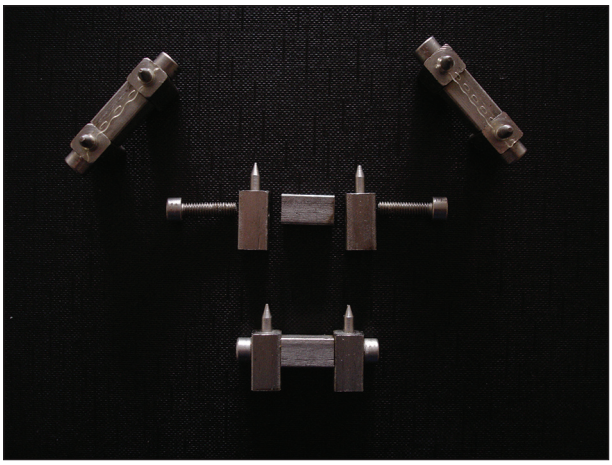

Figure 1: Jigs designed for stretching of elastomeric chains.

poloxamer 407, cetylpyridinum chloride, sodium fluoride, sodium saccharin, propylparaben.[14]

The remained force of the chains in each group was measured at time 0 (control groups) and after 24 h, 1, 2, 3 and 4 weeks by a force gauge (Lutron, model DC-515, Taiwan) [Figure 2].

The two-way analysis of variance (ANOVA) of Statistical Package for the Social Sciences (SPSS) software (SPSS Inc., Chicago, IL, USA) was employed to compare the amount of force loss percentage among the groups. The level of significance (α) was set at 5%.

RESULTS

In this experimental cross-sectional-analytic study, the effects of three different mouthwashes (chlorhexidine, sodium fluoride, and persica) on the force loss of two configurations of orthodontic chains (closed and short connector) at 6 times points (0, 24 h, 1, 2, 3 and 4 weeks) were evaluated.

Initially, data were studied using Kolmogorov–Smirnov statistical test to assess normal distribution. Then, two-way ANOVA and Tukey *post-hoc* were used to compare force degradation percentage.

Results showed that the amount of force degradation percentage in both chain configurations, in all solutions including the artificial saliva, showed significant loss ($P < 0.05$) [Tables 1-3].

In all solutions, from the beginning to the end of week 4, significant force loss was observed in short and closed connector chains ($P < 0.05$), but in all situations, persica caused less force loss compared to other media.

Figure 2: Force gauge coupling with jig. The distance between the posts remained constant while transferring to gauge.

DISCUSSION

Although elastomeric chains are widely used in orthodontics to move and close the space, force loss over time is inevitable. Several studies have examined the force degradation of elastomeric chains.[15-17] Many factors influence the rate of force decay including the manufacturer of the chain, the study design (*in vitro* or

Table 1: Percentage of force decay in short- and closed-connector chains in different environments and times (compered to initial)

Environment	Time	Force decay (%) ±SD	
		Short-connectors	Closed-connectors
Artificial saliva	24 h	21.519±0.24	21.684±1.11
	1-week	26.684±0.65	26.164±0.31
	2 weeks	33.428±1.31	31.720±1.42
	3 weeks	40.888±1.08	40.501±1.64
	4 weeks	44.045±0.43	51.612±1.07
Sodium fluoride	24 h	23.958±0.65	24.014±0.62
	1-week	29.554±0.65	27.598±0.62
	2 weeks	35.293±0.24	33.691±1.11
	3 weeks	42.897±0.49	41.218±1.35
	4 weeks	46.053±0.65	56.810±3.05
Chlorhexidine	24 h	25.823±0.24	27.240±0.82
	1-week	30.271±1.13	32.437±0.62
	2 weeks	36.441±0.24	38.172±0.93
	3 weeks	44.906±0.00	43.727±0.82
	4 weeks	49.640±1.29	59.856±1.64
Persica	24 h	20.945±0.65	18.638±3.65
	1-week	23.815±0.43	20.967±3.27
	2 weeks	27.976±0.89	28.136±0.62
	3 weeks	38.162±1.94	38.172±1.93
	4 weeks	40.314±0.65	43.190±1.64

SD: Standard deviation.

Table 2: A comparison between different times in short- and closed-connector chains

Time 1	Time 2	Mean difference (Time 1−Time 2)			
		Closed-connectors	*P*	Short-connectors	*P*
24 h	1-week	−3.8978	0.001	−4.5194	0.000
	2 weeks	−10.0358	0.000	−10.2225	0.000
	3 weeks	−18.0108	0.000	−18.6516	0.000
	4 weeks	−29.9731	0.000	−21.9515	0.000
1-week	2 weeks	−6.1380	0.000	−5.7031	0.000
	3 weeks	−14.1129	0.000	−14.1322	0.000
	4 weeks	−26.0753	0.000	−17.4321	0.000
2 weeks	3 weeks	−7.9749	0.000	−8.4291	0.000
	4 weeks	−19.9373	0.000	−11.7290	0.000
3 weeks	4 weeks	−11.9624	0.000	−3.2999	0.000

Table 3: A comparison between different solutions in short and closed-connector chains

Solution$_1$	Solution$_2$	Mean difference (Solution$_1$ - Solution$_2$)			
		Closed connectors	*P* Value	Short connectors	*P* Value
Artificial saliva	Chlorhexidine	−5.9498	0.000	−4.1034	0.000
	Persica	4.5161	0.000	3.0703	0.000
	Sodium fluoride	−2.3297	0.029	−2.2382	0.000
Chlorhexidine	Persica	10.4659	0.000	7.1737	0.000
	Sodium fluoride	3.6201	0.000	1.8652	0.000
Persica	Sodium fluoride	−6.8459	0.000	−5.3085	0.000

in vivo), the shape of the chain, different environments, temperature and potential of hydrogen (pH).[15-18] There has been little research on controllable factors like the effects of mouthwashes. In this study, we evaluated the effects of three different mouthwashes on the force decay of orthodontic chains. Artificial saliva was chosen as a control group because in some studies force degradation was higher in wet than in dry environments.[19-21] As changes in the temperature is an important parameter that affects the behavior of orthodontic chains,[17,22,23] the chains were thermocycled in this study. The initial force of approximately 200-g was used because this is the force that usually is needed for distal movement of canine.[24,25]

The results of the current study show that both closed and short connector chains in all mouthwashes had significant force losses at all times. Almost all previous studies showed that in any test environment, the highest force loss occurred during the 1st h or the first 24 h and then progressed in a more steady and gradual rate.[16,17,26-29] In the present study, during the first 24 h, the force loss was 21-26% and 19-27% of the initial force in short connector and in closed connector chains, respectively. At the end of week 4, 40-50% of the initial force had been lost in short connector chains. The loss was 43-60% of the initial force in closed connector chains. This range of force loss was similar to Motta *et al*.[30] and Buchmann *et al*.[31] studies. Other studies, however, showed a higher range of force loss (up to 75% of the initial force) in the first 24 h.[27,28] This difference was found to be highly dependent on the experimental conditions as the force loss is higher in wet *in vitro* conditions than in the air or dry conditions. It has also been shown that force decay is higher in *in vivo* compared to wet *in vitro* conditions.[4,16,17,19]

In this study, both chain configurations showed the lowest range of force loss when immersed in persica and had the highest force loss in chlorhexidine. This was significant in all time points. In an attempt to reconstruct the oral environment in studies on elastomeric chains, the effects of different materials with different pH, and different compositions have also been considered. The pH of <7.26 results in less force decay and contrary to the previous assumptions, more acidity do not cause higher force loss.[15,32] If we note the pH of mouthwashes in the present study, persica (pH = 5.68) was more acidic than chlorhexidine (pH = 7.47). The highest force loss caused by chlorhexidine can also be attributed to its ethanol content (13.65%). The effects of alcohol in mouthwashes on molecular and structural changes of elastomeric chains and the resulting force loss have been proven.[33,34]

In addition, the required force for orthodontic movement of canine is 100-300 g.[26] Despite the force loss after 4 weeks, optimal force remained approximately in all mouthwashes in short connector chains group, but in closed connector chains group, only remained in persica. Some studies have investigated the effect of distance between links on the force decay.[3,26] Their results showed that the elastomeric chains with less distance between modules produced higher initial force and underwent less force decay.[3] In this study, the pattern was different from these results, and the force loss was greater in closed connector chains, but persica was able to reduce the force loss.

CONCLUSION

All short and closed connector elastomeric chains showed a significant range of force loss during 4 weeks. The force loss was statistically significant in artificial saliva, persica, chlorhexidine, and sodium fluoride. The largest amount of force loss occurred in the first 24 h, and it was about half of the whole force loss in 4 weeks. Chlorhexidine caused the highest force loss followed by sodium fluoride and the artificial saliva. Chains in the persica had the lowest force loss.

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REFERENCES

1. Brantley WA, Eliades T. Orthodontic Materials: Scientific and Clinical Aspects. New York: George Thieme Verlag; 2001.
2. Bousquet JA Jr, Tuesta O, Flores-Mir C. *In vivo* comparison of force decay between injection molded and die-cut stamped elastomers. Am J Orthod Dentofacial Orthop 2006;129:384-9.
3. De Genova DC, McInnes-Ledoux P, Weinberg R, Shaye R. Force degradation of orthodontic elastomeric chains – A product comparison study. Am J Orthod 1985;87:377-84.
4. Eliades T, Bourauel C. Intraoral aging of orthodontic materials: The picture we miss and its clinical relevance. Am J Orthod Dentofacial Orthop 2005;127:403-12.
5. Haffajee AD, Yaskell T, Socransky SS. Antimicrobial effectiveness of an herbal mouthrinse compared with an essential oil and a chlorhexidine mouthrinse. J Am Dent Assoc 2008;139:606-11.
6. Al-Otaibi M, Al-Harthy M, Gustafsson A, Johansson A, Claesson R, Angmar-Månsson B. Subgingival plaque microbiota in Saudi Arabians after use of miswak chewing stick and toothbrush. J Clin Periodontol 2004;31:1048-53.
7. Darout IA, Albandar JM, Skaug N. Periodontal status of adult Sudanese habitual users of miswak chewing sticks or toothbrushes. Acta Odontol Scand 2000;58:25-30.
8. Khalessi AM, Pack AR, Thomson WM, Tompkins GR. An *in vivo* study of the plaque control efficacy of Persica: A commercially available herbal mouthwash containing extracts of *Salvadora persica*. Int Dent J 2004;54:279-83.
9. al-Otaibi M. The miswak (chewing stick) and oral health. Studies on oral hygiene practices of urban Saudi Arabians. Swed Dent J Suppl 2004;167:2-75.
10. Taloumis LJ, Smith TM, Hondrum SO, Lorton L. Force decay and deformation of orthodontic elastomeric ligatures. Am J Orthod Dentofacial Orthop 1997;111:1-11.
11. Kim KH, Chung CH, Choy K, Lee JS, Vanarsdall RL. Effects of prestretching on force degradation of synthetic elastomeric chains. Am J Orthod Dentofacial Orthop 2005;128:477-82.
12. Balhoff DA, Shuldberg M, Hagan JL, Ballard RW, Armbruster PC. Force decay of elastomeric chains — A mechanical design and product comparison study. J Orthod 2011;38:40-7.
13. Gale MS, Darvell BW. Thermal cycling procedures for laboratory testing of dental restorations. J Dent 1999;27:89-99.
14. Danaei SM, Safavi A, Roeinpeikar SM, Oshagh M, Iranpour S, Omidkhoda M. Ion release from orthodontic brackets in 3 mouthwashes: An *in-vitro* study. Am J Orthod Dentofacial Orthop 2011;139:730-4.
15. Ferriter JP, Meyers CE Jr, Lorton L. The effect of hydrogen ion concentration on the force-degradation rate of orthodontic polyurethane chain elastics. Am J Orthod Dentofacial Orthop 1990;98:404-10.
16. Ash JL, Nikolai RJ. Relaxation of orthodontic elastomeric chains and modules *in vitro* and *in vivo*. J Dent Res 1978;57:685-90.
17. Lu TC, Wang WN, Tarng TH, Chen JW. Force decay of elastomeric chain – A serial study. Part II. Am J Orthod Dentofacial Orthop 1993;104:373-7.
18. Kuster R, Ingervall B, Bürgin W. Laboratory and intra-oral tests of the degradation of elastic chains. Eur J Orthod 1986; 8:202-8.
19. Huget EF, Patrick KS, Nunez LJ. Observations on the elastic behavior of a synthetic orthodontic elastomer. J Dent Res 1990;69:496-501.
20. Hwang CJ, Cha JY. Mechanical and biological comparison of latex and silicone rubber bands. Am J Orthod Dentofacial Orthop 2003;124:379-86.
21. Kanchana P, Godfrey K. Calibration of force extension and force degradation characteristics of orthodontic latex elastics. Am J Orthod Dentofacial Orthop 2000;118:280-7.
22. Stevenson J, Kusy R. Structural degradation of polyurethane-based elastomeric modules. J Mater Sci Mater Med 1995;6:377-84.
23. Bishara SE, Andreasen GF. A comparison of time related forces between plastic alastiks and latex elastics. Angle Orthod 1970;40:319-28.
24. Quinn RS, Yoshikawa DK. A reassessment of force magnitude in orthodontics. Am J Orthod 1985;88:252-60.
25. Reitan K. Some factors determining the evaluation of forces in orthodontics. Am J Orthod 1957;43:32-45.01.
26. Baty DL, Storie DJ, von Fraunhofer JA. Synthetic elastomeric chains: A literature review. Am J Orthod Dentofacial Orthop 1994;105:536-42.
27. Andreasen GF, Bishara S. Comparison of alastik chains of elastics involved with intra-arch molar-to-molar forces. Am J Orthod 1971;60:200-1.
28. Wong AK. Orthodontic elastic materials. Angle Orthod 1976;46:196-205.
29. Killiany DM, Duplessis J. Relaxation of elastomeric chains. J Clin Orthod 1985;19:592-3.
30. Motta AF, Cury-Saramago AA, Nojima LI. *In vitro* evaluation of force delivered by elastomeric chains. Dental Press J Orthod 2011;16:36-7.
31. Buchmann N, Senn C, Ball J, Brauchli L. Influence of initial strain on the force decay of currently available elastic chains over time. Angle Orthod 2012;82:529-35.
32. Teixeira L, Pereira Bdo R, Bortoly TG, Brancher JA, Tanaka OM, Guariza-Filho O. The environmental influence of Light Coke, phosphoric acid, and citric acid on elastomeric chains. J Contemp Dent Pract 2008;9:17-24.
33. Eliades T, Eliades G, Silikas N, Watts DC. *In vitro* degradation of polyurethane orthodontic elastomeric modules. J Oral Rehabil 2005;32:72-7.
34. Larrabee TM, Liu SS, Torres-Gorena A, Soto-Rojas A, Eckert GJ, Stewart KT. The effects of varying alcohol concentrations commonly found in mouth rinses on the force decay of elastomeric chain. Angle Orthod 2012;82:894-9.

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