

Effect of Sodium Fluoride Mouth Rinse on Elastic Properties of Elastomeric Chains

Barat Ali Ramazanzadeh * / Arezoo Jahanbin ** / Nadia Hasanzadeh *** / Neda Eslami ****

Objective: This study evaluated Sodium Fluoride mouth rinse effects on elastic properties of different elastomeric chains. **Study design:** In this *in vitro* experiment, two orthodontic chains were tested. In the first group, they were stored in artificial saliva for the entire duration, and in the second group they were immersed daily in 0.05% NaF mouth rinse for 1 minute, artificial saliva–NaF mixture for 30 minutes, and then in artificial saliva for the rest of the day. Specimens were tested at baseline, 1 hour, 24 hours, 1, 2 and 3 weeks and then the displacement of specimens to obtain 150g and 300g, also the applied force after stretching them to 100% of their original length were evaluated. **Results:** In contrast to force degradation, chains of both companies required more displacement to achieve both forces in the saliva–NaF mixture than saliva itself; however, the difference was only significant for the 300g force ($P = 0.020$). American Orthodontics chains required more displacement than Dentaurum chains to obtain both forces, also they had more load relaxation ($P < 0.001$). **Conclusions:** Daily use of NaF mouth rinse does not affect force degradation and the displacement of both chains to achieve conventional orthodontic forces, but for higher force levels the displacement increase is statistically significant.

Keywords: Elastomeric chains, Force degradation, Sodium Fluoride mouth rinse

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INTRODUCTION

It is now accepted that efficient physiologic corrections of a malocclusion occurs through the application of light and continuous forces to the teeth. There are different force systems to produce optimal force levels in orthodontics. For example, space closure in the dental arch may be accomplished with closed and open coil springs, retraction springs, closing loop arch wires, elastomeric chains, and more recently magnets. Although they have some advantages and disadvantages, elastomeric chains are economical, hygienic, easy to use, and do not require patient cooperation.^{1, 2, 3}

Elastomeric chains have different usage such as diastema closure, midline shift correction, canine retraction, and rotational correction.^{2,4,5} Despite the widespread use of elastomeric chains in clinical practice, there are some limitations in their usage. When extended and exposed to an oral environment, they absorb water and saliva, permanently stain, and suffer from permanent deformation and internal bond break down.²

Moreover, elastomeric chains undergo stress-relaxation, a decrease in the magnitude of force transmitted while held at a fixed strain. This phenomenon is partly related to the rearrangements within the polymer structure.^{1, 4, 6, 7}

Andreasen and Bishara showed 74% and 42% force decrease after 24 hours for Alastic and Latex chains respectively; thus, they proposed the initial force level should be four times greater than the optimal force level to compensate for their potential force decay.⁸

Other investigators recommended using a force gauge in order to determine the elastomeric chain forces in clinical practice.⁹

Wong reported 2 loops elastomeric chains of Ormco and Unitek companies had the greatest force decay in the initial 3 hours after 17mm stretching and water storage. He reported 50 to 75% force decay after 24 hours. Thus, he recommended in order to improve force decay and clinical performance it is better to pre-stretch chains before placing them on the brackets.¹⁰

Several studies investigated the effect of pre-stretching on force decay of chains over time,^{11, 12, 13} but they were different according to pre-stretching level, the length of inter

* Barat Ali Ramazanzadeh, Associate Professor, Department of Orthodontics, Faculty of Dentistry and Dental School Research Center, Mashhad University of Medical Sciences, Mashhad, IRAN

** Arezoo Jahanbin, Assistant Professor, Department of Orthodontics, Faculty of Dentistry and Dental School Research Center, Mashhad University of Medical Sciences, Mashhad, IRAN

*** Nadia Hasanzadeh, Assistant Professor, Department of Orthodontics, Faculty of Dentistry and Dental School Research Center, Mashhad University of Medical Sciences, Mashhad, IRAN

**** Neda Eslami, Assistant Professor, Department of Orthodontics, Faculty of Dentistry and Dental School Research Center, Mashhad University of Medical Sciences, Mashhad, IRAN

Send all correspondence to: Dr. Arezoo Jahanbin, Department of Orthodontics, Faculty of Dentistry, Park square, Mashhad, IRAN.

Mobile: 00989151107306

Fax : 00985118829500

E- mail: Jahanbina@mums.ac.ir

Dr_Arezoo_Jahanbin@yahoo.com

loop filament and the types of elastomeric chains.¹⁴ In general, it is suggested, elastomeric chains pre-stretching should be between 50-100% of their initial length. Some investigators, showed force degradation in elastomeric chains over time.¹⁵

Natran *et al* showed greater force degradation in chains when placed in a wet and hot place compared with immersion just in water itself.¹⁶

In addition, Ferritier showed after 4 weeks, a high PH caused greater force decay in elastomeric chains comparing with lower pH.¹⁷

Fraunhofer *et al* showed Acidulated Phosphate Fluoride had an affect on elastic properties of elastomeric chains and increased distraction required delivering the same force.¹

On the other hand, it was known that Fluoride treatment could decrease the incidence of tooth decay especially in orthodontic patients who are susceptible to enamel demineralization around the orthodontic attachments.¹⁸⁻²¹

Although topical Fluoride application could be as a gel, mouthwash, varnish, etc, Sodium Fluoride mouth wash costs less.

Accordingly, the present study was designed to evaluate the effect of 0.05% Sodium Fluoride mouthwash on elastic properties of elastomeric chains, which are used frequently in fixed orthodontic treatment.

METHOD AND MATERIALS

In this experimental study, two orthodontic elastomeric chains with open loop filament configurations were studied: Dentaaurum (Dentaaurum, Germany), American Orthodontics (American Orthodontics, USA).

The chains were kept in air tight plastic bags as originally received from the manufacturer. Six unit modules with half extra unit in each ends in case of damage to the chain during cutting was selected.

After trimming chains to the specific length they were stretched by slow stretching to 100% of initial length for 10 seconds. The Boley gauge was used in order to increase the reliability of the test.

The elastomeric chains from different companies were randomly divided into two groups. In group 1, the chains were immersed in artificial saliva (Danesh Daru Toos, IRAN) including NaCl, MgCl₂, Water, celluloid materials as a viscous agent which gave a pH equal to 7.2 and a viscosity equal to 110 cps.

In group 2, the chains were immersed daily in 0.05% NaF mouth rinse for 1 minute, then in a solution of artificial saliva and NaF mouth rinse for 30 minutes, and were stored again in artificial saliva. This was done to approximate the study to clinical use of NaF mouthwash.

In each group a tensile test was performed on half of the specimens and a force degradation test was performed on the other half.

The force degradation test regimen involved storing the specimens in the media stretched between a pair of stainless steel fixtures that were fixed in a self-cured acrylic.

Each fixture diameter was equal to the bracket width of the upper central incisor and the inter fixture distance was

two times greater than the initial length of the elastomeric chains. Chains were tested in their initial state (0 min) and at 1 h, 24 h, 1 week, 2 weeks and 3 weeks after storage in the test media at $37^{\circ} \pm 0.5^{\circ}\text{C}$ in an incubator. Four specimens from each material were tested at each time period.

For force degradation testing the machine was adjusted so after stretching the chain to 100% of initial length the stretching stopped, and applied force magnitude was recorded by the testing machines.

All tensile and force degradation tests were performed on the Zwick/258 testing machine (Germany).

In the tensile test, in order to determine the displacement value needed for force application of 150g and 300g, each sample was suspended between a pair of stainless hooks (diameter = 1mm), one attached to the movable cross-head of the tensile tester and the other attached to the fixed base of the machine.

The chain was then distracted at a crosshead speed of 50 mm/min until rupture of the chain. The crosshead motion and force required to distract the chain were automatically recorded by the force and displacement transducers of the tensile testing machine. For each sample the distractions corresponding to forces of 150g and 300g were determined from force displacement curves.

After data collection, mean values and then standard deviations were calculated by SPSS software and a general linear model was used to analyze the data.

RESULTS

Tensile data for two materials in the two test media are summarized in Tables 1 and 2. In virtually every case there was a progressive increase in the displacement required to produce 150 g ($F = 5.8$, $P < 0.001$) and 300 g ($F = 8.7$ and $P < 0.001$) throughout the entire test period.

According to Table 1, American Orthodontics elastomeric chains showed a rapid increase in displacement required to produce required force followed by a more gradual increase in displacement between 1 hour and 21 days. Moreover, this study showed that for two test elastomeric chains, the distractions to achieve forces of 150g and 300g were greater for the mixture of saliva and NaF mouth rinse compared to just saliva.

However, the difference between the solutions was statistically significant just for the force of 300g ($P=0.020$), and no significant difference was found for a force of 150 g. In addition, there were significant differences between distraction means of a force 150gr for American Orthodontics ($3.6 \pm 0.6\text{mm}$) and Dentaaurum chains ($3.2 \pm 0.6\text{mm}$) as well as for a force of 300gr ($11.6 \pm 2.0\text{mm}$ for American Orthodontics, $9.2 \pm 1.4\text{mm}$ for Dentaaurum) ($P\text{-value} < 0.001$).

Thus, for the two test media, the required distraction to achieve 150g and 300g forces was greater in American Orthodontics than Dentaaurum chains.

According to this study, NaF mouthwash does not have a significant effect on required distraction to produce 150g force. The force degradation data for the two elastomeric chains after immersion in different media were presented in Tables 3 and 4 and Figures 1 and 2.

Table 1. Displacement of American Orthodontics elastomeric chains (mm) to deliver 150g and 300 g forces

Time	Base line Mean ± SD	1 hour Mean ± SD	24 hours Mean ± SD	7 days Mean ± SD	14 days Mean ± SD	21 days Mean ± SD
Saliva 150 g	2.8 ± 0.0	3.7 ± 2.0	3.2 ± 0.0	3.4 ± 0.4	3.5 ± 0.0	3.6 ± 0.0
300g	8.8 ± 0.0	11.4 ± 0.8	9.6 ± 0.7	10.1 ± 0.1	12.0 ± 0.7	12.1 ± 0.7
Saliva + NaF 150g	2.9 ± 0.0	4.1 ± 1.2	3.8 ± 0.0	3.8 ± 0.3	4.0 ± 0.2	4.6 ± 0.7
300g	8.8 ± 0.1	12.4 ± 2.9	12.3 ± 0.9	13.1 ± 0.4	13.7 ± 0.2	14.4 ± 2.1

Table 2. Displacement of Dentaurem elastomeric chains (mm) to deliver 150g and 300 g forces

Time	Base line Mean ± SD	1 hour Mean ± SD	24 hours Mean ± SD	7 days Mean ± SD	14 days Mean ± SD	21 days Mean ± SD
Saliva 150 g	2.4 ± 0.1	2.5 ± 0.0	2.8 ± 0.1	2.9 ± 0.3	3.0 ± 0.1	3.0 ± 0.1
300g	7.5 ± 0.4	7.8 ± 0.2	8.9 ± 0.5	9.3 ± 0.8	10.3 ± 0.3	10.3 ± 0.3
Saliva + NaF 150g	2.7 ± 0.0	2.8 ± 0.5	2.6 ± 0.0	3.0 ± 0.1	3.1 ± 0.5	3.2 ± 0.1
300g	8.8 ± 0.3	8.2 ± 0.9	8.4 ± 0.4	9.9 ± 0.1	10.5 ± 3.1	11.1 ± 0.5

This study showed that the force delivered by each chain by stretching to 100% of initial length was decreased throughout the test period (P < 0.001).

The force degradation of American Orthodontics elastomeric chains was greater than Dentaurem after immersion in the two test media for 3 weeks (P < 0.001).

However, there were no significant differences between force degradation of the two elastomeric chains in saliva and NaF mouth rinse mixture as well as saliva itself.

DISCUSSION

White spots are early carious lesions that are seen in caries-susceptible areas around bracket margins and in the gingival third of teeth in patient's undergoing orthodontic treatment.

The white-spot occurrence was recorded from 5-8 % to 44% on the anterior teeth and 7.7 to 71% on the posterior teeth. An increasing reservoir of Fluoride in the saliva and in dental plaque will promote remineralization and reverse the early carious lesions. It was proved that daily use of NaF

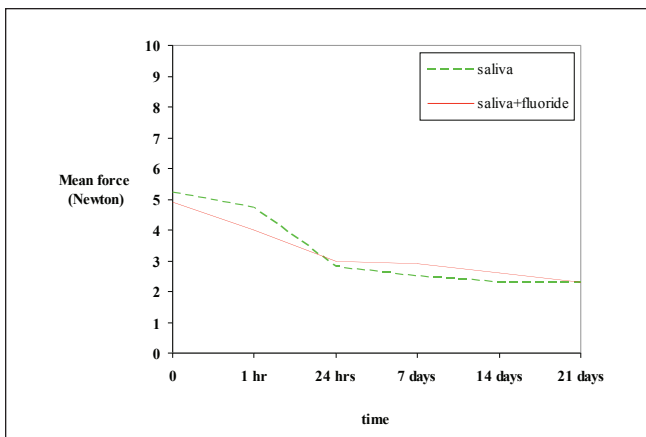


Figure 1. Force levels (N) in displacement of American Orthodontics elastomeric chains to 100% of initial length

Table 3. Force delivery (N) at a distraction of 100% of initial length for American Orthodontics elastomeric chains

Time	Base line Mean ± SD	1 hour Mean ± SD	24 hours Mean ± SD	7 days Mean ± SD	14 days Mean ± SD	21 days Mean ± SD
Saliva	5.2 ± 0.1	4.7 ± 0.2	2.8 ± 0.6	2.5 ± 0.0	2.3 ± 0.2	2.3 ± 0.1
Saliva + NaF	4.9 ± 0.0	4.0 ± 0.1	3.0 ± 0.0	2.9 ± 0.6	2.6 ± 0.2	2.3 ± 0.1

Table 4. Force delivery (N) at a distraction of 100% of initial length for Dentaurem elastomeric chains

Time	Base line Mean ± SD	1 hour Mean ± SD	24 hours Mean ± SD	7 days Mean ± SD	14 days Mean ± SD	21 days Mean ± SD
Saliva	5.4 ± 0.0	5.0 ± 0.0	4.4 ± 0.1	4.0 ± 0.8	3.9 ± 0.0	3.0 ± 0.1
Saliva + NaF	5.4 ± 0.1	4.7 ± 0.1	4.3 ± 0.2	3.9 ± 0.1	3.4 ± 0.2	3.3 ± 0.0

mouth rinse could decrease the incidence of white spot lesions in orthodontic patients.²⁰ Thus, in this study we studied the effect of NaF mouth rinse on elastic properties of common elastomeric chains used in orthodontic treatment.

According to the results of force/distraction curves that was recorded by the Zwick test machine, the displacements required to achieve loads of 150g and 300g were greater for American Orthodontics than Dentaurem elastomeric chains, indicating that the Dentaurem chains had a greater stiffness (modules) than the another elastomer.

The elastic chains of the two companies required increased distractions to deliver the same force over time; however, for American Orthodontics chains, most of the increased distraction occurred within the first hour of loading with a gradual increase in required distraction thereafter for up to 21 days.

According to Fraunhofer et al's study, the greatest increased distraction for delivery of 150g and 300g forces was within the first 4 hours with a slow increase in distraction up to 28 days.¹

In the present study, the required increased distraction of elastomeric chains after 21 days immersion in saliva was 0.6-0.8mm for 150g force and 2.8-3.3mm for 300g force, but the required distraction after storage in the mixture of

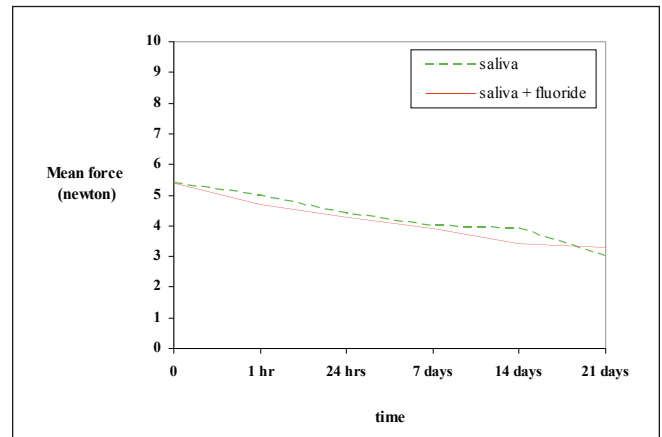


Figure 2. Force levels (N) in displacement of Dentaurem elastomeric chains to 100% of initial length

saliva and NaF mouth rinse was 0.5 – 1.7mm for 150g force and 2.7 – 5.6mm for 300 g force.

According to the results of the study, NaF mouth rinse does not have a significant effect on the required distraction of elastomeric chains to produce 150g force, but for 300g force the effect of the mouth rinse was significant, however, its comparison with saliva does not have clinical significance ($P = 0.020$).

Fraunhofer et al showed that 31% Acidulated Phosphate Fluoride increased the displacement required to produce 150g and 300g force and this appeared to be clinically significant for a force of 300g (2-9mm).¹

Force degradation data for American Orthodontics and Dentaurem elastomeric chains indicate that there were no significant differences between saliva-NaF mixture and just the saliva.

In the present study, American Orthodontics chains loose 46% of their force over the first day and 51% of it up to one week after storage in artificial saliva.

In this regard, Lu showed 45% force loss of elastomeric chains over the first day and 50% over one week, while Santos reported 46% force loss of American Orthodontics chains after 21 days immersion in water.^{3,6}

In the present study we showed 56% force loss after 21 days that could not only be explained by the different media and the initial force used in the two studies, but also by different chains lengths (4 loops).

This study showed the force degradation of American Orthodontics chains after 3 weeks storage in media tests was significantly greater than Dentaurem chains.

This means that in similar distractions, American Orthodontics chains loose their forces faster and would need to be frequently replaced in order to maintain the force level.

The frequent replacement of elastomeric chains may not be an appropriate solution because it causes long duration of treatment, higher cost and extra problems for patients and orthodontists.

It is recommended that additional works be undertaken on evaluating these differences and the effect of different storage media on elastic properties of elastomeric chains. This article reports the findings of an in vitro study on the effect of NaF mouth rinse on properties of two elastomeric chains (American Orthodontics and Dentaurem). The *in vivo* behavior of the modules may differ remarkably due to such variables as wide temperature swings, masticator forces and parafunctional oral behavior. Therefore, extrapolating in vitro findings to in-vivo behavior must be with caution.

CONCLUSION

This study showed, NaF mouth rinse increases the required distraction to produce 150g and 300g forces. The increase was statistically significant for 300gr force which is higher than common forces used in orthodontics, but for 150g force (in common range of orthodontic forces) it is not significant.

In addition, there were no significant differences between mouth rinse-saliva mixture and saliva alone in force degradation of elastomeric chains.

American Orthodontics and Dentaurem chains have a

significant difference for force degradation and distraction required to produce 150g and 300g forces in the two test media; thus, for American Orthodontics chains the required distraction for application of 150 g and 300g forces as well as the force degradation was greater than Dentaurem chains.

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