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RESEARCH ARTICLE

Degradation of the Strength of Elastomeric Chains subjected to Different Levels of Salivary pH associated with Exposure to Mouthrinses with and without Fluoride

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ABSTRACT

Aim: To evaluate the degradation of strength of elastomeric chains submitted to different levels of salivary pH and exposed to mouthrinses with and without fluoride.

Materials and methods: Seven groups of chain elastics (n = 18) mounted on test devices that remained immersed in artificial saliva were tested. Group 1 (pH 5 and without fluoride), 2 (pH 5 and with fluoride), 3 (pH 6 and without fluoride), 4 (pH 6 and with fluoride), 5 (pH 7.5 and without fluoride) and 6 (pH 7.5 and with fluoride) and 7 (control group). The test groups were exposed to mouthrinses twice a day for 30 seconds, with an interval of 12 hours between one exposure and the other. A control group was immersed in distilled water. The strength of samples was gauged with a dynamometer. Six measurements of strength were made in the following time intervals: initial (0), 1, 7, 14, 21 and 28 days. The force values were submitted to the analysis of variance (ANOVA) and Tukey's test to determine whether there were statistical differences between each group. The level of significance adopted was 5% ($\alpha = 0.05$).

Results: When the groups were evaluated individually, comparing the factor time in the initial period, the force was statistically higher than that in all the other experimental time intervals ($p < 0.05$). From the 7th day up to day 28, no statistical differences were found among the groups ($p > 0.05$). The factors pH and the presence of mouthwash with or without fluoride did not interfere in the results among the groups ($p < 0.05$).

Conclusion: The presence or absence of fluoride in the mouthrinses used in the study made no difference to the force degradation of the chain elastics, as the test groups obtained similar results among them in the studied time intervals.

Keywords: Elastomers, Test of materials, Orthodontics.

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INTRODUCTION

The principle of corrective orthodontic treatment is to transmit mechanical forces to the teeth with the object of moving them to an adequate position in the dental arch.[1] In order to perform the treatment appropriately, orthodontists have a range of mechanical devices at their disposal.[2] Among these, there are retraction loops, coil springs and elastomeric chains. One of the property of the elastomeric chains is elasticity, defined as the capacity to return to the initial conformation, after undergoing deformations.[3]

There are various factors that influence the magnitude of force released by elastomeric chains, such as color, material composition, commercial brand, quantity and speed of activation, and local alterations in the medium to which they are exposed.[4-6] Thus, when they are in the oral environment, they are also subjected to the influence of saliva, alterations in pH, enzymes, pigments, food in the diet, and chemical products for hygiene.[7] All these factors associated with the time of use and temperature of the oral environment have a direct effect on the mechanical properties and, consequently, the release of force and loss of effectiveness of orthodontic elastomeric auxilliaries.[8,9]

The appearance of white spot lesions is common during orthodontic treatment, and occur in 2 to 96% of cases.[10] Tooth enamel demineralization around the orthodontic accessories is normally associated with bacterial biofilm retention, resulting in a reduction in pH of the buccal medium, and later mineral loss from tooth structure, particularly in patients that do not have adequate oral hygiene habits.[11] In these cases, it is extremely important to implement prophylaxis (maintenance of hygiene and application of substances containing fluorine), with the goal of preventing the loss of tooth structure and achieving successful orthodontic treatment. The literature[12] has shown that different forms of fluorides associated with correct oral hygiene instruction and adequate diet may contribute to inhibiting dental demineralization during orthodontic treatment.

Mouthrinses are one of the forms of fluorides most easily found on the market, and are commonly used for the prevention of caries lesions.[13] The effects of fluorides on the properties of orthodontic chain elastics under conditions that simulate the intraoral pH variations has not yet been extensively studied in the literature. Therefore, the aim of the present *in vitro* study was to evaluate the degradation of strength of orthodontic elastomeric chains when submitted to different levels of salivary pH and exposure to mouthrinses.

MATERIALS AND METHODS

A laboratory study was developed to test the effect of exposing orthodontic elastomeric chains to mouth washes with and without fluoride. Seven groups of samples were tested, with each group containing a total of 18 elastic segments (n = 18). Group 1 (pH 5 and without fluoride), 2 (pH 5 and with fluoride), 3 (pH 6 and without fluoride), 4 (pH 6 and with fluoride), 5 (pH 7.5 and without fluoride), 6 (pH 7.5 and with fluoride) and 7 (control group). To perform the test, the short, gray color, (Morelli, Sorocaba, São Paulo, Brazil) type of orthodontic elastomeric chains, obtained in sealed packaged, within the period of validity of the product were used. After being carefully removed from their spool, without distending them, 126 segments containing five links (number routinely used when making up a canine retraction) each were selected.

The elastic segments were mounted on personalized test devices, fabricated to keep the chain elastics distended to a standard distance of 35 mm (corresponds to the 50% stretch activated) (Fig. 1A). These devices were kept emerged in artificial saliva with the following different pH levels: 5.0, 6.0 and 7.5, throughout the time the experiment was conducted.

Each test group was submerged in artificial saliva (Fig. 1B), independently; kept in an oven at 37ºC (Splabor, São Paulo, Brazil) and monitored with a thermometer and digital thermostat (Splabor, São Paulo, Brazil). A control group was kept immersed in distilled water, also placed in an oven at 37ºC. Test groups numbers 1, 3 and 5 were exposed to mouthrinse without fluoride, Colgate Plax Whitening (Colgate-Palmolive Company, São Paulo, Brazil). And test groups numbers 2, 4 and 6 were exposed to mouthrinse with fluoride, Colgate Plax Ice (Colgate-Palmolive Company, São Paulo, Brazil) (Table 1), twice a day for 30 seconds, with an interval of 12 hours between one exposure and the other. After exposure, the test groups were washed with distilled water, simulating the washing that occurs in the oral cavity after using the mouthrinse, with the object of eliminating the residues of the solutions. After this, they were again placed in artificial saliva at 37ºC.

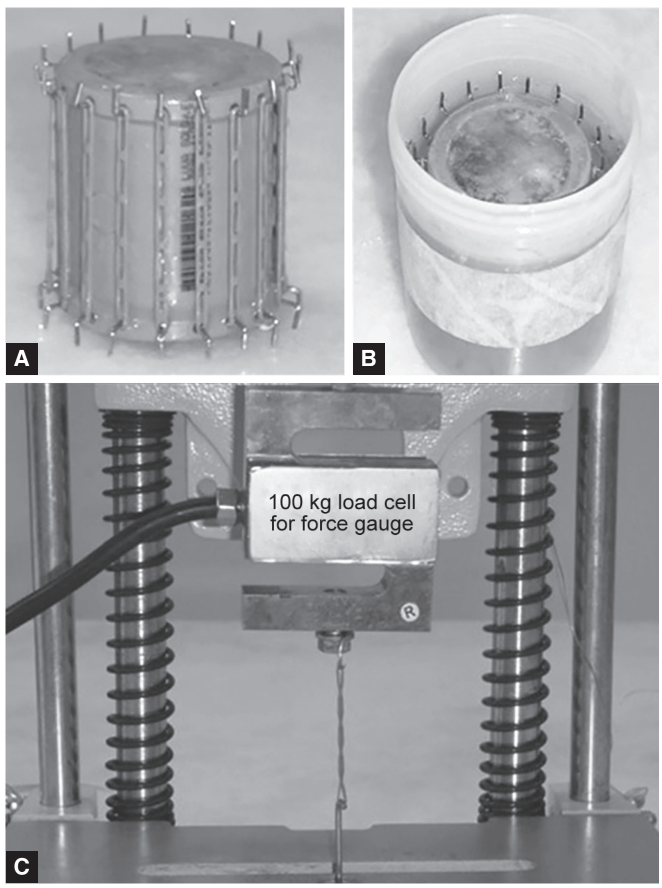
The control group did not undergo any type of exposure. The test period was completed after 28 days.

The force of each of the orthodontic elastic samples was gauged with a digital dynamometer (Force Gauge, Reed FG-5100, Puchong). Six measurements of strength were made in the following time intervals: initial (0), 1, 7, 14, 21 and 28 days. After each measurement, the force meter was reset to zero readout before taking the next measurement.

To take the measurements, the orthodontic elastomeric chains were removed from the test devices and fixed onto the two pins of the dynamometer, thus allowing the tensile force of each sample to be gauged (Fig. 1C). Each elastomeric chains segment was distended to a length of 35 mm, keeping to the same distance as that between the pins of the test device. In order to obtain standardized measurements, all the samples were manipulated by the same operator (Table 2).

STATISTICAL ANALYSIS

Statistical analyses were performed with the program SPSS 13.0 (SPSS Inc, Chicago, Illinois, USA). For the groups



Figs 1A to C: (A) Test specimen with stretched chain elastics, (B) test specimen dipped in artificial saliva and (C) Digital dynamometer (Instrutherm DD-300)—measurement of chain elastic

Table 1: Exposure to mouthrinses

Groups exposed	*Mouthrinse used*	*Presence of fluoride*	*Components*
1, 3 and 5	Colgate Plax Whitening	Without fluoride	Water, sorbitol, ethylic alcohol, hydrogen peroxide (1.5%), poloxamer 338, polysorbate 20, methyl salicylate, menthol, sodium saccharin, CI 42090
2, 4 and 6	Colgate Plax Ice	With fluoride	Water, glycerine, sorbitol, propylene glycol, alcohol, poloxamer 407, polysorbate 20, aroma, cetylpyridinium chloride, sodium fluoride, sodium saccharin, CI 42051, 0.05% sodium fluoride (225 ppm of fluoride)

Table 2: Test groups evaluated

Test groups	*Immersion in artificial saliva*	*Exposure to mouthrinse (every 12 hours)*	*Test of force of chain elastics*
Group 1	pH 5.0	Without fluoride	Test of force: initial (0), 1, 7, 14, 21 and 28 days
Group 2	pH 5.0	With fluoride	
Group 3	pH 6.0	Without fluoride	
Group 4	pH 6.0	With fluoride	
Group 5	pH 7.5	Without fluoride	
Group 6	pH 7.5	With fluoride	
Control group	Did not undergo exposure	Did not undergo exposure	

evaluated, descriptive statistical analysis including mean and standard deviation were also performed. The force values were submitted to the analysis of variance (ANOVA) and Tukey's test to determine whether there were statistical differences between each group. The level of significance adopted was 5% ($p = 0.05$).

RESULTS

When the groups were compared among one another in the same time interval, no statistical differences were observed among them, as may be observed in Table 3. When the groups were evaluated individually, comparing the factor time, in the initial period the force was statistically higher than that of all the other experimental periods ($p < 0.05$). From the 7th day up to day 28 no statistical differences were found among the groups ($p > 0.05$), as may be observed in Table 4.

The factors pH and the presence of mouthwash with or without fluoride did not interfere in the results among the groups ($p < 0.05$).

The force values evaluated in the present study ranged between 6.86 N (group 7, initial) and 3.63 N after 21 days (groups 6 and 7). After 24 hours group 6 had the highest strength loss (from 6.63 N initially to 4.30 N after 24 hours). After 7 days the group 6 showed the lowest value (3.75 N), 14 days was the groups 5 and 6 (3.72 N) at 21 days was the 7 (3.66 N) and 28 days for groups 6 and 7 (3.66 N). After 28 days, the groups 1 and 3 were those with greater strength (4.05 and 3.97) respectively.

DISCUSSION

The appearance of white spot lesions during the period of orthodontic treatment continues to be a common occurrence. To revert this process and stimulate the remineralization of active white spot lesions when treating patients, the professional may resort to prophylaxis with the use of fluoridated compounds.[12,14]

Mouthrinses are composed of low cost fluoridated compounds easily found on the market, and may be indicated to help orthodontic patients to prevent caries lesions.[13] Thus, the use of fluoride associated with correct oral hygiene may promote satisfactory control of bacterial biofilm.

In order to obtain successful orthodontic treatment, chain elastics have been shown to be the orthodontist's great ally, as they are low cost, quick to put into place and their efficiency has been proved in the literature.[15,16] Nevertheless, substances used to help with the maintenance of oral health, such as mouthrinses, associated with changes in oral pH, may influence the physical and mechanical properties of these orthodontic materials.[17,18]

An important *in vitro* study, conducted by Larrabee et al (2012),[19] evaluated the effect of mouthrinses containing different concentrations of alcohol on the degradation of force of elastomeric chains for the period of 28 days. The results presented by the study proved that the components present in mouthrinses, such as alcohol, caused a statistically significant increase in the amount of force degradation in elastomeric chains when compared with those exposed to water only. Therefore, to perform satisfactory treatment, it is fundamental for professionals to know the possible effects these oral hygiene products may cause on the properties of orthodontic materials.

When orthodontic chain elastics are distended, they have a predictable performance, and lose their force over the course of time. Studies *in vitro*, well established in the literature,[20,21] have found that synthetic chain elastics lost 74.21% of the force they initially presented in the first 24 hours of the test. In the present study, after the

Table 3: Mean values, standard deviation and statistical analysis (comparison between groups by time) of groups

	Initial		24 hours		7 days		14 days		21 days		28 days	
Groups	*Mean (SD)**	*Stat.*	*Mean (SD)**	*Stat.*	*Mean (SD)**	*Stat.*	*Mean (SD)**	*Stat.*	*Mean (SD)**	*Stat.*	*Mean (SD)**	*Stat.*
1	6.55 (0.70)	–2, p = 1.000 –3, p = 1.000 –4, p = 1.000 –5, p = 1.000 –6, p = 1.000 –7, p = 0.900	4.38 (0.93)	–2, p = 0.980 –3, p = 1.000 –4, p = 0.684 –5, p = 0.737 –6, p = 1.000 –7, p = 0.999	4.27 (0.59)	–2, p = 1.000 –3, p = 0.993 –4, p = 0.989 –5, p = 0.120 –6, p = 0.958 –7, p = 1.000	4.25 (0.59)	–2, p = 0.671 –3, p = 0.839 –4, p = 0.479 –5, p = 0.085 –6, p = 0.085 –7, p = 0.168	4.11 (0.65)	–2, p = 0.895 –3, p = 0.993 –4, p = 0.724 –5, p = 0.149 –6, p = 0.149 –7, p = 0.100	4.05 (0.72)	–2, p = 0.777 –3, p = 0.999 –4, p = 0.858 –5, p = 0.368 –6, p = 0.205 –7, p = 0.205
2	6.58 (0.52)	–3, p = 1.000 –4, p = 1.000 –5, p = 1.000 –6, p = 1.000 –7, p = 0.935	4.70 (0.72)	–3, p = 0.980 –4, p = 0.988 –5, p = 0.994 –6, p = 0.929 –7, p = 1.000	4.30 (0.62)	–3, p = 0.981 –4, p = 0.993 –5, p = 0.086 –6, p = 0.922 –7, p = 1.000	3.94 (0.56)	–3, p = 1.000 –4, p = 1.000 –5, p = 0.901 –6, p = 0.901 –7, p = 0.975	3.91 (0.52)	–3, p = 0.999 –4, p = 1.000 –5, p = 0.820 –6, p = 0.820 –7, p = 0.724	3.80 (0.64)	–3, p = 0.961 –4, p = 1.000 –5, p = 0.995 –6, p = 0.961 –7, p = 0.961
3	6.58 (0.84)	–4, p = 1.000 –5, p = 1.000 –6, p = 1.000 –7, p = 0.935	4.38 (0.75)	–4, p = 0.684 –5, p = 0.737 –6, p = 1.000 –7, p = 0.997	4.12 (0.65)	–4, p = 1.000 –5, p = 0.450 –6, p = 1.000 –7, p = 1.000	4.13 (0.78)	–4, p = 0.997 –5, p = 0.761 –6, p = 0.761 –7, p = 0.901	4 (0.61)	–4, p = 0.979 –5, p = 0.501 –6, p = 0.501 –7, p = 0.392	3.97 (0.49)	–4, p = 0.984 –5, p = 0.680 –6, p = 0.468 –7, p = 0.468
4	6.63 (0.70)	–5, p = 1.000 –6, p = 1.000 –7, p = 0.970	4.91 (1.22)	–5, p = 1.000 –6, p = 0.518 –7, p = 0.929	4.16 (0.61)	–5, p = 0.364 –6, p = 1.000 –7, p = 1.000	3.88 (0.50)	–5, p = 0.975 –6, p = 0.975 –7, p = 0.997	3.86 (0.44)	–5, p = 0.948 –6, p = 0.948 –7, p = 0.890	3.83 (0.38)	–5, p = 0.994 –6, p = 0.920 –7, p = 0.920
5	6.61 (1.02)	–6, p = 1.000 –7, p = 0.960	4.88 (1.11)	–6, p = 0.574 –7, p = 0.951	3.75 (0.49)	–6, p = 0.634 –7, p = 0.230	3.72 (0.46)	–6, p = 1.000 –7, p = 1.000	3.69 (0.42)	–6, p = 1.000 –7, p = 1.000	3.68 (0.42)	–6, p = 1.000 –7, p = 1.000
6	6.63 (0.83)	–7, p = 0.978	4.30 (0.92)	–7, p = 0.988	4.08 (0.49)	–7, p = 0.993	3.72 (0.06)	–7, p = 1.000	3.69 (0.30)	–7, p = 1.000	3.63 (0.37)	–7, p = 1.000
7	6.86 (0.70)		4.55 (1.13)		4.22 (0.66)		3.77 (0.46)		3.66 (0.34)		3.63 (0.47)	

SD: Standard deviation; *Correspond of statistical differences ($p < 0.05$); Groups: (1) Control distillation water; (2) pH 5, without rinsing fluoride; (3) pH 5, rinsing with fluoride; (4) pH 6, without rinsing fluoride; (5) pH 6, rinsing with fluoride; (6) 7.5, without fluoride rinse and (7) 7.5, rinsing with fluoride

Table 4: Comparisons between groups individually at different times of evaluation

	1	*Stat.*	*2*	*Stat.*	*3*	*Stat.*	*4*	*Stat.*	*5*	*Stat.*	*6*	*Stat.*	*7*	*Stat.*
Initial	6.55 (0.70)	24 hrs, p = 0.000* 7 d, p = 0.000* 14 d, p = 0.000* 21 d, p = 0.000* 28 d, p = 0.000*	6.58 (0.52)	24 hrs, p = 0.000* 7 d, p = 0.000* 14 d, p = 0.000* 21 d, p = 0.000* 28 d, p = 0.000*	6.58 (0.84)	24 hrs, p = 0.000* 7 d, p = 0.000* 14 d, p = 0.000* 21 d, p = 0.000* 28 d, p = 0.000*	6.63 (0.70)	24 hrs, p = 0.000* 7 d, p = 0.000* 14 d, p = 0.000* 21 d, p = 0.000* 28 d, p = 0.000*	6.61 (1.02)	24 hrs, p = 0.000* 7 d, p = 0.000* 14 d, p = 0.000* 21 d, p = 0.000* 28 d, p = 0.000*	6.63 (0.83)	24 hrs, p = 0.000* 7 d, p = 0.000* 14 d, p = 0.000* 21 d, p = 0.000* 28 d, p = 0.000*	6.86 (0.70)	24 hrs, p = 0.000* 7 d,p = 0.000* 14 d, p = 0.000* 21 d, p = 0.000* 28 d, p = 0.000*
24 hours	4.38 (0.93)	7 d, p = 0.997 14 d, p = 0.991 21 d, p = 0.839 28 d, p = 0.707	4.70 (0.72)	7 d, p = 0.476 14 d, p = 0.007* 21 d, p = 0.004* 28 d, p = 0.001*	4.38 (0.75)	7 d, p = 0.894 14 d, p = 0.563 21 d, p = 0.563 28 d, p = 0.486	4.91 (1.22)	7 d, p = 0.023* 14 d, p = 0.000* 21 d, p = 0.000* 28 d, p = 0.000*	4.88 (1.11)	7 d, p = 0.000* 14 d, p = 0.000* 21 d, p = 0.000* 28 d, p = 0.000*	4.30 (0.92)	7 d, p = 0.900 14 d, p = 0.074 21 d, p = 0.053 28 d, p = 0.026*	4.55 (1.13)	7 d, p = 0.687 14 d, p = 0.011* 21 d, p = 0.002* 28 d, p = 0.001*
7 days	4.27 (0.59)	14 d, p = 0.1.000 21 d, p = 0.980 28 d, p = 0.831	4.30 (0.62)	14 d, p = 0.476 21 d, p = 0.391 28 d, p = 0.140	4.12 (0.65)	14 d, p = 0.991 21 d, p = 0.991 28 d, p = 0.980	4.16 (0.61)	14 d, p = 0.845 21 d, p = 0.784 28 d, p = 0.716	3.75 (0.49)	14 d, p = 1.000 21 d, p = 1.000 28 d, p = 1.000	4.08 (0.49)	14 d, p = 0.302 21 d, p = 0.448 28 d, p = 0.296	4.22 (0.66)	14 d, p = 0.376 21 d, p = 0.152 28 d, p = 0.116
14 days	4.25 (0.59)	21 d, p = 0.991 28 d, p = 0.960	3.94 (0.56)	21 d, p = 1.000 28 d, p = 0.983	4.13 (0.78)	21 d, p = 1.000 28 d, p = 1.000	3.88 (0.50)	21 d, p = 1.000 28 d, p = 1.000	3.72 (0.46)	21 d, p = 1.000 28 d, p = 1.000	3.72 (0.06)	21 d, p = 1.000 28 d, p = 0.999	3.77 (0.46)	21 d, p = 0.996 28 d, p = 0.990
21 days	4.11 (0.65)	28 d, p = 1.000	3.91 (0.52)	28 d, p = 0.994	4 (0.61)	28 d, p = 1.000	3.86 (0.44)	28 d, p = 1.000	3.69 (0.42)	28 d, p = 1.000	3.69 (0.30)	28 d, p = 1.000	3.66 (0.34)	28 d, p = 1.000
28 days	4.05 (0.72)		3.80 (0.64)		3.97 (0.49)		3.83 (0.38)		3.68 (0.42)		3.63 (0.37)		3.63 (0.47)	

SD: Standard deviation; *Correspond of statistical differences ($p < 0.05$); Groups: (1) Control distillation water; (2) pH 5, without rinsing fluoride; (3) pH 5, rinsing with fluoride; (4) pH 6, without rinsing fluoride; (5) pH 6, rinsing with fluoride; (6) 7.5, without fluoride rinse and (7) 7.5, rinsing with fluoride first 24 hours of distension, while immersed in artificial saliva, and being exposed to mouthrinses every 12 hours, the chain elastics lost a large quantity of initial force, corroborating the data of the above-mentioned studies.

In an experiment conducted in a dry environment, Ren et al (2003)[1] showed that after 21 days, depending on the brand of elastomeric chains tested, the percentage of force degradation may vary from 42 to 63%. Whereas, researches conducted by Lu et al (1993)[22] and Kanchana et al (2000)[8] found that the force degradation occurred in a more accentuated manner when the elastomeric chains were submitted to a humid environment. According to these parameters, the test groups remained immersed in artificial saliva throughout the entire experiment, with the intention of simulating that which really occurs clinically when they are used in the oral environment.

De Genova et al (1985)[23] promoted an experiment in which the factor temperature was added to exposure of elastomeric chains to an aqueous medium, resulting in high elastic force degradation in each time interval studied. Thus, after 21 days of the experiment, the percentage of force lost by the samples reached up to 68%. Because it was found that temperature influenced the levels of elastomer force degradation, the experiment performed sought to simulate the oral medium, by maintaining the chain elastics continuously immersed in artificial saliva at a controlled temperature of 37ºC, this representing the mean body temperature.

In the present study, the results obtained demonstrated that there were no significant difference in force degradation of the elastic ligatures when the test groups were compared among one another in the same time interval. Therefore, it may be affirmed that after the chain elastics were distended, dissipation of their force was not significantly influenced by exposure to the fluoride-containing mouthrinses.

Important to be said that the testing of orthodontic elasomeric auxilliaries is standardized by ISO 21606: 2007—Dentistry — Elastomeric auxiliaries for use in orthodontics.

During the experiment, the elastomeric chains were evaluated at six different time intervals. Thus, specimens had to be removed from the jig and taken to the distended dynamometer six times, which may be a limitation of the present study as this procedure may have influenced the force values. A single group for each time interval could have eliminated this problem, but it would have led to a huge amount of specimens. Hence, only six groups were introduced in the present study.

In their studies, Baty et al (1994)[15] and Huget et al (1990)[24] also analyzed the amount of tension lost by synthetic elastics considering the time of distension of the elastic chain. They in turn, showed that after the first hour of the experiment, the samples lost a significant quantity of the force they had presented in the initial test. By conducting the proposed experiment according to these same patterns, it was verified that the largest quantity of force presented by the chain elastic was lost after the first 24 hours of being stretched. Thus, finding that in the initial period, the force of the elastic ligatures was higher in comparison with the force presented in the other periods of the study.

Previous studies[25,26] have shown that the force degradation of elastomeric chains submitted to tests occurs in an accentuated manner in the first 24 hours, reaching consistent levels of force in the remaining experimental period. In agreement with the data found in the literature, the results of this study showed that after the first 24 hours, in spite of the well known initial degradation of force that occurs, the decline in the remaining force of the synthetic elastic ligatures occurred at lower levels, and was more constant during the following weeks of the period of tests. Therefore, the chain elastics may be exchanged on a monthly basis, as the dissipation of tensions over the course of time on fixed devices, at different levels of pH, and exposure to mouthrinses with and without fluoride is considered acceptable.

CONCLUSION

Based on the results found, it may be concluded that:

- The presence or absence of fluoride in the mouthrinses used in the study had no significant influence on the force degradation of chain elastics.
- In spite of losing a large quantity of force after 24 hours of distension, orthodontic chain elastics present consistent and satisfactory force after this period.

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