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Analysis in vitro of strength degradation comparing latex and non-latex elastics

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Aim: This study was conducted in order to evaluate and compare the behavior of latex and non-latex elastics, as the loss of strength over time *in vitro*. **Methods:** The study evaluated 15 of each elastic material for the pre-selected times: 0, 1, 3, 12 and 24 hours. The rubber bands were transferred to the testing machine (EMIC DL-500 MF). The force values were recorded after stretching the elastic to a length of 25mm. Independent t-test was applied. Analysis of variance (ANOVA) was used to check the variation of the forces generated between those determined times. To identify between which times the difference was present, Tukey post-hoc test was accomplished. **Results:** As regards the initial forces (zero time), the values of force for non-latex elastic were slightly higher than the latex elastic. In subsequent times, the forces generated by the latex elastic showed higher values. Regarding the material degradation, at the end of 24 hours the highest percentage was observed for non-latex elastic. **Conclusion:** The latex elastic had a more stable behavior during the studied period compared with non-latex. Thus, it is suggested that the non-latex elastics should be changed more frequently and that larger initial forces must be applied than the latex elastics.

Keywords: Elastomers. Tensile strenght. Latex. Silicone elastomers.

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Introduction

Intermaxillary elastics have been prescribed for interarch discrepancies treatment[1-3] since the 1890s, when they were first used by Calvin S. Case and Henry A. Baker[1]. Elastics present many advantages such as low cost[4], biocompatibility, easy installation and removal by patients[2,5-9]. However, when the elastics are exposed to the oral environment they absorb water and saliva, which can promote the breakdown of their internal connections, leading to loss of properties and permanent deformation.

Most of the orthodontic elastics on the market are latex elastics[10]. But since the early 1990s, non-latex orthodontic elastics have been offered to the orthodontic treatment for latex-sensitive patients[10,11]. But is the performance of these non-latex elastics similar than the obtained by the latex elastics?

In order to answer this question, it is imperative that controlled laboratory studies be carried out on a consistent sample with only one elastic size from a single manufacturer distended at the same distance in a neutral environment in order to remove all possible variables so that only the intrinsic behavior of materials (latex and non-latex) are tested and compared. All the studies we found in the literature used different sizes, manufacturers or environment[3,8,10-16].

The purpose of this study was to evaluate the force degradation in a controlled *in vitro* experiment where the intraoral latex and non-latex elastics were exchanged at different times over a period of 24 hours.

Materials and methods

Intraoral latex and non-latex elastics (American Orthodontics, Sheboygan, EUA), at a 3/16-inch size were tested. They were within their expiration dates and stored in sealed plastic packages in a cool and dark environment.

Sample size calculation was performed in a pilot study (n=5) and the values in gram-force (gf) generated by these elastics were used. The sample size was determined to be 12 elastics, with 90% of test power, 5% of alpha level, 7.42 of standard deviation of difference and 10 of average difference. To avoid missing data, it was determined to select 15 elastics for the study.

Fifteen elastics[7,8,12-14,17,18] were removed from the same package and placed between stainless steel pins on an acrylic board at a 25 mm distance for each period of time, 0, 1, 3, 12 and 24 hours, totalizing 75 elastics (Figure 1). This distance value was proposed because it is the average value of clinical use during talking and chewing activities[2,10,11,14,19]. The set remained stretched for the determined periods in a tank with distilled water at 37^{0}C. After each specific time one by one of the fifteen elastics were transferred to the setup extension testing mounted in the universal Emic DL500 MF testing machine in cotton tweezers. The whole process was conducted by the same operator.

The cross-head speed of the testing machine was 30 mm/min as recommended by Fernandes et al.[11] and Lopez et al.[12] and the calibrated load cell capacity was 2,0Kgf.

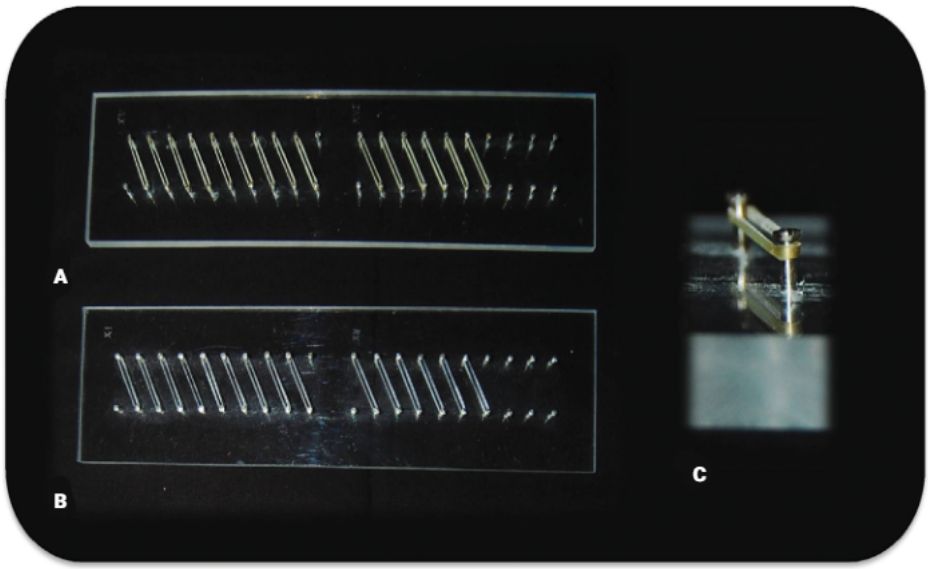


Figure 1. Stainless steel pins on an acrylic board at a 25 mm distance. A - Latex elastics. B - Non-latex elastics. C - Approximate view of the elastic between the pins.

Extention force magnitudes of the elastics were recorded immediately after they were removed from the steel pins and stretched at a distance of 25mm. All the procedures were performed by the same examiner.

Descriptive statistics were used as mean, and standard deviation referred to the elastic force values measured in gram-force (gF) and organized for the amounts of liberated force, observed at different time intervals.

The Shapiro-Wilk test was used to evaluate if the data presented a normal distribution. Since all p values were higher than the level of significance adopted (0.05), parametric tests were accomplished.

The collected data were analyzed by Independent t test in order to compare the different types of elastic at each time and by analysis of variance (One way ANOVA) to check the variation of the forces generated at all times considered. Tukey post hoc test was applied to identify which pairs of the force remained significantly different during the study (SPSS software version 20.0; IBM, Armonk, NY). A P value less than 0.05 was considered statistically significant.

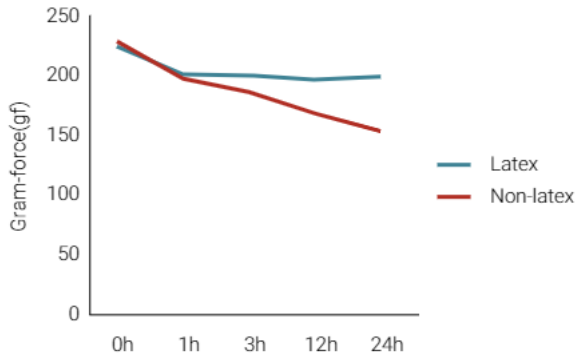
Results

Although in zero time (control group), non-latex elastics have generated higher values than latex elastics when stretched to 25mm, in all the other times the latex strength force values were superior to non-latex elastics (Table 1). When independent t test was applied, significant difference between latex and non-latex elastics was noticed in 3, 12 and 24 hours (Table 1).

Table 1. Mean and standard deviation of the forces (gf) generated by intermaxillary orthodontic latex and non-latex elastics, according time of experiment.

Type of elastic	Time				
	0h	1h	3h	12h	24h
Latex	224.58 ± 9.10^{a}	201.45 ± 4.88^{b}	200.79 ± 11.84^{b}	197.26 ± 9.19^{b}	199.60 ± 11.39^{b}
Non-latex	228.31 ± 9.80^{a}	197.71 ± 9.14^{b}	186.69 ± 9.41^{c}	168.63 ± 12.28^{d}	153.97 ± 5.77^{e}
Independent t test	p = 0.2890	p = 0.1770	p = 0.0012	p < 0.001	p < 0.001

Values with different superscript letters (a, b, c, d, e) indicate significant differences, according to time (Tukey post-hoc test).



	0-1h	1-3h	3-12h	12-24h	0-24h
Latex	10,29%	0,32%	1,75%	-1,18%	11,12%
Non-latex	13,40%	5,57%	9,67%	8,69%	32,56%

Figure 2. Latex and synthetic elastics behavior and force degradation percentages, among 24 hours.

Analysis of variance (One-way ANOVA) detected significant difference when comparing the strength force values of latex and non-latex elastics between all times studied ($p<0.001$). To identify between which times the difference was present, Tukey post-hoc test was accomplished. Significant difference was observed between the latex means forces between zero time and 1, 3, 12 and 24 hours. For the non-latex elastics significant difference was noticed between all times (Table 1).

Force degradation percentages for latex and non-latex elastics, between all the settled times are shown in Figure 2. The highest percentage difference generated of force decay occurred between zero time and 1 hour. Over the 24 hours of the study, the biggest difference between the degradation percentage of the force was observed for non-latex elastics.

Discussion

The literature has shown several studies evaluating the force released by the intermaxillary elastics conducted in laboratorial environment[3,5,8,10-16,19]. Some have evaluated the

differences between the forces released by latex and non-latex elastics[7,12-14,19]. However, most of them include several variables such as different trademarks[8,11], different sizes of elastics[3,11], static and dynamic study[7], different pH[10,14-16,19], leading to confuse the interpretation of the results. The present study sought to eliminate these variables, focusing only on the difference in their composition.

Latex elastics showed a notable and statistical significant drop off the forces until the first hour, as shown in table 1 and figure 2. Similar to the present study, Bishara and Andreasen[19] found a 10% of difference in the first hour. After 24 hours, the difference was a little higher in their study (17,2%), than it was in the present one (11,12%) (Figure 2). Fernandes et al.[11] detected greater decrease in the percentage of force released after 1 hour, ranging from 9.24% to 20.72%, and after 24 hours the percentage varied between 10.60% and 31.17%. Moreover, Gioka et al.[20] found that the most significant decrease in the force released by latex elastics occurred between 3 and 5 hours and within 24 hours the reduction in the amount of force released was between 20% and 25%, higher than found in this study.

Non-latex elastics also showed a large decrease in the generated force values between 0 and 1 hour, as shown in table 1 and figure 2. However, unlike the latex elastics, the amount of force decrease continued occurring in an expressive way between all the other times observed with statistical difference between all times. At the end of 24 hours, the percentage of degradation forces by the non-latex elastics was 32,56%, and the largest percentage difference in the force generated was seen between 0 and 1 hour, 13.40% (Figure 2). Kersey et al.[7], studying intermaxillary non-latex elastic of 1/4-inch size, in the laboratory, noted decrease in the forces generated values between 20% to 30% in the first hour and 40% to 60% after 24 hours.

When the percentage difference was compared between the forces generated by the latex and non-latex orthodontic elastics, the non-latex elastics obtained greater percentage of force decay between all time (Figure 2). At the end of 24 hours of the experiment, 32.56% of percentage difference was observed for non-latex elastics, while the latex elastics obtained percentage difference of 11.12%, in the same period. These findings are in agreement with the work of Aljhani and Aldrees[5] that observed the effect of static and dynamic orthodontic latex and non-latex elastic tests, and concluded that, in all six groups, the three latex groups were statistically superior to non-latex in retaining force. Non-latex rubber bands showed greater degree of force decay, requiring more frequent changes. Likewise, Lopez et al.[12] study showed a higher strength loss for non-latex elastic when compared to latex.

The present study confirmed the work of Kersey et al.[7], comparing latex and non-latex elastics from a single manufacturer, American Orthodontics, same manufacturer used in this study and found that the latex elastic remained higher strength levels over 24 hours, retaining 83% of initial force compared to 69% retained by non-latex elastic. The results showed continuous loss of elastic force of the non-latex presenting statistically difference from the latex elastics after 8 hours of the experiment. Hwang and Cha[13] found that after 24 hours, latex elastics showed strength loss from 23% to 28%, while non-latex elastics achieved 27%.

Comparing the force generated values between latex and non-latex elastics, non-latex elastics presented in the first hour, greater value of the force released than that obtained by the latex elastics. However, during the remaining time (1, 3, 12 and 24 hours), the latex elastic had higher force released values when compared to non-latex elastics, as seen in Figure 2.

It is necessary to understand the behavior of non-latex elastics because they are an alternative for patients with latex sensitivity. The findings of this study are important in order to establish the best way to use them. As the behavior was different at all tested times and having these non-latex elastics losing greater amount of force over time, it is suggested that the non-latex elastics should be changed more frequently and that larger initial forces must be applied than the latex elastics.

It is important to emphasize that this study evaluated the difference in composition between elastics. Thus, only one trademark and one size were evaluated for a better interpretation of the results. Other brands and diameters may behave differently and must be tested.

In conclusion, latex and non-latex elastics had drops in force values generated in 24 hours, with different behavior and values. Both elastics presented a sharp fall on the first hour, however, latex elastics had a relatively force stability up to 24 hours and non-latex elastics continued to lose large amounts of strength throughout the same period.

Thus, it is suggested that the non-latex elastics should be changed more frequently and that larger initial forces must be applied than the latex elastics.

Competing interests

The authors declare that they have no competing interests.

Authors'contributions

AM, MG and DN designed the study. DN collected the data. DN and AM interpreted the data. DN, MM, AM, MG and CQ drafted the article. AM, MG, DN, MM and CQ read and approved the final manuscript.

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