COMPARATIVE STUDY BETWEEN DIFFERENT COLORS OF ELASTOMERIC CHAIN: AN *IN VITRO* STUDY

ESTUDO COMPARATIVO ENTRE DIFERENTES CORES DE ELÁSTICOS EM CADEIA SINTÉTICOS: *IN VITRO*

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ABSTRACT

This *in vitro* study aimed to measure the influence of colors on the force degradation of orthodontic power chain from Morelli® brand, after stretched and submerged in artificial saliva. The values were obtained after immediate measurement (time zero), 0.5, 1 and 24 hours of immersion. Twenty samples were selected at random from each of the colors of elastomeric chain. Each sample, composed of 4 links, was initially pre-stretched, with two probes, until stress. The determination of the amount of stretch of the elastics for measurement corresponds to 50% of the value of the initial pre-stretch. After the initial reading, each sample was removed from the dynamometer with the aid of a clinical tweezers and then placed on a device (template with pins) developed to accommodate the rubber bands. The sets (device + samples) were immersed in artificial saliva at 37 °C (hysteresis ± 1°). In the time intervals 30 minutes, 1 hour and 24 hours. The samples at time zero showed significant differences ($p < 0.05$) between colors, with greater variation for gray and lesser for black. All colors showed greater force degradation in the first hour.

Keywords: Color. Elasticity. Elastomers. Orthodontics.

RESUMO

Este estudo, *in vitro*, teve como meta medir a influência das cores sobre a degradação da força de elásticos ortodônticos em cadeia da marca Morelli®, após estirados e submersos em saliva artificial. Os valores foram obtidos após mensuração imediata (tempo zero), 30 minutos, 1 hora e 24 horas de submersão. Foram analisadas vinte amostras, escolhidas aleatoriamente, de cada uma das cores de elásticos em cadeia sintéticos. Cada amostra, composta por 4 elos, foi inicialmente pré-estiradas, com o auxílio de duas sondas exploradoras, até o estresse. A determinação da quantidade de estiramento dos elásticos para aferição corresponde a 50% do valor do pré-estiramento inicial. Após a leitura inicial, cada um dos elásticos foi retirado do dinamômetro com o auxílio de uma pinça clínica e em seguida assentados sobre um gabarito com pinos desenvolvidos para acomodação dos elásticos. Os conjuntos (gabarito + elásticos) foram imersos em saliva artificial a 37 °C (histerese ± 1°). Nos intervalos de tempo 30 minutos, 1 hora e 24 horas. As amostras no tempo zero apresentavam diferenças significativas (p<0,05) entre as cores, com maior variação para a cinza e menor para a cor preta. Todas as cores mostraram maior degradação de força na primeira hora.

Palavras-chave: Cor. Elasticidade. Elastômeros. Ortodontia.

INTRODUCTION

The term elastomer is used to materials which return to its original configuration after suffering from substantial deformation, they are polyurethanes amorphous polymers. Natural rubber, initially used by the ancient Incan and Mayan civilizations, was the first known elastomer (YOUNG; SANDRIK, 1979; BATY; STORIE; VON FRAUNHOFER, 1994).

The main characteristic of the elastomers is elasticity, a property that defines its effectiveness. Elasticity is defined by the geometric pattern and the existing type of molecular attraction in the elastics (ALEXANDRE *et al.*, 2008).

Orthodontic techniques have been improving and perfecting over the years, which enables better treatment conduction and increasingly satisfactory results. Elastics and elastomers have undergone a lot of modifications to improve their properties, such as the vulcanization process, allowing more elasticity and thermal stability (ALEXANDRE *et al*., 2008).

Synthetic elastics began to be produced in the 1920s, their use in orthodontics spread in the 60s. These elastomers are practical, biocompatible and efficient. The most used elastomer in orthodontics are elastomeric chains and ligatures (KOCHENBORGER *et al*., 2011).

There are several devices in today's orthodontics to promote tooth movement, the elastomers are widely used due to their low cost, easily use and their variety of colors, increasing the acceptance by the patients (NETO; CAETANO, 2004).

The clinical application of the elastics must be based in scientific evidence, according to the type of movement or required effect. For corrective orthodontic treatments, elastic chains are indispensable accessories for the professional, being considered important sources of strength in orthodontic movement, in order to gain greater control over the treatments and individualized orthodontics results (LORIATO; MACHADO; PACHECO, 2006; QUEZER *et al*., 2015).

However, synthetic elastics have a relatively weak molecular structure and cannot be considered ideal elastic materials, because when they are stretched and exposed to water, enzymes and also variations in temperature, they promote a permanent deformation. In addition, they suffer significant degradation in the amount of force released over the time of use (HUGET; PATRICK; NUNEZ, 1990; ARAUJO; URSI, 2006).

To minimize the loss of force and elasticity, especially the reduction that occurs in the first 24 hours, the elastics need to be pre-stretched after their clinical application. This procedure is a mechanical feature used to prevent a sudden decline in the elastic force after its application. The elastics may be stratched at different speeds (slow or fast) (KOVATCH; LAUTENSCHLAGER APFEL, 1976; MARTINS; LIMA; SOARES, 2008).

The stretching procedures of the elastic chains, performed through the manual method with clamp holders were effective, since the force released after the pre-stretching procedures became constant and at clinically acceptable levels for tooth movement (MARTINS; LIMA; SOARES, 2008).

Changes in the mechanical properties of the elastic chains when stretched are of great interest for the use of these materials, since they may remain for a relatively long time in the oral cavity, being extremely desirable that, during this interval, they continue to exert a clinically stable force (SOUZA *et al*., 2008).

The aim of this study is to measure, *in vitro,* the amount of force achieved by orthodontic elastic chains from Morelli® brand, medium type, and the influence of the colors on this degradation, when submerged in artificial saliva at 37±1 °C, depending on the force and the time of stretching they were submitted.

The elastomeric chains have been a popular way of force immersion in orthodontic treatments. The forces applied must be slight and continual, which justifies studying the force degradation of different colors elastics from Morelli® brand.

MATERIAL AND METHOD

Orthodontic elastics in sealed packages and within the validity period were used for the study. Twenty samples were analyzed, randomly chosen, from each of the colors of synthetic elastic chains (Table 1).

Table 1 - Commercial colors of the synthetic elastics studied

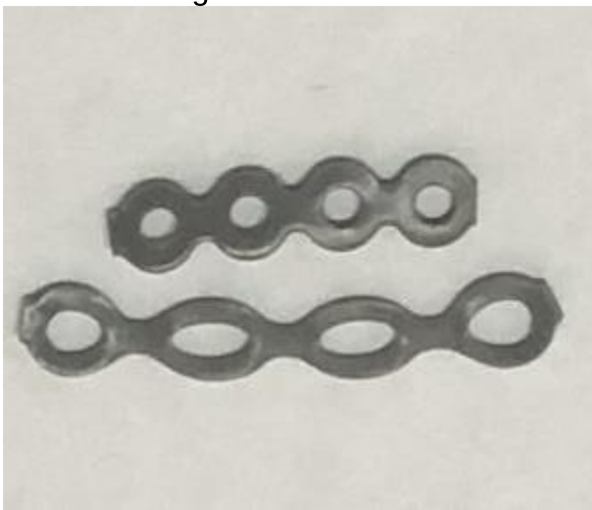
Brand Name	Type	Color	Reference Number
Morelli®	Medium	Black	60.05.211
Morelli®	Medium	Moss Green	60.05.207
Morelli®	Medium	Transparent	60.05.251
Morelli®	Medium	Gray	60.05.511

Source: the authors.

Each one of the eighty samples, composed of 4 links, was initially pre-stretched (Figure 1), using two explorer probes, until the strain. The determination of the amount of stretch of the elastics for measurement corresponds to 50% of the initial pre-stretch value.

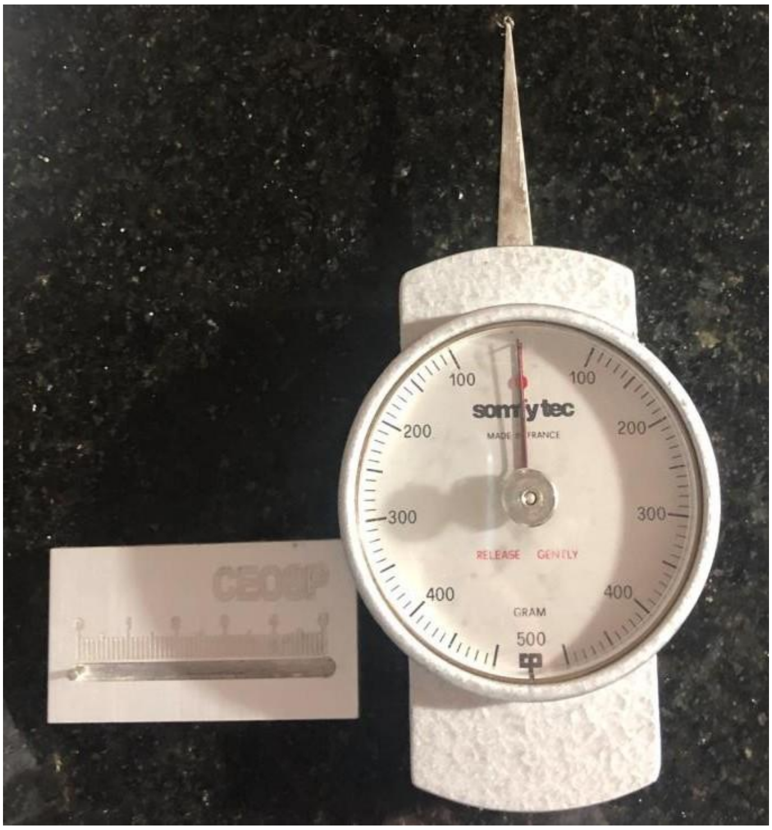
A dynamometer from Somfytec® was used to perform the readings, and also rulers created to enable force stabilization for all samples (Figure 2).

Figure 1 - Picture of a sample before and after stretching



Source: the authors.

Figure 2 - Picture of the dynamometer and the ruler used to measure the elastics force



Source: the authors.

Before the beginning of the experiment, the artificial saliva was preheated (Table 2) to 37±1 °C in a thermal cycler device in static testing.

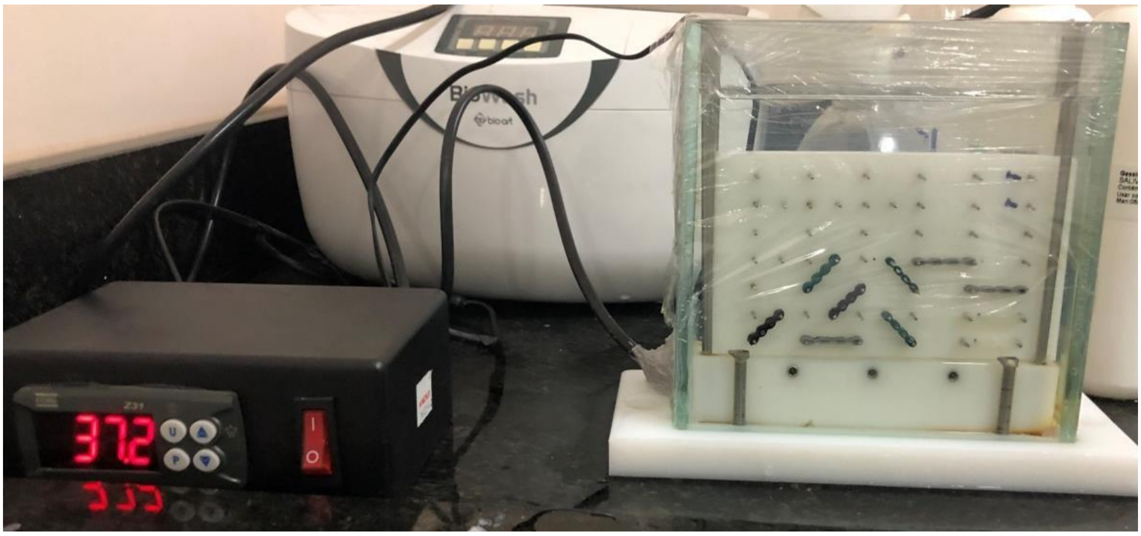
Table 2 - Artificial Saliva Formulation

Sodium Carboxymethyl Cellulose	10g
Sorbitol	30g
Potassium Chloride	1,2g
Potassium Phoshate Monobasic	342mg
Sodium Chloride	84mg
Anhydrous Calcium Chloride	146mg
Magnesium Chloridecdx	52mg
Distilled water QS	1.000ml

Source: the authors.

After the initial reading, each one of the elastics was removed from the dynamometer using a cotton forceps, and seated on an acrylic plate with pins, developed to the elastic accommodation. The sets (jigs + elastics) were immersed in artificial saliva at 37±1 °C (Figure 3). In the time intervals 30 minutes, 1 hour and 24 hours; the plate was removed from the artificial saliva and placed on absorbent paper and, with the previously mentioned forceps, the elastics were taken to the dynamometer for measurement.

Figure 3 - Picture of the sets plate-pins + elastics immersed in artificial saliva at 37±1 °C



Source: the authors.

The Shapiro-Wilk and Levene tests were used to analyze the normality and equality of the variance, respectively. Descriptive statistics with mean and respective confidence intervals were used to represent the variables analyzed or Friednmann midpoints.

The comparisons of elastomer resistance in the studied times were performed by Friedmann's two factors variance analysis. The comparison among groups at time zero was performed by the Kruskal-Wallis test and for multiple comparisons the Mann-Whitney test with the Bonferroni correction was used. All the tests were two-tailed, with 5% of significance level and the SPSS™ software version 24.0 was used.

RESULTS AND DISCUSSION

It was observed the existence of significant differences between the elastics evolution profiles over time, through the analysis of variance for repeated measures

The analysis of Table 3 demonstrated that the black elastic chain showed the highest mean in initial force (442,25g), followed by the moss green elastomeric modules (383,5g), transparent (292,75) and gray (272,75). Throughout the 24 hours of experiment the highest final mean of tension remained the same, with the black color sample (321,75g), followed by the moss green sample (245,74g), transparent (135,5g) and gray (110,5g).

Table 3 - Averages and standard errors for the tension of elastics of different colors as a function of time

Time	Black	Moss Green	Gray	Transparent
0 min.	442,25 (2,5)	383,5 (4,0)	272,75 (4,9)	292,75 (5,4)
30 min.	407 (4,7)	346,25 (3,5)	181,75 (3,3)	214,25 (4,0)
60 min.	345,5 (2,7)	282,5 (2,5)	113,25 (4,0)	150 (3,2)
24 hours	321,75 (2,4)	245,75 (3,3)	110,50 (1,5)	135,5 (3,5)

Source: the authors.

There were already significant differences ($p<0,05$) between some colors in the first force measurement (0min.), even before the action of time and the immersion in artificial saliva, with higher mean values for the black color and lower values for the gray color (Table 3). These data indicate that the group 0min is not homogeneous and suggest that the production process of the different colors may influence in the amount of force generated by the elastics. Authors such as Martins *et al*. (2006), have already suggested that the material used to color the elastics chain could promote changes in the amount of initial force and in the elastic ability of holding the original force. However, for Souza (2003), the elastics coloring does not interfere in the initial force in a significant way.

In the investigation (30min.) there was the highest degradation of force, which certifies the research of Araujo and Ursi (2006), in which the elastomeric chains underwent a significant reduction in the average amount of force in the first 30 minutes of the trial, and then the tensions were gradually released at a lower intensity.

The samples underwent significant reduction in the values of force in the first hour (60 min.), regardless of the color, proving, together with Baty, Storie and Von Fraunhofer (1994), that the elastic chains are incapable of generating continuous forces during a considerable period of time.

The values found in relation to the percentage of degradation of the forces generated in this study confirm the data found by Bishara and Andreasen (1970) who evaluated the degradation of the force released by the synthetic elastics, as a function of the stretch time to which they were submitted, and observed that the greatest reduction in the amount of load released by the elastics occurred in the first hour of the test.

In the time (24h), all the groups of colors showed significant difference in relation to the initial time. This Result agrees with the research conducted by Martins *et al*. (2006), which found statistically significant differences between the mean forces generated by elastics ligatures in 0min and 24 hours.

The results suggest that the pigments used to color the elastic ligatures may affect the generated force, because the experiment was standardize, and the different colors remained immersed in artificial saliva for the same period of time, and were stretched with standardize speed and distance.

The gray elastomeric chains showed higher percentage of reduction in the amount of generated force in 24 hours of trial (59,4%), followed by the transparent specimens (53,7%), moss green (35,9%) and black (27,2%) (Table 03 and 04).

The degradation of force analyzed agrees with the authors Baty, Storie and Von Fraunhfer (1994) who reported a variation between 50% to 75% of loss in initial force. For Andreasen and Bishara (1970), the choice of the synthetic elastic should be made obtaining an initial force about 4 times greater the force desired for the tooth, because, after the first day, there is a decrease in the force of approximately 75%. However, during orthodontic movement, very high forces are not desired.

Table 4 - Percentage of force reduction as a function of the analysis time of the current elastics

Time	Black	Moss Green	Gray	Transparent
30 min.	7,9%	9,7%	33,3%	26,8%
60 min.	21,8%	26,3%	58,4%	48,7%
24 hours	27,2%	35,9%	59,4%	53,7%

Source: the authors.

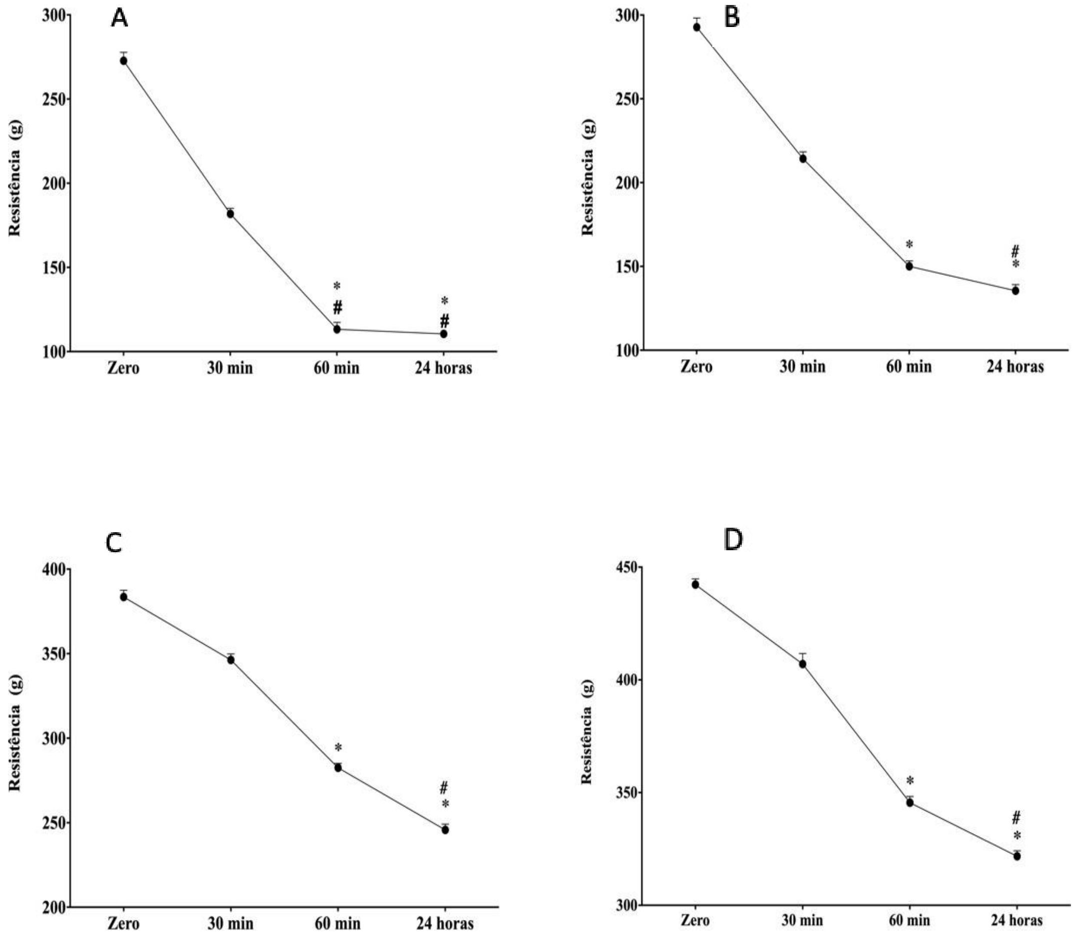
The Friedmann test (Figure 4) showed that the resistance of the gray elastomers (A) differed significantly among the analyzed times [X^2 (3) = 57,92; p < 0,001]: the *post hoc* test showed that the times of 60 minutes and 24 hours were different from the times zero e 30 minutes (p < 0,05).

For the elastomers of the colors transparent (B), green (C) and black (D) were also confirmed statistically significant differences among the measured times [X^2 (3) = 60,00; p < 0,001].

There were no significant differences in force degradation at the time (30 min.), probably because this study was conducted as an *in vitro condition* and the effects of the oral environment and its variables were overlooked, what agrees with the authors Mirhashemi *et al*. (2012).

The colors that presented the worst results of force degradation were the colors transparent (53,7%) and gray (59,4%). These data confirm those found in the literature, by authors such as Matta (1996) and Martins *et al*. (2006), which justify the best performance of all the other colors in relation to gray, due to pigments and material that make these elastomers transparent, except for gray, which its original form is presented in this color.

Figure 4 - Distribution by Friedmann ranks, relative to the elastomeric resistance of the colors gray (A), transparent (B), green (C) and black (D) in the times zero, 30 minutes, 60 minutes e 24 hours



Notes: * Statistically significant difference in relation to time zero (p < 0,05); # Statistically significant difference in relation to 30 minutes (p < 0,05).
Source: the authors.

CONCLUSIONS

The characteristics of degradation of force related to the different colors, of the elastomeric chains, differ significantly in force.

There are already statistically significant differences in time zero, among some colors, the highest mean values are related to the black color and the lowest to the gray color.

In relation to the time, the greatest amount of degradation was in the first hour. The development of the degradation was also different according to the color, indicating that the pigment affects the amount of initial force and the way the force reduces.

Clinically this information may base the operator on indicating colors according to the type of movement, need of force, or interval between appointments.

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