Published online: 2019-10-01

Original Article

The effect of toothpastes with bleaching agents on the force decay of elastomeric orthodontic chains

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ABSTRACT

Objective: The aim of this study was to evaluate the effect of agents available in whitening toothpastes (Crest® and Sensodyne®) *in vitro* on the force decay of elastomeric chains used in orthodontics. **Materials and Methods:** A total of 300 specimens of elastomeric chains were divided into five groups ($n = 60$) and were evaluated. These groups included (1) the regular Crest® toothpaste and distilled water solution, (2) whitening Crest® toothpaste and distilled water solution, (3) regular Sensodyne® toothpaste and distilled water solution, (4) whitening Sensodyne® toothpaste and distilled water solution, and (5) distilled water as a control group. The samples' force was measured using Instron at intervals of 0, 1, 7, 14, 21, and 28 days. Data were analyzed by SPSS software. **Results:** At the initial time point, the difference in the force values of elastomeric chain between any of the groups was not significant ($P > 0.05$). On the 1st day, there was a significant difference ($P < 0.05$) between all groups except the groups of whitening Crest®, regular, and whitening Sensodyne® ($P > 0.05$). On days 7, 14, and 28, the rate of decline for all groups was statistically significant ($P < 0.05$). **Conclusions:** According to the results obtained in the present study, it seems that toothpastes without whitening agents have less effect on force decay of elastomeric chain over time.

Key words: Crest®, elastomeric chain, Sensodyne®, tooth paste, whitening agent

INTRODUCTION

Elastomeric chains are one of the orthodontic force-exerting factors that are commonly used and have several advantages such as high flexibility and low price in comparison to other orthodontic approaches;[1-3] also they do not require patient cooperation and are relatively hygienic.[4] The elastomeric chains can be used for canine retraction. Elastic appliances are made of latex and patients are required to replace them every day.[5,6] Despite the numerous advantages of elastomeric chains over latex appliances, there are always concerns about their force decay. These chains are prone to fatigue during use and the amount of force exerted by them will be reduced and this process will be intensified in the oral cavity environment.

Access this article online

Quick Response Code:

Website: www.eurjdent.com

How to cite this article: Behnaz M, Dalaie K, Hosseinpour S, Namvar F, Kazemi L. The effect of toothpastes with bleaching agents on the force decay of elastomeric orthodontic chains. Eur J Dent 2017;11:427-31.

DOI: 10.4103/ejd.ejd_83_17

[7,8] Another disadvantage of these chains is their susceptibility to oral cavity changes that could lead to permanent transformation of the chains.[9] Therefore, to exert optimal forces and achieving the desired tooth movement in the shortest possible time, the dentist's awareness about the force exertion procedure by elastomeric chains and its decay process over time is essential.[10,11]Numerous laboratory studies have examined the effect of various pH (acidic or neutral) values,[12,13] temperature,[14] different formulations of artificial saliva,[7] different concentrations of alcohol in mouthwash,[15] and the presence or absence of whitening ingredients in mouthwash[16] on force decay of orthodontic elastomeric chains. Use of elastomeric chain due to its numerous benefits is common. The main weakness is rapid reduction in force values of elastomeric chains. Different studies have stated that several factors can cause force decay of chains.[7-8] Due to the increasing patients' demand for having whiter teeth, one of the goals of manufacturing companies is increasing toothpastes' cleaning and whitening effects.[17] The components of toothpastes may influence the force of elastomeric chains and as a result can lead to insufficient tooth movement. According to our knowledge to date, the effect of whitening agents of toothpastes on the reduction of elastomeric chains force has not been studied yet and only the factors that directly affect the teeth have been assessed.[16,18,19] Thereby, the aim of this study was to evaluate the impact of agents in whitening toothpastes on the force of elastomeric chains used in orthodontics.

MATERIALS AND METHODS

In this prospective, experimental study, a total of 300 pieces of elastomeric chain were assessed. In this study, Bobbin chain gray (3M Unitek, USA457, AlastiK™) along with four types of toothpastes which were divided into five groups including four experimental and one control group was used [Table 1]. Experimental groups were as follows: group 1: regular Crest® toothpaste and distilled water solution (n = 10 for each time point); Group 2: whitening Crest® toothpaste and distilled water solution (n = 10 for each time point); Group 3: regular Sensodyne® toothpaste and distilled water solution (n = 10 for each time point); Group 4: whitening Sensodyne® toothpaste and distilled water solution (n = 10 for each time point); and (5) distilled water as a control group (n = 10 for each time point). Elastomeric chains were kept in a sealed bag (company packaging) at the proper temperature until the start of the experiment.[20] The chains were cut identical to the pieces with 6 ring length and then the 300 pieces of elastomeric chains were divided into five aforementioned groups. In each group, two chain rings remain free in the middle and two rings were used to install the samples on jig. An additional free chain was considered to remove possible damages incurred during cutting and also for ease of doing the procedure. A total of six chain rings for the process were cut by a sharp cutter. Each piece of the elastomer was pulled to the ends of the jigs which are made of the polyvinyl chloride (PVC) pipes with the embedded small holes on either side of the pipe to put the supportive pins of elastomeric chains. The diameter of each pin was considered based on the standard bracket width, and length of each pin was considered 20 mm.[21] Autopolymerizing acrylic resin was injected into the hole for fixing the pins. Each series of pins with a distance of 25 mm apart (proportional to the distance between middle point of canine to the middle point of first upper molar teeth), at opposite ends of PVC pipe, was placed to hold the elastomeric chains under tension in a fixed length (4 rings).[22,23] This jigs allowed

Table 1: List of experimental groups and their components

Group	Components	Composition
1	Crest® anticavity (Procter and Gamble, Germany)	Sodium fluoride (1450 ppm 0.321%), hydrated silica, sodium lauryl sulfate, sodium saccharin, aqua, sorbitol, cellulose gum, aroma, carbomer, limonene, CI74160, CI77891, trisodium phosphate
2	Crest® 3D whitening (Procter and Gamble, Germany)	Sodium fluoride (1450 ppm 0.321%), hydrated silica, sodium lauryl sulfate, sodium saccharin, xanthan gum, aqua, sorbitol, disodium pyrophosphate, cellulose gum, aroma, sodium hydroxide, carbomer, limonene, CI74160
3	Sensodyne® (Neocosmed Co., Ltd., Thailand)	Sodium fluoride 0.221% w/w, potassium nitrate 5.00% w/w, glycerin, hydrated silica, sodium hydroxide, sodium saccharin, titanium dioxide, water, sorbitol, cocamidopropyl betaine, xanthan gum, flavor, sucralose
4	Sensodyne® gentle whitening (Neocosmed. Thailand)	Sodium fluoride 0.221% w/w, potassium nitrate 5.00% w/w, pentasodium triphosphate 5.00% w/w, glycerin, hydrated silica, PEG-6, sodium hydroxide, sodium saccharin, titanium dioxide, water, sorbitol, cocamidopropyl betaine, sodium methyl cocoyl taurate, xanthan gum, flavor
5	Distilled water	-

PEG: Polyethylene glycol, 3D: Three dimensional

complete immersion of chains in a container containing distilled water or the solution provided throughout the study period. Throughout the duration of the study, samples of the control group were kept in distilled water and samples of the experimental groups, each independently, were immersed in solutions containing distilled water and toothpaste once a day for 2 min. Control and experimental groups' samples were kept in incubator (37°C). The samples' force was recorded in universal mechanical testing machine (Instron) before, 1, 7, 14, and 28 days after the intervention for all groups.

All data were analyzed using SPSS 20.0.1 (IBM Corp., Armonk, NY, USA) for Windows software. The normal distribution of elastic force was examined using the Kolmogorov–Smirnov test between five groups and at six time points. Two-way ANOVA test was used to evaluate the effects of toothpaste type and the exposure time on mean force of elastomeric chains. In case that there was an interaction between different kinds of toothpaste and the exposure times, Bonferroni method was used to compare the 2 × 2 effects of toothpastes at any time.

RESULTS

Figure 1 shows the gradual reduction of forces from the start point to 28th day. At the initial time point, there was no significant difference among different groups ($P > 0.05$). One day after intervention, a significant difference ($P < 0.05$) was observed in all groups except between the Groups 2 with 4 ($P = 0.54$) or with Group 3 ($P = 0.063$). On days 7, 14, and 28 after intervention, the rate of decline in all groups was statistically significant ($P < 0.05$). The decline in the force decay of elastomeric chains (N) has been shown in Table 2. By the end of the 28-day period, the highest reduction was observed in Group 4 (95.90%) and the lowest reduction after the control group (50.11%) was observed in Group 1 (74.56%).

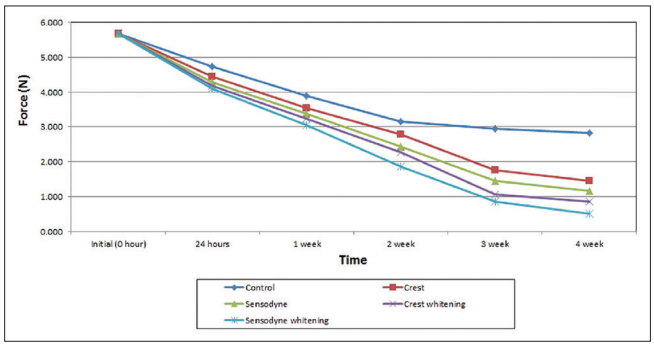

Figure 1: The gradual reduction of forces from the start point to the 28th day

DISCUSSION

Orthodontic elastics are widely used in orthodontic treatment for force transmission. As these devices are not ideal due to the gradual erosive forces during operations,[24] several studies have been carried out on the mechanical effects of environmental factors on the loss of chains' forces.[25,26] Due to the increasing use of whitening toothpastes by patients for various reasons, the study of these factors on the force of such orthodontic appliances is necessary. In this study, the effect of toothpastes containing bleaching agents on elastomeric chain force was assessed. The results showed that Crest® had the least and the Sensodyne® containing bleach had the highest effect on force decay. *In vitro* design has several advantages for evaluation of material characterizations. Standardization of the oral cavity environment is difficult. Differences in microbial flora and enzyme levels along with dietary factors and different functional forces undermine the validity of material properties' assessments.[7] Although the *in vitro* researches are valuable, direct generalization of the results to clinical situations should be taken with caution. One of the main limitations in analyzing the results of this study was the lack of similar *in vivo* studies. Ash and Nikolai showed that the loss of elastomeric chains force in the laboratory *(in vitro)* condition was lower compared to that of oral cavity environment (*in vivo*).[27] In a study by Rock *et al.*, it was also indicated that only 43%–52% of the initial force in elastomeric chains was maintained in oral cavity environment after 4 weeks while the chains which were kept in the air maintained 70%–75% of their initial force.[28] Several studies have shown a considerable difference between dry and *in vivo* environments while the difference between various aqueous and *in vivo* environments was not significant.[27,29] The researchers have investigated the effect of temperature variations in reducing the force of elastomeric orthodontic chains and have declared that these chains are very sensitive to changes in temperature.[4,27,30] In a study by Nattrass *et al.*, the force decay in chains was evaluated at different temperature conditions (10°C, 22°C, and 37°C) and the results showed that overall chains' force reduction exceeded by increasing the temperature.[31] Regarding the fact that there was no study on the effect of different toothpastes on force decay of immersed chains, this study was carried out for the first time and the results revealed that toothpastes containing bleaching agents have adverse effects on the elastomeric chains.

Table 2: Force measurements and percentage force decay of each group over 4 weeks

Type	Time point	Mean force (*n*)	Percentage of decay	SD
Control	Initial	5.66	-	0.086
	24 h	4.73	16.47	0.089
	1 week	3.88	31.41	0.064
	2 weeks	3.14	44.53	0.094
	3 weeks	2.94	48.01	0.082
	4 weeks	2.82	50.11	0.089
Crest® anticavity (Procter and Gamble, Germany)	Initial	5.66	-	0.086
	24 h	4.44	21.58	0.101
	1 week	3.53	37.58	0.086
	2 weeks	2.77	51.01	0.076
	3 weeks	1.75	69.03	0.083
	4 weeks	1.44	74.56	0.065
Sensodyne® (Neocosmed. Thailand)	Initial	5.66	-	0.086
	24 h	4.27	24.60	0.081
	1 week	3.37	40.54	0.097
	2 weeks	2.43	56.98	0.087
	3 weeks	1.45	74.37	0.099
	4 weeks	1.15	79.54	0.102
Crest® 3D whitening (Procter and Gamble, Germany)	Initial	5.66	-	0.086
	24 h	4.16	26.48	0.099
	1 week	3.22	3.06	0.065
	2 weeks	2.27	59.85	0.086
	3 weeks	1.06	81.26	0.119
	4 weeks	0.84	85.04	0.095
Sensodyne® gentle whitening (Neocosmed. Thailand)	Initial	5.66	-	0.086
	24 h	4.09	27.80	0.050
	1 week	3.05	46.08	0.088
	2 weeks	1.85	67.28	0.087
	3 weeks	0.86	84.80	0.076
	4 weeks	0.51	90.95	0.048

SD: Standard deviation, 3D: Three dimensional

CONCLUSIONS

Considering the results of this study, it seems that the regular toothpastes have less adverse effect on elastomeric chains compared to the whitening toothpastes and that the regular Crest® toothpaste showed the least impact on force decay of elastomeric chains in comparison to both the Sensodyne® toothpastes.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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