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Influence of elastic chain in the degradation of orthodontic forces - in vitro study

Influência de elásticos corrente na degradação de forças ortodônticas – estudo in vitro

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Resumo

Introdução: Os elásticos corrente são acessórios indispensáveis no tratamento ortodôntico, e suas propriedades de grande interesse para o profissional, a fim de obter maior controle sobre os movimentos dos dentes. **Objetivo:** Avaliar a influência da marca comercial e comprimento da cadeia espaçadora de elásticos corrente na degradação de força. **Material e método:** Foram utilizadas ligaduras elásticas ortodônticas em cadeia, tipo curto, médio e longo das marcas: Rocky Mountain (RMO), TP e GAC. Os elásticos, contendo elos correspondentes a 12,5 mm, foram tensionados entre pinos de aço na máquina de ensaio universal Instron 4411 até 25 mm. O valor foi anotado. Após a aferição inicial da força, os elásticos foram fixados em placa de resina acrílica e mantidos distendidos a 25 mm. Foram inseridas em recipiente contendo água deionizada e mantidas em estufa a 37 °C. A leitura da força dos elásticos foi feita nos tempos de 24 horas, 48 horas, 7 dias, 14 dias, 21 dias e 28 dias. Os dados foram submetidos ao teste estatístico apropriado, com nível de significância de 5%. **Resultado:** Os elásticos TP apresentaram força significativamente maior em todos os períodos. Os elásticos GAC e RMO apresentaram forças estatisticamente semelhantes. Os elásticos TP cadeia curta e longa apresentaram força significativamente maior que os elásticos cadeia média. Para GAC e RMO os elásticos curto apresentaram força maior que os médios e este maior que os longos. **Conclusão:** A cadeia espaçadora e a marca comercial influenciaram nos resultados obtidos, reforçando a importância do conhecimento dos tipos de elástico.

Descritores: Elastômeros; ortodontia; elasticidade.

Abstract

Introduction: Elastic chains are indispensable accessories in orthodontic treatment. Changes in their properties are of great interest to professionals in order to gain greater control over tooth movements. **Objective:** Evaluate the influence of trademark and length of the spacer chain on force degradation of elastic. **Material and method:** We used the following elastic chain types: TP, Rocky Mountain (RMO) and GAC short, medium and long varieties. The elastics, which contained links corresponding to 12.5 mm, were tensioned between steel pins using Instron 4411 universal testing machine up to 25 mm. The value was recorded. After initial measurement of the force, the elastics were fixed on an acrylic resin plate and kept distended to 25 mm. They were inserted in a container with deionized water and kept in an incubator at 37º. The elastic force data was collected at time intervals of 24 hours, 48 hours, 7 days, 14 days, 21 days and 28 days. These records were subjected to an appropriate statistical test, with significance level of 5%. **Result:** TP elastics showed significantly higher force in all periods. RMO and GAC elastics showed similar elastic forces. Short and long TP elastics exhibited significantly higher strength than the average elastic chain. As regards GAC and RMO, short elastics showed higher than average force values, and higher values than the long type. **Conclusion:** The spacer chain and the brand influenced the results, reinforcing the importance of knowledge of different types of elastic.

Descriptors: Elastomers; orthodontics; elasticity.

INTRODUCTION

The aim of orthodontic treatment is to transmit mechanical forces to the teeth, leading them to a suitable position in the dental arch. Orthodontic elastics and their properties are of great interest to professionals, in order to gain grater control over tooth movements[1,2].

In 1920, the production of synthetic elastics began, and in 1960, their use in Orthodontics was disseminated[1,3]. The elastics are amorphous polymers made of polyurethane material that has the characteristics of rubber and plastic[4]. In addition, they have the capacity to return to their original dimensions after undergoing deformation[3,5].

The type most used in orthodontics are chain elastics and elastic ligatures that have different clinical applications: closure of diastemas, correction of rotation, fixation of the arch to brackets, correction of midline deviations, canine retraction, among others[1,3].

Chain elastics have different spacer chains. They are classified into: short, medium and long types, according to the distance between the center of two consecutive links, and may measure 3 mm, 3.6 mm or 4 mm, respectively[6]. They are practical, low cost, hygienic. easy to use and acceptable to the patient because they come in a variety of colors[7,8].

Elastomeric chains have several unfavorable conditions, which may influence their clinical use in the intraoral medium, such as: saliva, variations in pH, presence of enzymes and temperature. Studies have shown that the elastics tested in a humid medium underwent greater degradation than those tested in a dry medium[3]. When they are distended around brackets, they lose force over time. Their properties undergo changes, and one of these is force degradation when they are subjected to traction, resulting the their gradual loss of effectiveness[9]. Various studies with chain elastics have shown that these materials cannot produce constant levels of force for a long period of time, and the greatest the reduction in their force occurs in the first few hours[10,11].

Knowledge of these changes is important so that the professional may opt to use an elastic with a lower level of degradation, thus guaranteeing the elastics will continue to exert a clinically adequate force during the entire period of orthodontic treatment.

This study is justified by the enormous variety of commercial brands and different spacer chains (short, medium and long) used during the course of orthodontic mechanics, however, without reports about the influence of these chains on force degradation.

MATERIAL AND METHOD

Orthodontic elastic chain ligatures, short, medium and long type, gray color, of the following brands were used: Rocky Mountain (Denver, USA), TP (La Porte, USA) and GAC (New York, USA), acquired in sealed packages and within the period of validity. The final sample consisted of 15 elastics of the respective commercial brands (n=135).

The elastic chain was cut into segments containing links equivalent to a distance of 12.5 mm (Figure 1). For the short TP brand elastics, 5 links; for medium, 4 links and for the long type, 5 links were used. For the short type RMO brand, 5 links; for medium, 4 links, and for the long type, 4 mm were also used. For the short type GAC brand, 5 links, and for the medium and long types, 4 links were used, as may be observed in Figure 1.

Initially, the length of each elastic segment was measured with a digital pachymeter, and afterwards they were pre-stretched by 50% in comparison with the original length. Right after pre-stretching, the elastics were distended to 25 mm, in an Instron 4411 Universal test machine, at a speed of 100 mm/minute, and the force was measured. This force was measured at the following time intervals: initial, 24 hours, 48 hours, 7 days, 14 days, 21 days and 28 days, for the three brands of elastics and three chain sizes (short, medium and long).

Between the different intervals of force measurement, the elastics remained stretched to a distance of 25 mm, and in order to keep them stretched, transparent acrylic resin plates were fabricated, measuring 15 cm long, 4 cm wide and 1 cm thick. Marks were made on the plate for fifteen pairs of pins, with a distance of 25 mm between them, and afterwards holes were drilled in the plate thickness. Orthodontic 0.9 mm Moreland (Sorority-SP, Brazil) steel arch wires were adapted, bent and fixed in these orifices with the use of acrylate adhesive (Super Bonder), to obtain a standard height of 10 mm. The chain elastics with the number of links corresponding to each brand were fitted onto each of the 15 pairs of pins. The commercial brand name of the manufacturer, type of chain and samples numbered from one to fifteen were engraved on the side of each plate.

The plates with elastic were inserted into receptacles containing deionized water, and kept in an oven at 37 °C.

The elastics on the plates were taken for measurement in the above-mentioned time intervals, by the same researcher, so that there would be no difference in the handling of the appliance. The data were recorded and submitted to appropriate statistical analysis by using the Tukey Test, at a level of significance of 5%. The statistical program SaS System for Windows 9.0 (SAS Institute Inc., Cary, NC, USA) was used.

RESULT

The results showed there was significant interaction between the factors (p=0.006).

The values obtained with the experiment were organized and represented in Table 1, showing the means of the times studied, standard deviation, comparison between commercial brands, elastomeric chain size and force in function of the time intervals evaluated.

TP elastics were found to present significantly higher force than the other elastics, in all time intervals. RMO and GAC elastic presented statistically similar forces.

The TP long and short chain elastics presented significantly higher force values than the medium chain elastics.

The RMO and GAC short chain elastics presented a significantly higher force value than the medium and long chain elastics; and the medium type presented a significantly higher force value than the long chain elastics.

A significant reduction in the force of elastics from the initial evaluation up to the period of 7 days was verified. For the TP and

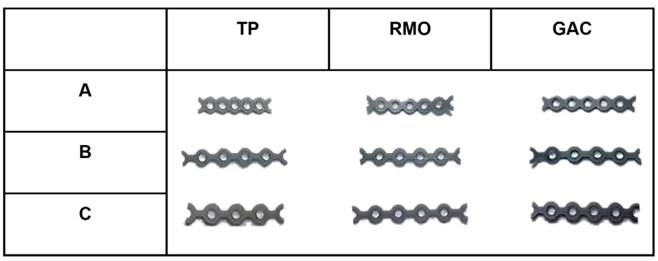

Figure 1. Chain elastics A: short chains; B: medium chains; C: long chains.

Table 1. Force of short, medium and long chain elastics in different time intervals

Elastic	Size		Force of elastics (gF)																												
			INITIAL FORCE				24 HOURS				48 HOURS				7 DAYS				14 DAYS				21 DAYS				28 DAYS			
TP	Short	Medium	801.7	a	a	A	519.8	a	a	B	469.3	a	b	C	444.0	a	a	CD	434.6	a	a	D	451.0	a	a	CD	424.1	a	a	D
		SD	45.2				43.8				37.8				51.8				38.0				42.7				42.8			
	Me-dium	Medium	637.7	a	b	A	457.7	a	b	B	421.2	a	c	C	384.1	a	b	D	368.4	a	b	D	362.4	a	b	D	360.6	a	b	D
		SD	23.8				25.7				35.0				25.1				29.3				21.0				33.0			
	Long	Medium	826.6	a	a	A	552.8	a	a	B	520.5	a	a	C	473.7	a	a	D	464.2	a	a	D	463.9	a	a	D	465.4	a	a	D
		SD	74.9				77.9				70.5				71.5				84.0				70.1				69.0			
RMO	Short	Medium	521.6	b	a	A	348.0	b	a	B	326.0	b	a	C	288.4	b	a	D	282.1	b	a	DE	274.9	b	a	E	263.2	b	a	F
		SD	2.2				15.1				10.3				11.8				10.9				12.2				15.7			
	Me-dium	Medium	464.8	ab	b	A	313.1	b	b	B	291.4	b	b	C	255.9	b	b	D	249.9	a	b	DE	243.2	b	b	E	230.8	b	b	F
		SD	12.4				14.1				15.9				14.9				12.9				14.5				15.0			
	Long	Medium	441.8	b	c	A	292.5	b	c	B	268.3	b	c	C	231.9	b	c	D	227.0	b	c	D	224.9	b	c	D	211.6	b	c	E
		SD	3.2				20.0				16.4				17.2				13.1				12.7				14.7			
GAC	Short	Medium	503.1	c	a	A	332.3	b	a	B	307.6	b	a	C	254.9	c	a	D	252.8	c	a	D	252.3	b	a	D	245.1	b	a	D
		SD	8.3				29.3				25.3				19.1				16.7				19.5				12.6			
	Me-dium	Medium	444.2	b	b	A	288.5	b	b	B	272.1	b	b	C	234.9	b	ab	D	232.1	a	ab	D	228.8	b	b	D	222.3	b	b	D
		SD	3.9				24.4				28.4				28.2				29.6				22.9				28.8			
	Long	Medium	419.6	b	c	A	268.2	b	c	B	250.7	b	c	C	218.7	b	b	D	213.2	b	b	DE	208.6	b	c	DE	203.0	b	c	E
		SD	4.8				20.7				19.0				20.3				20.1				18.3				29.8			

Different lower case letters in column and capital letters on line represent significant differences. In the first columns within each evaluation time interval the comparison between the commercial brands is shown for one and the same size of elastomeric chain. In the second column within each evaluation time interval the comparison between the sizes of elastomeric chains is shown for one and the same commercial brand ($p<0.05$). In the third line the significant difference as a function of time is shown.

GAC elastics, the force did not diminish significantly as from 7 days, except for the GAC long chain elastic that presented a significant reduction in 28 days.

For the RMO elastics there was continuous degradation of force up to the end of the 28 days, and there was significant reduction in force as from 21 days for the short and medium chain, and in 28 days for the long chain elastics.

DISCUSSION

Chain elastics are widely used materials in Orthodontics, and knowledge about their properties and structural changes is of fundamental importance to the clinician, since these elastics may remain in the oral cavity for a relatively long time[3].

During orthodontic treatment is its desirable for elastics to maintain adequate force, in order to have the tooth movement required by the orthodontist. In this study, the degradation of force of orthodontic elastics of different chain sizes (short, medium and long) were evaluated. One of the causes of degradation is relaxation, which is the tendency towards decrease in force released over time some materials have when they are kept distended at a certain fixed distance[11].

The elastics were kept stretched at a distance of 25 mm on an acrylic plate, thereby preventing the phenomenon of elastic recovery, inserted in deionized water and kept in an oven at 37 ºC, to simulate oral conditions[12,13]. Determination of this amount of stretching of the elastics corresponds to the distance between the mesial surface of a bracket bonded to the vestibular surface of a maxillary canine, up to the distal surface of a bracket bonded to the vestibular surface of a maxillary second premolar, on the same side of the arch,, when the maxillary first molar has been extracted as part of the therapy[1,14].

The in vitro study has limitation, because during clinical use, orthodontic elastics are submitted to other deformations resulting from the action of salivary enzymes, mastication and brushing, salivary pH associated with the ingestion of hot and cold foods, among others[8].

In order not to damage the elastic chain structures and eliminate the possibility of accidental damage during the procedure of cutting the links and placing them onto the plate, the extremities of the elastics were cut in the center of the discarded link, and only the central links were activated[15].

The color of the chain elastics were a standard gray color. Previous studies have concluded that the properties related to the distribution of elastomeric forces are significantly affected by the pigmentation incorporated into the material[16-18].

The final period of 28 days of the research was determined, because it corresponds to the mean period of change of elastics performed by orthodontists, as has been indicated in various studies[5,11,13,14,18-21].

Studies have also affirmed that if there has not been strict quality control in the manufacture of the elastics, there could be a great deal of variation in the results within each commercial brand, changing the elastic properties of the materials. Therefore, 15 specimens were used for each group[10,12].

The behavior of elastomers during the time intervals evaluated in this research may be observed in Table 1. The study demonstrated that the samples of all the groups of elastics underwent greater force degradation in the first 24 hours of stretching, with the intensity varying according to the group tested.

This fact has also been observed in studies conducted by other authors[1,3,11,14,18,19,22,23]. This degradation has also bee associated with the fact of elastics being in a humid medium, leading to weakening of the intermolecular forces, absorption of water and formation of hydrogen bridges between the water molecules and polymer macromolecules[4,15,23].

The fact that the group of TP elastics showed higher force values at the end of 28 days probably occurred because this group presented the highest initial force, when compared with the other groups, and a great variability in the values of these forces initially, as was also found in the study of Weissheimer et al.[5].

According to Andreasen, Bishara[19], the use of a force four times higher than the desired value is recommended when one wishes to apply chain elastics to compensate the degradation of force in the first 24 hours. However, the behavior of elastic chains may vary according to the manufacturer, as shown in the present study, so that this increase is not justified. The initial force should be determined according to the commercial brand and the type of elastomeric chain used, because the initial force was shown to be different for each group. Measuring the clinically used force of an elastomer by means of a precise instrument is high advisable when using any commercial brand[5].

As presented in the results, the final force of the elastics was acceptable for orthodontic movement, because according to Boester, Johnson[24] force between 100 and 350g is considered effective.

A study conducted by Kochenborger et al.[3], in which elastics only of the short type of different brands (Moreland, Ormco, TP and Unitek) were compared, showed that the TP brand presented the lowest potential elastic loss in the time intervals studied (30 minutes, 7 days, 14 days and 21 days) compared with other brands, This could also be observed in the present study, in which the short TP elastics presented the lowest force degradation value.

Another study, conducted by Araújo, Ursi[1], in which elastic chains of the medium type, of the TP, GAC, Moreland, Ormco and Unitek brands showed that elastomeric chains of the GAC brand presented the lowest mean initial and final force values in comparison with the other brands analyzed; whereas the samples of the TP brand presented the highest mean final force value, in comparison with the other commercial brands studied.

This was also observed in the present study, in which the TP medium chains presented higher force values than the GAC chains; not only for the medium type, but also for the short and long types. As the RMO elastics had forces statistically similar to those of GAC, the same fact was analyzed for RMO.

The elastomer chains were observed to undergo greater reduction in force up to the period of 7 days. When verifying the individual profile of the brands, the TP and GAC elastics were observed to stabilize in 7 days, whereas the RMO elastics underwent graduation reduction in force until the end of the 28 days.

As regards the spacer chain, the forces of short and long TP elastics had a similar behavior and showed higher values than the medium elastics, and it was only in the time interval of 48 hours that the long elastics showed higher force values than the short type.

For GAC there was a lower level of degradation for short elastics, followed by the medium and long types. In the time intervals of 7 and 14 days, the short and medium elastics were observed to have similar forces, and higher force values than the long type. A significant reduction in force was observed in the long elastics in 28 days, in comparison with 7 days, which also occurred with the RMO long elastics. This may indicate that it would be better to change the long GAC and RMO elastics in 21 days.

For the RMO elastics, the short chains presented higher force values, followed by the medium and long types, with the short and medium types undergoing significant reduction in force as from 21 days.

However, the RMO and GAC brans of long elastics presented a higher level of force degradation, differently from the TP long type, which had the lowest level of degradation, together with the short type.

In general, the short elastics that have a shorter distance between links, presented a lower level of degradation and the long type with a longer distance between links underwent greater degradation. The exception was the TP long elastics that presented a different elastomeric chain configuration to that of the other long types, with the distance between links being greater. This could be observed since only 3 links of TP were used, against 4 links used for RMO and GAC.

For the short elastics, all were observed to present a larger number of links than the other types, a total of 5 links. A study conducted by Ferreira, Caetano[25], in which elastic chains of the short type with different numbers of links were evaluated, they had groups of 3, 5 and 7 links that were distended with a force of 200g, considered optimal for canine retraction. The group with the highest number of links (7 links) at the end of the research maintained the highest percentage of force, suggesting its use in longer intervals of time. These data corroborate those of the present study with respect to the larger number of links.

Moreover, as observed in this study, and according to De Genova et al.[14] and Baty et al.[17], the "closed" elastics (without space between links), called short, appear to retain a higher percentage of force over the course of time than the long elastics that were stretched at the same distance.

Due to the limitations of the present in vitro study, further clinical studies are suggested in order to evaluate the degradation of force of different spacer chains during the mechanics of retraction.

CONCLUSION

Based on the results, it was concluded that for all the types and brands of elastics there was greater degradation of force in the first 24 hours. The force of the TP and GAC elastics diminished up to the period of 7 days. The RMO elastics presented continuous degradation of force up to 28 days, TP brand elastics presented the highest force values among the elastics. The size of the elastic chains had an influence on force. In elastics of the TP brand, the medium chains presented lower force values than the short and long types. In the RMO and GAC Brands, the short chains presented a higher force value than the medium type, and the latter showed higher force than the long type.

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CONFLICTS OF INTERESTS

The authors declare no conflicts of interest.

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