

ORIGINAL RESEARCH



Effect of Bleaching Mouthwash on Force Decay of Orthodontic Elastomeric Chains

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ABSTRACT

Introduction: Force decay elastomeric chains are significant, and it is a clinical problem.

Aim: The aim of this study was to evaluate the effects of bleaching agent in the mouthwash on the force decay of orthodontic chains.

Materials and methods: In this experimental study, 160 gray closed elastomeric chains were randomly divided into three groups (one control and two test groups). Four loops of chains were stretched for 25 mm on custom-made jig. Control group specimens were immersed in artificial saliva during the test period. Test group specimens were immersed twice a day for 30 seconds in the whitening (LISTERINE® HEALTHY WHITE™) and daily sodium fluoride (LISTERINE® TOTAL CARE ZERO) mouthwashes. All specimens were immersed in artificial saliva at 37°C. Force was measured at different time points (initial, 1, 7, 14, 21, 28 days). Statistical analysis was performed by two-way analysis of variance (ANOVA) and Bonferroni methods ($\alpha = 0.05$).

Results: Force of elastomeric chains was decreased dramatically in all groups during the experiment. After 24 hours, force was decreased by 42.18, 48.34, and 53.38% in control group, daily, and bleaching mouthwash groups respectively. The corresponding numbers after 4 weeks were 66.30, 76.73, and 86.48. The difference between three groups at days 1 and 28 was statistically significant ($p < 0.05$).

Conclusion: Within the limitations of the current *in vitro* study, bleaching and sodium fluoride mouthwashes could cause force decay of orthodontic elastomeric chains. Whitening mouthwash is more weakening for elastomeric chains.

Clinical significance: Use of whitening mouthwash by orthodontic patients could decrease the force of elastomeric chains, so it could be recommended to use them for a short time.

Keywords: Bleaching agent, Elastomeric chains, Force decay, Mouthwash.

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INTRODUCTION

Elastomeric power chains are extensively used in orthodontics as they are effective, easy to use, colorful, and comfortable for the patient. Although the main feature of these chains is to return to their original length to exert force, several studies have demonstrated reduction of their force following *in vivo* and *in vitro* usage.¹⁻⁴

Several factors including primary stretch, experiment environment, pH, temperature, design of chains, and manufacturer (commercial brand) could influence force decay of elastomeric chains.^{1,5-7} Another influencing factor is mouthwash which is used by the patients during orthodontic therapy. Clinicians usually recommend the use of fluoride mouthwash to prevent white spots and dental caries during treatment with braces. Previously, some investigators assessed the effect of sodium fluoride mouthwash on force decay of elastomeric chains.^{4,8-10} However, there is a controversy among the results of these studies. Some reported significant force decay following immersion of chains in sodium fluoride mouthwash,^{9,10} while others revealed no effect of this mouthwash on force decay.^{4,8}

On the one hand, some patients may not be satisfied with tooth discoloration during orthodontic therapy.

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As a result, they may use whitening mouthwashes to bleach their teeth. There are limited data regarding the effect of bleaching mouthwash on force decay of elastomeric chains.¹¹ Pithon et al¹¹ reported that whitening mouthwash has no significant effect on force decay of elastomeric chains.

The aim of this study was to assess the effect of whitening mouthwash on force decay of orthodontic elastomeric chains during a 4-week period.

MATERIALS AND METHODS

The materials used in this *in vitro* study were gray closed orthodontic elastomeric chains (American Orthodontics, Sheboygan, Wisconsin, USA), and two types of mouthwashes including daily sodium fluoride mouthwash (LISTERINE® TOTAL CARE ZERO) and bleaching mouthwash (LISTERINE® HEALTHY WHITE™). Both mouthwashes had 0.02% sodium fluoride as an active ingredient, while the whitening mouthwash had hydrogen peroxide for tooth bleaching. The sample size was calculated 10 elastomeric chains in each group at each time point considering $\alpha = 0.05$ and power 80% based on study of Larrabee et al⁵ that reported a mean difference of 12 and standard deviation (SD) of 7.7 and 9.6 in two groups.

For each sample, a piece of elastomeric chain including 6 loops was cut. Fifteen custom-made jigs were made using polyvinyl siloxane (Fig. 1). This jig had two holes 25 mm apart on each side, and four 20 mm pins were inserted in holes and fixed with autopolymerized acrylic resin. The pins supported 10 stretched elastomeric chains. Endpoint loops of each chain were left, and the inner loops were attached to the jig pins. The final setup constituted of four closed loops of elastomeric chains (11 mm non-stretched) attached to the pins which were 25 mm apart. Distance of 25 mm was chosen to mimic

the distance between canines and first molar following tooth extraction.^{12,13}

The samples were randomly divided into three groups (two types of mouthwashes and one control group). All samples were immersed in artificial saliva (sodium chloride 0.067%, natrosol 0.5%, sodium benzoate 0.05%, sorbitol 2.4%, and deionized water qsp 100%, neutral pH)¹⁴ and kept in an incubator at 37°C for 28 days similar to previous studies.^{6,15} During these 28 days, the samples of intervention groups were immersed in bleaching or daily mouthwashes twice a day for 30 seconds and then immersed in the intermediate plate containing distilled water for 10 seconds. Following rising, samples were returned to their plates containing artificial saliva and kept in an incubator at 37°C.

The force was measured before and 1, 7, 14, 21, and 28 days after initiation of the study. An Instron machine (Instron Corporation, Canton, Massachusetts, USA) with the rate of 30 mm/min was used to measure elastomeric chain force by a skilled operator who was blind to the type of intervention. Amount of force was measured while four inner loops of elastomeric chains were stretched to 25 mm.

Mean and SD of force in each group at each time point was calculated. Kolmogorov–Smirnov test showed normal distribution of values ($p > 0.05$). Two-way ANOVA was used to find the significant difference among three groups at different time points. A pairwise comparison at each time point was done by Bonferroni’s method. Furthermore, to compare mean force of each group with the initial force, Dunnett test was used. Statistical analysis was performed using Statistical Package for the Social Sciences, version 21, software (SPSS, Inc., Chicago, Illinois, USA) with a significance level of 0.05.

RESULTS

The mean force of elastomeric chains in each group at each time point is demonstrated in Table 1, and pairwise comparison of mean force between groups at different time points is reported in Table 2. According to two-way ANOVA analysis, the effect of time ($p < 0.001$) and mouthwash ($p < 0.001$) on force on elastomeric chains was statistically significant.

During the experiment, amount of force was decreased significantly in all groups (Graph 1). One day after activation of elastomeric chains, largest force decay occurred in all groups ($p < 0.05$). After 24 hours, in control group force was decreased by 42.18%, while in daily and bleaching mouthwashes, force decay was 48.34 and 53.38% respectively ($p < 0.05$). Force decay after 1 to 3 weeks was not statistically different between three groups ($p > 0.05$) except for mean force of elastomeric chains in bleaching mouthwash compared with control

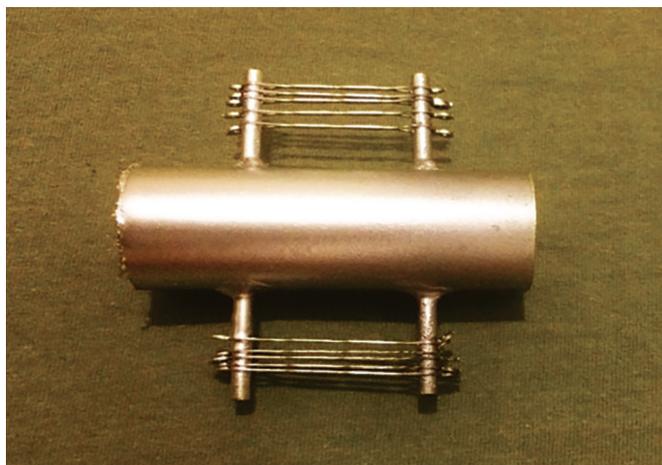


Fig. 1: Custom jig for stimulation of stretched elastomeric chains (four loops of closed elastomeric chain, originally 11 mm were stretched to 25 mm)

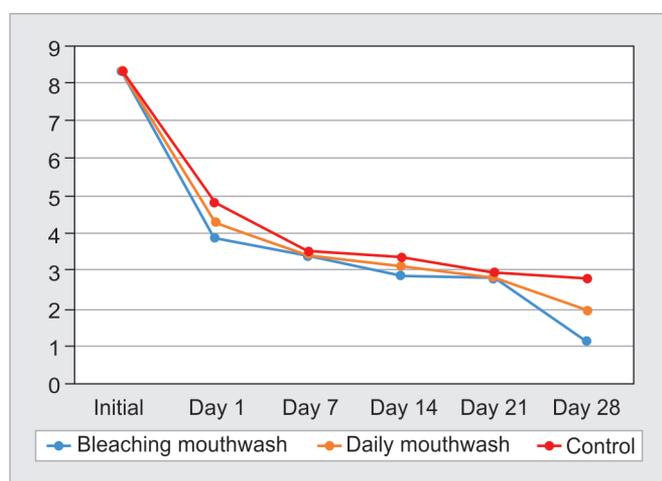
Table 1: Mean and SD of force (N) of elastomeric chains in three groups at different time points

Environment	Time (in days)	Mean (n)	Force decay (%)	SD	Minimum	Maximum
Initial	0	8.342085	–	0.14948	8.175559	8.634902
Control	1	4.822796	42.18	0.302743	4.2091	5.2466
	7	3.5444	57.51	0.204765	3.3007	3.8825
	14	3.363681	59.67	0.173009	3.0928	3.5839
	21	2.936092	64.8	0.111382	2.7645	3.1627
	28	2.811113	66.3	0.10658	2.6456	3.0052
Bleaching mouthwash	1	3.88835	53.38	0.033184	3.8349	3.9468
	7	3.413434	59.08	0.120861	3.2791	3.6099
	14	2.884334	65.42	0.152159	2.6759	3.1236
	21	2.821391	66.17	0.220551	2.5546	3.1993
	28	1.127102	86.48	0.079977	1.0023	1.2265
Daily mouthwash	1	4.309454	48.34	0.148058	4.0059	4.5552
	7	3.461086	58.51	0.182224	3.1979	3.6952
	14	3.142358	62.33	0.129199	2.9453	3.3155
	21	2.835666	66	0.311434	2.4548	3.2129
	28	1.941028	76.73	0.134969	1.831	2.052

Table 2: Pairwise comparison of force of elastomeric chains between three groups and compared with initial force at different time points

(J) Group	(I) Group	Day 1		Day 7		Day 14		Day 21		Day 28	
		Mean difference (I – J)	p-value								
Initial	Control	3.519	<0.001	4.797	<0.001	4.978	<0.001	5.405	<0.001	5.53	<0.001
	Bleach MW	4.453	<0.001	4.928	<0.001	5.457	<0.001	5.52	<0.001	6.401	<0.001
	Daily MW	4.032	<0.001	4.88	<0.001	5.199	<0.001	5.506	<0.001	6.214	<0.001
Control	Bleach MW	0.934	<0.001	0.13	1	0.479	<0.001	0.114	0.447	0.87	<0.001
	Daily MW	0.513	0.017	0.083	1	0.221	0.446	0.1	0.618	1.684	<0.001
Daily MW	Bleach MW	0.421	<0.001	0.047	1	0.258	0.083	0.014	1	0.813	<0.001

MW: Mouthwash



Graph 1: Mean force (N) of elastomeric chains in three groups at different time points compared with initial force

group after 2 weeks ($p < 0.001$). After 4 weeks, there was another large force decay in elastomeric chains of both mouthwashes. Force decays after 4 weeks in bleaching and daily mouthwashes and control groups were 86.48, 76.73, and 66.30% respectively ($p < 0.05$).

DISCUSSION

Elastomeric chains are used to enhance tooth movement and space closure in orthodontics. Several factors could influence force decay of these chains.^{1,5-7,16,17} The current study was performed to assess the effect bleaching mouthwash on force decay of elastomeric chains. The results revealed a significant effect of these mouthwashes 1 and 28 days after activation. Amount of force suggested for canine retraction is between 1 and 3.5 N.^{18,19} Initial force of elastomeric chains used in the current study was more than twofolds of suggested force, while after 1 until 4 weeks, force was within the limit.

A noteworthy finding of the current study was dramatic force decay in all groups after 1 day of activation. Time-dependent force decay of elastomeric chains has been reported in previous studies.^{1,5,9,17,20,21} Immersion of elastomeric chains in distilled water after 1 and 7 days showed 51.6 and 56.8%,⁹ 49 and 50.3%,²⁰ 48.1 and 54.3%⁵ force decay in elastomeric chains respectively. The current study revealed 42.18 and 57.51% force decay of

orthodontic chains kept in artificial saliva 1 and 7 days after activation respectively.

Large force decay occurred in all three groups during the experiment. In control group, steep force decay continued during the first week, and mean force was not statistically different after 1 week between three groups. Amount of force was relatively similar between three groups until fourth week when there was a significant decrease in force of elastomeric chains of bleaching mouthwash followed by daily mouthwash.

The main finding of this study was dramatic force decay of elastomeric chains immersed in whitening mouthwash 1 and 28 days after activation. The active ingredient of bleaching mouthwash was hydrogen peroxide which could react with organic molecules and change optical properties of the teeth.²² Previously, Pithon et al¹¹ revealed that there was no significant difference between immersion of elastomeric chains in two types of whitening mouthwashes containing hydrogen peroxide and distilled water. However, the results of the current study showed a significant decrease of elastomeric chain force immersed in whitening mouthwash compared with artificial saliva.

Oshagh et al⁹ reported significant force decay of elastomeric chains immersed in sodium fluoride mouthwash compared with control group (57.4, 63.1, and 66.1% decay after 1, 7, and 21 days respectively). Another study revealed 57.49% force decay after 3 weeks of use of sodium fluoride mouthwash which was not significant compared with control group.⁴ Omidkhoda et al¹⁰ measured force decay of elastomeric chains (Dentaurum) in sodium fluoride mouthwash and the following thermocycling and reported 24.01, 27.60, 33.69, 41.21, and 56.81% of force decay after 1, 7, 14, 21, and 28 days respectively. In their study, the difference was significant compared with control group. In the current study, force decay of elastomeric chains immersed in sodium fluoride mouthwash was 48.34, 58.51, 62.33, 66, and 76.73% after 1, 7, 14, 21, and 28 days respectively. The difference among the results of these studies might be due to the difference in the manufacturers.¹

One of the limitations of this study was due to *in vitro* setup. Although *in vitro* studies permit controlling confounding factors, several influencing factors might be ignored while their effect might be significant. It has been reported that several factors including microbial flora, enzymatic activity of saliva, diet, and functional forces could influence the force of elastomeric chains *in vivo*.²³ To control the possible effect of saliva on force decay, the control group was immersed in artificial saliva. One the most important factor for simulating *in vivo* setup is humidity. Previously, it has been demonstrated that force decay is more probable in the humid environment

compared with dried one.²⁴ However, there was no difference in force decay of elastomeric chains between *in vivo* setup and wet experimental environment.^{7,24} Therefore, in the current study samples were immersed in artificial saliva to mimic *in vivo* situation.

CONCLUSION

Within the limitations of the current *in vitro* study, the following conclusions could be made:

- The force of orthodontic elastomeric chains decreases significantly from the first day after activation.
- Daily use of sodium mouthwash could increase force decay of elastomeric chains at days 1 and 28 after activation.
- Bleaching mouthwash compared with daily sodium fluoride mouthwash could cause more force decay of elastomeric chains at days 1 and 28 after activation.

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