

# Evaluation of degradation of force of esthetic elastomeric chains

## Avaliação da degradação de força de correntes elastoméricas estéticas

Mayra Teixeira Cortat LUCINDO<sup>a</sup> , Diego Patrik Alves CARNEIRO<sup>a</sup> ,  
Felipe Alexandre de SOUZA<sup>a</sup> , Américo Bortolazzo CORRER<sup>b</sup> , Heloisa Cristina VALDRIGHI<sup>\*\*</sup>

<sup>a</sup>UNIARARAS/FHO – Fundação Hermínio Ometto, Programa de Pós-graduação em Ortodontia, Araras, SP, Brasil  
<sup>b</sup>UNICAMP – Universidade Estadual de Campinas, Faculdade de Odontologia de Piracicaba, Departamento de Odontologia Restauradora, Piracicaba, SP, Brasil

**How to cite:** Lucindo MTC, Carneiro DPA, Souza FA, Correr AB, Valdrighi HC. Evaluation of degradation of force of esthetic elastomeric chains. Rev Odontol UNESP. 2019;48:e20190111. <https://doi.org/10.1590/1807-2577.11119>

### Resumo

**Introdução:** Os elastômeros são considerados aliados importantes do tratamento ortodôntico e, devido à demanda estética, os elastômeros estéticos são cada vez mais utilizados em pacientes adultos. **Objetivo:** O objetivo desse estudo experimental *in vitro* foi avaliar a degradação de forças geradas pelas cadeias elastoméricas estéticas, em três diferentes tamanhos curto, médio e longo. **Material e método:** Para a avaliação da degradação da força foram utilizados 90 segmentos de cadeias elastoméricas, divididos em 9 grupos (n=10), sendo: elastômero Morelli curto, Morelli médio, Morelli longo, Orthometric curto, Orthometric médio, Orthometric longo, American Orthodontic curto, American Orthodontic médio e American Orthodontic longo. Foram utilizadas placas de acrílico com pinos que proporcionaram o estiramento das cadeias elastoméricas. A força inicial de estiramento da cadeia elastomérica foi de 150 gramas, medidas por um tensiômetro. Em seguida foram pré-estiradas em 50% do seu comprimento original, medidas em uma máquina Universal Instron 4411 e levadas ao pino de assentamento na placa. A placa foi imersa em um recipiente plástico com saliva artificial a 37 °C e removida após 21 dias para aferição. Foi aplicada metodologia de modelos mistos para medidas repetidas no tempo e teste de Tukey-Kramer. A degradação das forças foi analisada por análise de variância (ANOVA) “2 fatores” e teste de Tukey. **Resultado:** Todas as correntes elastoméricas apresentaram redução estatisticamente significativa da força (p<0,05). As correntes elastoméricas da American Orthodontic apresentaram maior redução de força, independentemente do tamanho do elástico (p<0,05). **Conclusão:** As três marcas comerciais estudadas sofreram uma redução significativa na quantidade de força liberada, sendo o elastômero da marca American Orthodontic o que apresentou maior degradação de força.

**Descritores:** Ortodontia; elastômeros; módulo elástico; estética dentária.

### Abstract

**Introduction:** Elastomers are considered important allies to orthodontic treatment and due to the aesthetic demand, aesthetic elastomers are increasingly used in adult patients. **Objective:** The aim of this experimental *in vitro* study was to evaluate the degradation of force of esthetic elastomeric chains, of three different sizes: short, medium and long. **Material and method:** For evaluating the degradation of force, 90 elastomeric chain segments were used, divided into 9 Groups (n=10), as follows: Morelli short elastomer, Morelli medium, Morelli long, Orthometric short, Orthometric medium, Orthometric long, American Orthodontic short, American Orthodontic medium and American Orthodontic long. Acrylic plates with pins were used to provide stretching of the elastomeric chains. The initial stretching force of the elastomeric chain was 150 grams, measured by a tensiometer. After this, they were prestretched to 50% of their original length, measured in an Instron 4411 Universal test machine, and placed on the seating pin on the plate. The plate was immersed in artificial saliva at 37 °C in a plastic receptacle, and removed for measurement after a time interval of 21 days. For statistical analysis, the methodology of mixed models for repeated measures in time and Tukey-Kramer test were used. Degradation of the forces was analyzed by 2-way



analysis of variance (ANOVA) and the Tukey test. **Result:** All the elastomeric chains showed statistically significant reduction in force ( $p < 0.05$ ). The American Orthodontic elastomeric chains showed higher reduction in force values, irrespective of the elastic size ( $p < 0.05$ ). **Conclusion:** The three commercial brands studied underwent significant reduction in the quantity of force released; the American Orthodontic brand of elastomer showed the highest value of degradation in force.

**Descriptors:** Orthodontics; elastomers; elastic modulus; dental esthetics.

## INTRODUCTION

Elastomers are considered important adjuvant materials in orthodontic treatment and have many clinical applications<sup>1,2</sup>. This refers especially to esthetic elastomers used in adult patients who are highly demanding about the esthetic appearance of orthodontic appliances<sup>3,4</sup>. Elastomer chains can be classified as short, medium or long according to the distance between the links<sup>5,6</sup>. They have the advantages of being practical, hygienic, having elastic memory, being easy to place and comfortable for the patient to use, biocompatible and inexpensive<sup>7-9</sup>. However, they also have disadvantages because they are incapable of releasing constant levels of force for a long period of time and undergo changes in their physical properties when exposed to the oral environment, where they absorb saliva and become deformed due to breakdown of internal bonds. In addition, they undergo changes due to chemical cleaning products and the chemical action of chewing and toothbrushing; and stains are directly related to daily diet and eating habits<sup>10-12</sup>.

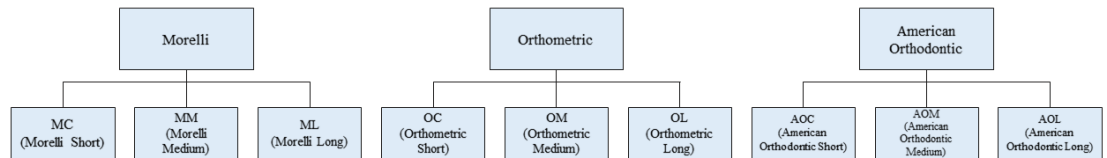
During orthodontic treatment, it is desirable for the elastics to maintain adequate force, for the purpose of achieving the dental movement desired by the orthodontist. However, the elastomeric chains dissipate a decreasing force<sup>6,13</sup>. To achieve greater efficiency during orthodontic treatment, it is necessary to know about some important factors such as the force applied on the teeth to be moved, because continuous forces obtain better results than intermittent forces<sup>6,13</sup>.

Some authors have suggested prestretching of chain elastics before their clinical application. This is a mechanical resource used for minimizing the abrupt drop in force released by the elastic after its fixation in the dental arch. These elastics may be stretched at different speeds (slow or fast), with variation of 50%, 75% and 100% in distention in relation to their initial length<sup>1,14</sup>. The recommendation is that they should be changed every three weeks, and that elastomeric chains should not be used for a period longer than four weeks. This is because, on an average, the elastics lose 30% of the magnitude of initial force, in addition to the occurrence of bacterial plaque accumulation and chemical interaction with foods and oral fluids<sup>1,6</sup>.

When evaluating the degradation for force undergone by elastics of the chain type, because of stretching time to which they were submitted<sup>1,6,13,15</sup>, the orthodontist frequently has difficulty in determining the adequate force to be transmitted to the teeth by the elastomeric chains and their time interval of dissipating useful force<sup>13</sup>. In the literature there is a scarcity of studies about the degradation of force of esthetic elastomeric chains. This fact justified the hypothesis that elastomeric chains long in size would show a higher level of degradation of force than the short and medium sizes. The authors also expected to find difference in the degradation of force between the different commercial brands (Morelli, Orthometric and American Orthodontic). Therefore, the aim of this study was to evaluate the degradation of forces of esthetic elastomeric chains in three different sizes: short, medium and long.

## MATERIAL AND METHOD

For conducting this experimental *in vitro* study, short, medium and long elastomeric chains of three commercial brands (Sorocaba, SP, Brazil), Orthometric (Marília, SP, Brazil) and American Orthodontic (Sheboygan, WI, USA) were used. In total, 90 elastomeric chain segments were used, divided into 9 Groups ( $n=10$ ) (Figure 1).



**Figure 1.** Flowchart of the groups.

All the elastics were acquired from the same manufacturer and were stored in their original packaging, with adequate “use by” date, kept in a dry place and protected from light, thus eliminating eventual changes caused by variations in temperature and lighting.

To evaluate the degradation of force, transparent acrylic resin plates were used. Each plate measured 11 cm long × 4 cm wide × 0.5 cm thick, where perforations 0.5 cm deep were made with a carbide tip 151 XL (Fava, São Paulo, SP, Brazil) adapted to a low speed motor. The pins were fabricated of orthodontic archwire measuring 0.9 mm in diameter by 10 mm high, which were fixated with transparent selfpolymerizing acrylic resin (Jet, Campo Limpo Paulista, SP, Brazil) in the perforations that had been made at a distance of 15 to 16 mm between them. On each plate, 10 pairs of pins were fixated to keep the chain type elastics stretched, with the distance between the pins corresponding to a stretching force of 150 gf of the elastics, measured by a tensiometer. After this they were prestretched to 50% of their initial length, measured with an Instron 4411 Universal test machine<sup>6,14</sup>. The elastics were cut with an extra half chain on each side to prevent distortion at the time of cutting them.

The elastic was removed from the (Instron) test machine and taken to its seating pin on the plate, which was immersed in artificial saliva at 37 °C in a plastic receptacle<sup>6</sup>. After a time interval of 21 days, the elastics were removed from the receptacle for new force measurement. This time interval is used by orthodontists for replacing the elastics, thus simulating the clinical use of these orthodontic accessories<sup>14</sup>. The plates were identified by means of a label containing the brand name of the elastic manufacturer and were numbered.

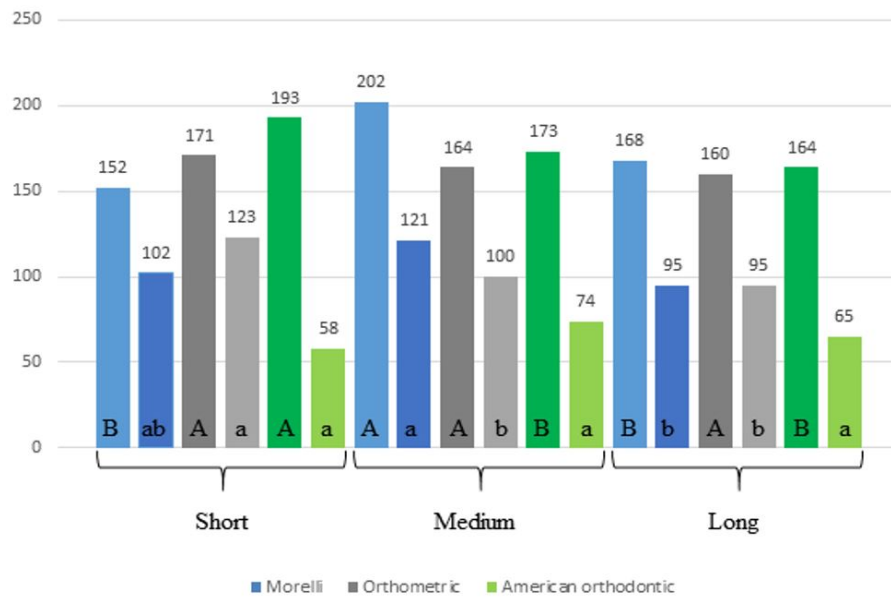
Selection of adequate force to be applied for orthodontic movement is of fundamental importance for performing good orthodontic treatment. The clinician must be concerned about maintaining integrity of the capillary blood supply in the periodontal ligament to promote bone resorptions and avoid areas of hyalinization around the alveolar bone on the pressure side. Very heavy forces may retard bone formation in the zone of traction<sup>6,16</sup>.

## Statistical Analysis

After exploratory analysis of the force data they underwent logarithmic transformation so that the data would meet with the presuppositions of a parametric analysis. Thus, the methodology of mixed models for repeated measures in time and Tukey-Kramer test were applied. The percentages of degradation of the forces were analyzed by 2-way analysis of variance (ANOVA) and the Tukey test. All the analyses were performed with the R program (R Foundation for Statistical Computing, Vienna, Austria) software program, considering a level of significance of 5%.

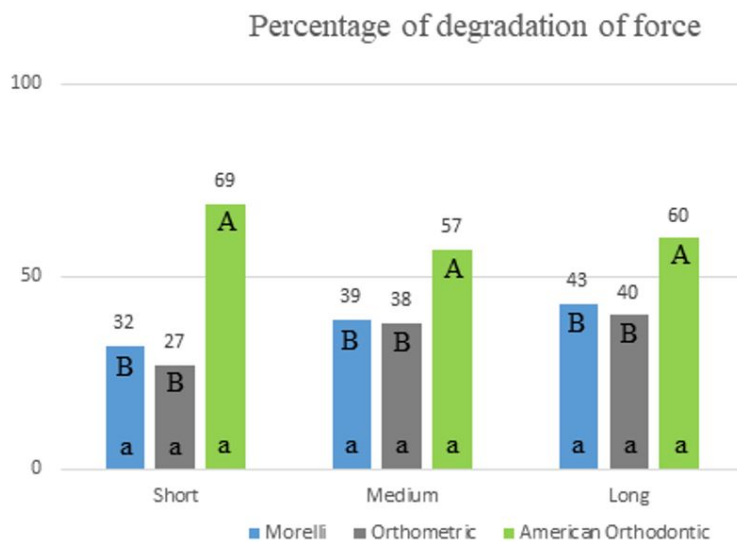
## RESULT

There was significant reduction in force value in the final time interval in comparison with the initial time ( $p < 0.05\%$ ) for all the brands and sizes of elastics (Figure 1). For the medium sized elastics, in the two (initial and final) time intervals, the highest mean force value was observed in the Morelli brand ( $P < 0.05\%$ ) (Figure 2).



**Figure 2.** Measurement of standard deviation of force (grams) considering size and time, the three brands (Morelli, Orthometric and American Orthodontic). Dark colors represent initial mean values and Light colors represent final mean values. Capital letters compare the amount of force (grams) between the marks in the initial time. Lower case letters compare the amount of force (grams) between the marks in the final time.

There was no significant difference between the three sizes with regard to degradation of force in percentage ( $p > 0.05$ ). The American Orthodontic brand showed the highest percentage of degradation of force in the three sizes of elastics ( $p < 0.05$ ). (Figure 3).



**Figure 3.** Percentage of degradation of force of the three commercial brands (Morelli, Orthometric and American Orthodontic). Lower case letter compared sizes in each brand and capital letters compared brands within each size.

## DISCUSSION

During orthodontic treatment, it is desirable for the elastics to maintain adequate force, with the purpose of obtaining correct tooth movement<sup>1,6,13</sup>. The main finding of this study was that the three commercial brands studied (Morelli, Orthometric and American Orthodontic) and the three

sizes of elastics (short, medium and long) showed significant degradation of force values, corroborating the findings in the study of Kochenborger et al.<sup>14</sup>.

In terms of percentages, at the end of the time interval of 21 days, the mean degradation of force values among the groups were as follows: Morelli 28%, Orthometric 35% and American Orthodontic 62%, Figure 2. In a previous study evaluated the American Orthodontic brand of elastomer being stretched at different speeds; the result was that there was degradation of force in all the tests<sup>1</sup>.

For the short size elastics, in the initial time the highest force was observed for American Orthodontic, followed by Orthometric and Morelli brands. The ideal orthodontic appliance must have the capacity to release constant forces during its activation. Our findings suggested that the elastomeric chains of the American Orthodontic brand (short, medium and long) did not fully satisfy this premise, because their force diminished. These results corroborated the findings of previous studies in which the elastomer of the American Orthodontic brand had the lowest degradation of force value when compared with the other brand (Unitek), however, this study had been conducted with elastomers of the chain type in gray color<sup>2</sup>.

Chain elastics may vary in thickness, elastic properties, manufacturing process, addition of pigments and in the distance between links<sup>2</sup>. These factors influence the magnitude of force released and the degree of deformation shown by these materials.

In the present study, a difference was observed between the sizes of the links of the medium size (MM 1.5mm, OM 2mm, AOM 1.5mm) and long (ML 2mm, OL 3mm, AOL 3mm) esthetic elastomers when compared with the studied commercial brands. This could explain the difference between the results obtained. There are studies in the literature that have been conducted with different methodologies, providing results of evaluating the degradation of force compared with colored and gray elastomers of the chain type<sup>15</sup>. Furthermore, there is a scarcity of studies that evaluated the degree of degradation of force undergone by esthetic elastomers of the chain type.

Because this was an *in vitro* study, it has limitations, 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<sup>6,17</sup>. In addition, previous studies have found that the use of alcohol or chlorhexidine mouthwashes in their composition considerably decreased the force produced by elastomeric chains<sup>18,19</sup>.

## CONCLUSION

It was concluded that all the elastomeric chains: short, medium and long underwent significant reduction in the quantity of force released; the American Orthodontic brand of elastomer showed the highest value of degradation in force. When analyzing the results of this research, it was concluded that the medium size esthetic elastomeric chains of the Morelli brand were the type that obtained the best results, in addition to showing a satisfactory cost-benefit to the orthodontist.

## REFERENCES

1. Martins MM, Lima TA, Soares CMO. Influência do pré-estiramento nas forças geradas por elásticos ortodônticos em cadeia. *Cienc Odontol Bras*. 2008 Jul;11(3):38-46.
2. Yagura D, Baggio PE, Carreiro LS, Takahashi R. Deformation of elastomeric chains related to the amount and time of stretching. *Dental Press J Orthod*. 2013 May-Jun;18(3):136-42. <http://dx.doi.org/10.1590/S2176-94512013000300022>. PMID:24094024.

3. Fernandes AB, Ribeiro AA, Araujo MV, Ruellas AC. Influence of exogenous pigmentation on the optical properties of orthodontic elastic ligatures. *J Appl Oral Sci.* 2012 Jul-Aug;20(4):462-6. <http://dx.doi.org/10.1590/S1678-77572012000400012>. PMID:23032209.
4. Almudhi AA, Talic NF. The effect of dietary pigmentation on the esthetic appearance of clear orthodontic elastomeric modules. *J Orthod Sci.* 2016 Apr-Jun;5(2):70-3. <http://dx.doi.org/10.4103/2278-0203.179418>. PMID:27127754.
5. Masoud AI, Tsay TP, BeGole E, Bedran-Russo AK. Force decay evaluation of thermoplastic and thermoset chains: a mechanical desing comparison. *Angle Orthod.* 2014 Nov;84(6):1026-33. <http://dx.doi.org/10.2319/010814-28.1>. PMID:24784844.
6. Quenzer JP, Lucato AS, Vedovello SAS, Valdrighi HC, Vedovello M Fo. Influence of elastic chain in the degradation of orthodontic forces: *in vitro* study. *Rev Odontol UNESP.* 2015 Dec;44(6):320-5. <http://dx.doi.org/10.1590/1807-2577.0075>.
7. Santos ACS, Tortamano A, Naccarato SRF, Dominguez-Rodriguez GC, Vigorito JW. An *in vitro* comparison of the force decay generated by different commercially available elastomeric chains and NiTi closed coil springs. *Braz Oral Res.* 2007 Mar;21(1):51-7. <http://dx.doi.org/10.1590/S1806-83242007000100009>. PMID:17384855.
8. Rembowski Casaccia G, Gomes JC, Alviano DS, de Oliveira Ruellas AC, Sant'Anna EF. Microbiological evaluation of elastomeric chains. *Angle Orthod.* 2007 Sep;77(5):890-3. <http://dx.doi.org/10.2319/091106-367>. PMID:17685763.
9. Nakhaei S, Agahi RH, Aminian A, Rezaeizadeh M. Discoloration and force degradation of orthodontic elastomeric ligatures. *Dental Press J Orthod.* 2017 Mar-Apr;22(2):45-54. <http://dx.doi.org/10.1590/2177-6709.22.2.045-054.oar>. PMID:28658355.
10. Balhoff DA, Shuldberg M, Hagan JL, Ballard RW, Armbruster PC. Force decay of elastomeric chains: a mechanical design and product comparison study. *J Orthod.* 2011 Mar;38(1):40-7. <http://dx.doi.org/10.1179/14653121141227>. PMID:21367827.
11. Weissheimer A, Locks A, Menezes LM, Borgatto AF, Derech CDA. *In vitro* evaluation of force degradation of elastomeric chains used in orthodontics. *Dental Press J Orthod.* 2013 Jan-Feb;18(1):55-62. <http://dx.doi.org/10.1590/S2176-94512013000100014>. PMID:23876950.
12. Fernandes AB, Ruellas AC, Araújo MV, Sant'Anna EF, Elias CN. Assessment of exogenous pigmentation in colourless elastic ligatures. *J Orthod.* 2014 Jun;41(2):147-51. <http://dx.doi.org/10.1179/1465313313Y.0000000083>. PMID:24521746.
13. Alexandre LP, Oliveira G Jr, Dressano D, Paranhos LR, Scanavini MA. Avaliação das propriedades mecânicas dos elásticos e cadeias elastoméricas em ortodontia. *Rev Odonto.* 2008 Jul-Dez;16(32):53-63. <http://dx.doi.org/10.15603/2176-1000/odonto.v16n32p53-63>.
14. Kochenborger C, Silva DL, Marchioro EM, Vargas DA, Hahn L. Assessment of force decay in orthodontic elastomeric chains: an *in vitro* study. *Dental Press J Orthod.* 2011 Dec;16(6):93-9. <http://dx.doi.org/10.1590/S2176-94512011000600015>.
15. Aldrees AM, Al-Foraidi AS, Murayshed MS, Almoammar KA. Color stability and force decay of clear orthodontic elastomeric chains: an *in vitro* study. *Int Orthod.* 2015 Sep;13(3):287-301. <http://dx.doi.org/10.1016/j.ortho.2015.06.003>. PMID:26277455.
16. Zaniboni E, Vedovello M Fo, Santamaria MP, Jardini MAN, Martins-Ortiz MF, Consolaro A, et al. Root morphology can be a risk fator for periodontal damage and root resorption in Orthodontic movement. *Braz J Oral Sci.* 2017;16:1-8. <http://dx.doi.org/10.20396/bjos.v16i0.8651188>.
17. Baratieri C, Mattos CT, Alves M Jr, Lau TC, Nojima LI, de Souza MM, et al. In situ evaluation of orthodontic elastomeric chains. *Braz Dent J.* 2012;23(4):394-8. <http://dx.doi.org/10.1590/S0103-64402012000400014>. PMID:23207855.

18. Omidkhoda M, Rashed R, Khodarahmi N. Evaluation of the effects of three different mouthwashes on the force decay of orthodontic chains. *Dent Res J*. 2015 Jul-Aug;12(4):348-52. <http://dx.doi.org/10.4103/1735-3327.161453>. PMID:26288625.
19. Behnaz M, Namvar F, Sohrabi S, Parishanian M. Effect of bleaching mouthwash on force decay of orthodontic elastomeric chains. *J Contemp Dent Pract*. 2018 Feb;19(2):221-5. <http://dx.doi.org/10.5005/jp-journals-10024-2240>. PMID:29422474.

### **CONFLICTS OF INTERESTS**

The authors declare no conflicts of interest.

### **\*CORRESPONDING AUTHOR**

Heloisa Cristina Valdrighi, UNIARARAS/FHO – Fundação Hermínio Ometto, Programa de Pós-graduação em Ortodontia, Av. Dr. Maximiliano Baruto, 500, Jardim Universitário, 13607-339 Araras - SP, Brasil, e-mail: [heloisavaldrighi@gmail.com](mailto:heloisavaldrighi@gmail.com)

Received: December 16, 2019

Accepted: December 27, 2019