ARTICLE IN PRESS

Available online at www.sciencedirect.com

ScienceDirect
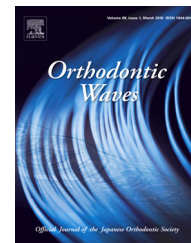
Original article

Effect of four different mouthwashes on force-degradation pattern of orthodontic elastomeric chains

AmirHossein Mirhashemi [a], Niloofar Farahmand [b],
Atefe Saffar Shahroudi [a], Mohammad Sadegh Ahmad Akhoundi [c,*]

[a] Department of Orthodontics, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
[b] School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
[c] Dental Research Center, Dentistry Research Institute, Tehran, Iran; Department of Orthodontics, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran

ARTICLE INFO

ABSTRACT

Purpose: Elastomeric chains are widely used for exerting force in orthodontics. Since orthodontic patients are prone to plaque accumulation they are usually advised to apply antibacterial agents. The aim of this study was to compare the effects of three different mouthwashes including persica, chlorhexidine, sodium fluoride and the combination of chlorhexidine and sodium fluoride on force decay of orthodontic elastomeric chains.

Materials and methods: In this study, 315 pieces of elastomeric chains were divided into 5 groups: persica, chlorhexidine 0.2%, sodium fluoride 0.2% and the combination of chlorhexidine and sodium fluoride and a control group. The samples were kept in artificial saliva and were soaked in the mouthwashes twice a day for 60 s each time. The control group was kept in artificial saliva throughout the day. The forces exerted by the samples were measured by a universal testing machine at initial, 1 day, 7, 14 and 28 days. To compare the results, repeated measure ANOVA was performed.

Results: A significant force-degradation over time was observed in all groups ($p < 0.005$). However, there were no significant differences among study groups and between study groups and the control group.

Conclusions: Application of persica, chlorhexidine, sodium fluoride and the combination of chlorhexidine and sodium fluoride mouthwashes had no adverse effect on the force-degradation of orthodontic elastomeric chains.

* Corresponding author. Fax: +98 2122923041.
E-mail address: ahmadakh@tums.ac.ir (M.S. Ahmad Akhoundi).

1. Background

During an orthodontic treatment, the force is exerted to the teeth by different appliances including elastomeric chains, stainless steel spring and NiTi coil springs etc. Among them elastomeric chains (ECs) are more popular due to ease of application and low cost [1]. ECs are polyurethane elastomeric products that have been used from 1960 in orthodontic treatment for inter-arch tooth movements. However, there are some disadvantages including discoloration, plaque accumulation and force degradation from which the latter is the most challenging problem [2]. ECs undergo permanent deformation and force decay over time that results in inadequate tooth movement which in turn leads to more frequent appointments to change the chains and elongate the length of the whole treatment [3,4].

Force decay characteristics and force relaxation patterns of elastomeric materials are influenced by various factors such as manufacturing techniques, environmental conditions, temperature, moisture, pH, saliva enzymes, patient diet, sterilization technique and chemical composition as well as morphology and dimensions of the chains [5–11]. Thus, any changes in oral environment caused by drinks, beverages, foods and medicines can potentially affect the force-degradation of ECs.

Mouthwashes have been widely used as a means of oral hygiene to decrease the load of cariogenic oral microorganisms and decrease caries and gingival inflammation. Orthodontic appliances facilitate plaque accumulation and compromise oral hygiene, which in turn predispose the patient to dental caries and periodontal problems [12,13]. Thus, the application of antimicrobial agents is more commonly advised during orthodontic treatment [14]. Chlorhexidine glucanate is a well-known antibacterial agent that is frequently used and its effectiveness as a therapeutic mouthwash in controlling the Streptococcus mutans and lactobacilli levels of orthodontic patients with fixed appliances has been shown in previous studies [15,16]. Recently chlorhexidine and fluoride combination was found to be a more effective way to reduce possible caries-associated problems in patients who undergo fixed appliance therapy [17]. Another type of mouthwashes is herbal ones which have been advocated in preserving periodontal health, and reduction of microbial plaques. Persica is a kind of herbal mouthwash which is prepared from *Salvadora persica* extract and its efficacy in improving gingival health and lowering carriage rate of cariogenic bacteria has been demonstrated [18]. All these antimicrobial agents can be beneficial in inhibiting salivary MS levels and reducing gingivitis therefore improving oral hygiene in orthodontic patients [19]. However, mouthwashes are chemicals that can change the pH of oral environment and affect the orthodontic appliances. Several studies have addressed the force decay of orthodontic ECs, among them the effect of pH changes [20], different types of artificial saliva [21], temperature, bleaching agents [10] and sodium fluoride [22], have been studied.

This study was conducted with the aim of comparing the effects of three different mouthwashes including persica, chlorhexidine, sodium fluoride (NaF) and the combination of chlorhexidine and sodium fluoride on the force decay of orthodontic elastomeric chains in in vitro conditions.

2. Materials and methods

In this experimental in vitro study, 315 pieces of elastomeric chains with the length of 24 mm, all of them clear and without intermodular link, (American Orthodontics) were selected. The specimens were divided into five groups: control group, persica, chlorhexidine 0.2%, sodium fluoride 0.2% and the combination of chlorhexidine and sodium fluoride — each containing about 15 pieces of chain.

A custom made device was designed to hold the chain stretched at the length of 24 mm. This length demonstrates the average distance between the mid-buccal point of the upper canine crown and the buccal groove of the first upper molar. The initial length of samples was so that they exert about 200 gr force at the length of 24 mm since the acceptable force for average orthodontic tooth movements is mentioned to be about 200 gr [23]. The test specimens were cut so that one extra loop was remained on each side to avoid any damage on terminal loops.

Five devices were fabricated for the five study groups. A number of round cross sectional rods were made of stainless steel and were inserted in a plexiglass plate. (Fig. 1). In order to

Fig. 1 – Fabricated device made of stainless steel rods to hold the chains stretched at the length of 24mm.

simulate oral condition, the specimens were immersed in a modified Fusayama artificial saliva which was prepared in the pharmacy school laboratory (NaCl 400 mg/L, KCl 400 mg/L, CaCl$_2$·2H$_2$O 795 mg/L, NaH$_2$PO$_4$·H$_2$O 690 mg/L, Na$_2$S·9H$_2$O 5 mg/L, urea 1000 mg/L, pH 6.75) [24], and subsequently stored in an incubator at body temperature (37±1°C). The specimens of groups 2–5 were immersed in the test mouthwashes twice a day for 60 s each time at 12-h intervals and were taken back to the artificial saliva. The force exerted by each group was measured by means of a universal testing machine (Zwick) using a load cell of 250 g at 1 day, 7 days, 14 days and 28 days intervals − fifteen specimens from each group were tested at each interval. (Fig. 2) To measure the initial force, fifteen specimens from the control group were tested before being placed in the study device.

To compare the changes of the force values at different time intervals repeated measure analysis of variance (ANOVA) was performed considering the test groups as between subject factor. The test was followed by a multiple comparison test (LSD test). The risk of a Type 1 error was set at 5% (significance level=0.05).

3. Results

In this study, the mean initial force at 24 mm extension was 1.922±0.04 N. According to repeated measured ANOVA, no significant difference was observed among the test groups and between the test groups and the control group (p>0.05).

According to the least significant difference (LSD) test, a significant force loss over time was observed for all groups and there was significant difference between the measured forces at each time interval with the previous one in all groups (p<0.0001) (Fig. 3).

In all study groups as well as the control group, the greatest reduction in the delivered force occurred in the first 24 h with the lowest reduction in the persica group (32.4%) and the highest in the combination of chlorhexidine and sodium fluoride group (38.7%) (Table 1). Among all time intervals, the lowest percentage of force loss was observed on the 28th day in

the sodium fluoride group which had a 1.3% reduction relative to the 14th day.

4. Discussion

In spite of force decay over time, elastomeric chain has been widely applied for delivering orthodontic force. Concerned about consistent and healthy dental movement, this study was conducted to survey the effect of different mouth rinses on the force loss pattern of ECs. Two common mouth rinse including chlorhexidine and sodium fluoride were selected in addition to their combination. An herbal mouthwash known as Persica was also studied. Force decay pattern of ECs which was exposed to the mentioned mouthwashes were measured by a universal testing machine and were compared with ECs which were soaked in artificial saliva. The results of this study suggest that none of the test mouthwashes adversely affect the force decay of EC since there were no statistical differences between the force loss over time of mouthwash groups and the control group (artificial saliva). At none of the time intervals, the force value of the mouthwash groups (notwithstanding the type of mouthwash) was significantly different from the control group (Table 1). The same was true about the percentage of the remaining which was defined as the percentage of the force value at each time interval relative to the initial force. It is worth to notice that the results were true in the limited exposure time. The time of exposure to the mouthwashes was 60 s at each time so that it nearly stimulate the maximum time of normal daily mouthwash application. The follow-up time was limited to 28 days which accounts for a common time interval between two orthodontic appointments for changing the elastomeric chains. The initial length and the elongation of the test ECs were selected so that they could deliver a force of about 200 gr since it was suggested as the acceptable force for average orthodontic tooth movements [23]. In order to stimulate oral environment the specimens were kept in artificial saliva at 37°C throughout the study except the time of soaking in mouthwashes. The studies of Nattrass et al. and Halimi et al. stated that humid environment

Fig. 2 – The force delivered by each group was measured by means of a universal testing machine (Zwick).
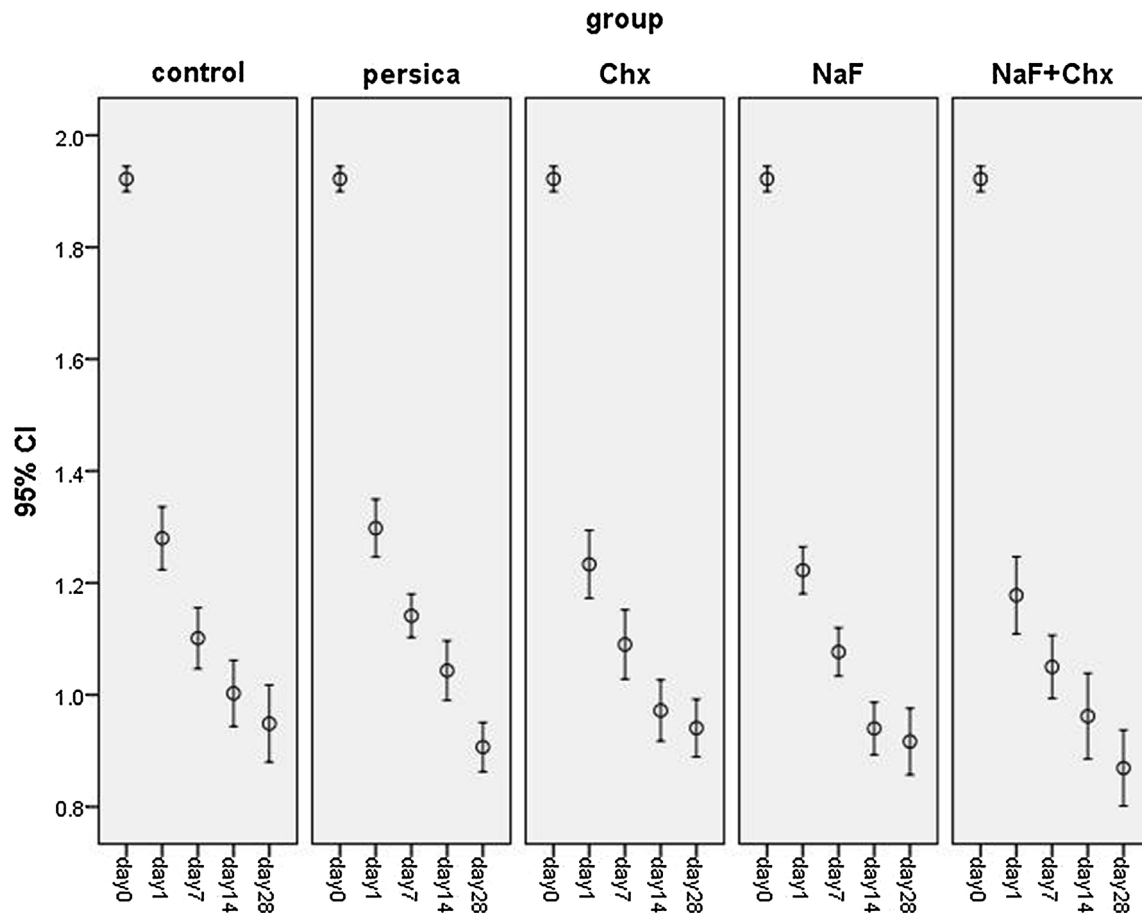
Fig. 3 – Error bar of the means and standard deviations of the force of the test elastomeric chains at the 95% confidence interval, at different times in different mouthwashes. Chx: chlorhexidine, NaF: sodium fluoride.

Table 1 – The average of force values (N) of the studied elastomeric chains at different time intervals (The percentage of remaining force-relative to the initial force %) Mean (SD).

	Initial	1st day	7th day	14th day	28th day
Control	1.9220 (100)	1.2800 (66.6)	1.1013 (57.3)	1.0027 (52.2)	0.9487 (49.4)
Persica	1.9220 (100)	1.2980 (67.6)	1.1413 (59.4)	1.0433 (54.3)	0.9067 (47.2)
Chx[+]	1.9220 (100)	1.2333 (64.2)	1.0900 (72.56)	0.9720 (50.6)	0.9407 (49.0)
NaF[++]	1.9220 (100)	1.2227 (63.7)	1.0767 (56.1)	0.9400 (49.0)	0.9167 (47.7)
Chx+NaF	1.9220 (100)	1.1780 (61.3)	1.0500 (54.7)	0.9620 (50.1)	0.8693 (45.3)

[+]: Chlorhexidine.
[++]: Sodium fluoride.
[*]: Significantly different from the control group.

led to less force decay of ECs relative to dry environment [5,25]. About the effect of the pH level on the ECs force decay, no consistency exists and some authors observed no significant correlation between pH and force decay [20,26]. To be on the safe side the pH level of the environment was set at 6.7 to simulate natural oral condition. The results of this study indicated that ECs of all study groups underwent a relatively consistent force loss over time with the greatest reduction at the first 24h (Fig. 3). Similar finding was reported in other studies [8,10,27]. In the current study the minimum reduction

was observed in persica group (32.4%) and the maximum in the combination of chlorhexidine and sodium fluoride group (38.7%) albeit they were not significantly different. At the last follow-up the highest remaining force was observed in the control group (49.4%) followed by the chlorhexidine group (49.0%) while the lowest remaining force belonged to the combination of chlorhexidine and sodium fluoride group (45.3%).

The effectiveness of chlorhexidine in decreasing the S mutans levels around the orthodontic braces in patients with fixed appliances has been demonstrated in several studies [15,27]. In the current study it was concluded that this mouthwash did not significantly increase the force decay of ECs. This is consistent with Pithon et al., study [28]. Ramazanzadeh et al., [22] evaluated the effects of sodium fluoride mouth rinse on elastic properties of different elastomeric chains and concluded that daily use of NaF mouth rinse did not affect force degradation to achieve conventional orthodontic forces. This finding does not conflict with our study. Persica mouth wash in orthodontic patient has not received much attention in the literature although its efficacy in enhancing periodontal health and lowering dental caries has been demonstrated [18]. Omidkhoda et al. [27] evaluated the effects of three different mouthwashes including chlorhexidine, sodium fluoride and persica on the force decay of orthodontic chains. Contrary to the current study, they reported that persica and chlorhexidine showed statistically significant differences in the amount of force decay over time and the chlorhexidine caused the highest percentage of force loss. This controversy can be attributed to differences in the methodology of the studies. In Omidkhoda study, the samples were thermocycled and the chlorhexidine contained 65.13% ethanol while in this study ethanol-free chlorhexidine mouthwash was applied.

In this study only one type of elastomeric chain was tested to evaluate the effect of different mouthwashes on the force decay pattern. However, it is suggested that different type of elastomeric products be compared in accordance with their behavior in exposure to different mouth rinses. Moreover, several new mouthwashes are introducing every day for orthodontic patients and evaluating the effect of other commercially available mouthwashes on the mechanical properties of elastomeric chains is suggested for further studies.

5. Conclusion

Within the limitation of this study, it was concluded that the application of chlorhexidine 0.2%, persica, sodium fluoride 0.2% and combination of chlorhexidine and sodium fluoride mouthwashes had no adverse effect on the force decay of elastomeric chains and they can be applied safely in orthodontic patients with fixed appliances.

Conflict of interests

The author(s) declare that they have no conflict of interests.

Acknowledgments

REFERENCES

[1] Santos AC, Tortamano A, Naccarato SR, Dominguez-Rodriguez GC, Vigorito JW. An in vitro comparison of the force decay generated by different commercially available elastomeric chains and NiTi closed coil springs. Braz Oral Res 2007;21:51–7.

[2] David C, McInnes-Ledoux P, Weinberg R, Shaye R. Force degradation of orthodontic elastomeric chains — a product comparison study. Am J Orthod Dentofac Orthop 1985; 87:377–84.

[3] 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;82:894–899.

[4] Eliades T, Eliades G, Silikas N, Watts DC. In vitro degradation of polyurethane orthodontic elastomeric modules. J Oral Rehabil 2005;32:72–7.

[5] Nattrass C, Ireland AJ, Sherriff M. The effect of environmental factors on elastomeric chain and nickel titanium coil springs. Eur J Orthod 1998;20:169–76.

[6] Paige SZ, Tran AM, English JD, Powers JM. The effect of temperature on latex and non-latex orthodontic elastics. Tex Dent J 2008;125:244–9.

[7] Dittmer PD, Demling AP, Borchers L, Stiesch M, Kohorst P, Schwestka-Polly R. The influence of simulated aging on the mechanical properties of orthodontic elastomeric chains without an intermodular link. J Orofac Orthop 2012; 73:289–97.

[8] 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.

[9] Evangelista MB, Berzins DW, Monaghan P. Effect of disinfecting solutions on the mechanical properties of orthodontic elastomeric ligatures. Angle Orthod 2007; 77:681–7.

[10] Pithon MM, Rodrigues AC, Sousa ÉL, de Souza Santos LP, dos Santos Soares N. Do mouthwashes with and without bleaching agents degrade the force of elastomeric chains? Angle Orthod 2013;83:712–7.

[11] Beattie S, Monaghan P. An in vitro study simulating effects of daily diet and patient elastic band change compliance on orthodontic latex elastics. Angle Orthod 2004;742:234–9.

[12] Ai H, Lu HF, Liang HY, Wu J, Li RL, Liu GP, et al. Influences of bracket bonding on mutans streptococcus in plaque detected by real time fluorescence-quantitative polymerase chain reaction. Chin Med J (Engl) 2005;118:2005–10.

[13] van Gastel J, Quirynen M, Teughels W, Coucke W, Carels C. Longitudinal changes in microbiology and clinical periodontal variables after placement of fixed orthodontic appliances. J Periodontol 2008;79:2078–86.

[14] Ahmed I, Saif-ul-Haque RN. Carious lesions in patients undergoing orthodontic treatment. J Pak Med Assoc 2011;61:1176–9.

[15] Oltramari-Navarro PV, Titarelli JM, Marsicano JA, Henriques JF, Janson G, Lauris JR, et al. Effectiveness of 0.50% and 0.75% chlorhexidine dentifrices in orthodontic patients: a double-blind and randomized controlled trial. Am J Orthod Dentofac Orthop 2009;136:651–6.

[16] Dogan AA, Cetin ES, Hüssein E, Adiloglu AK. Microbiological evaluation of octenidine dihydrochloride mouth rinse after 5 days' use in orthodontic patients. Angle Orthod 2009;79:766–72.

[17] Baygin O, Tuzuner T, Ozel MB, Bostanoglu O. Comparison of combined application treatment with one-visit varnish treatments in an orthodontic population. Med Oral Patol Oral Cir Bucal 2013;18:e362–70.

[18] 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.

[19] Salehi P, Sh MD. Comparison of antibacterial effect of persica mouthwash with chlorhexidine on streptococcus mutans in orthodontic patients. DARU 2006;14:178–82.

[20] Sauget PS, Stewart KT, Katona TR. The effect of pH levels on nonlatex vs latex interarch elastics. Angle Orthod 2011;81:1070–4.

[21] Von Fraunhofer JA, Coffelt MP, Orbell GM. The effects of artificial saliva and topical fluoride treatments on the degradation of the elastic properties of orthodontic chains. Angle Orthod 1992;62:265–74.

[22] Ramazanzadeh BA, Jahanbin A, Hasanzadeh N, Eslami N. Effect of sodium fluoride mouth rinse on elastic properties of elastomeric chains. J Clin Pediatr Dent 2009;34:189–92.

[23] Boester CH, Johnston LE. A clinical investigation of the concepts of differential and optimal force in canine retraction. Angle Orthod 1974;44:113–9.

[24] Baboian R. Corrosion tests and standards: application and interpretation. American Society for Testing and Materials (ASTM); 1995.

[25] Halimi A, Azeroual MF, Doukkali A, El Mabrouk K, Zaoui F. Elastomeric chain force decay in artificial saliva: an in vitro study. Int Orthod 2013;11:60–70.

[26] Lacerda dos Santos R, Pithon MM, Romanos MT. The influence of pH levels on mechanical and biological properties of nonlatex and latex elastics. Angle Orthod 2012;82:709–14.

[27] Omidkhoda M, Rashed R, Khodarahmi N. Evaluation of the effects of three different mouthwashes on the force decay of orthodontic chains. Dent Res J (Isfahan) 2015;12:348–52.

[28] Pithon MM, Santana DA, Sousa KH, Farias IM. Does chlorhexidine in different formulations interfere with the force of orthodontic elastics? Angle Orthod 2013;83:313–8.