

Degradation and deformation of latex and non-latex orthodontic elastics

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Background: Intermaxillary elastics are widely used in corrective orthodontic treatment particularly for the interdigitation of buccal segments and the correction of the midline. However, latex has been known to cause allergy, which may restrict elastic use. As alternative materials, non-latex elastics are available. However, clinicians must be aware of their mechanical properties, especially those of deformation and force degradation that affect these materials over time.

Objectives: The aim of this study was to compare force degradation and deformation of 3/16" non-latex and latex elastics supplied by several manufacturers.

Materials and methods: Special acrylic plates were fabricated to incorporate orthodontic brackets to which elastics were attached and stretched to a distance of approximately 20 mm. The internal diameter and force magnitude of each elastic was measured at time intervals of 0, 24, 72 and 504 hours. The samples were stored in artificial saliva at room temperature during the entire experimental period.

Results: Latex elastics showed smaller and more uniform deformation than the non-latex elastics. The non-latex elastics showed greater degradation at all time intervals ($p < 0.001$). The Morelli brand delivered greater force than other brands for both the latex and non-latex elastics at all time intervals ($p < 0.05$). The G&H latex elastics showed greater force degradation in comparison with the other brands ($p < 0.05$). The evaluation of the Dentaurum and Orthopli non-latex elastics showed greater degradation ($p < 0.05$).

Conclusions: The non-latex elastics showed greater force degradation than the latex elastics. Of the latex elastics, G&H showed greater force degradation, and for the non-latex elastics, those made by Dentaurum and Orthopli degraded most.

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Introduction

Elastics have been clinically used long before orthodontics became a dental specialty.^{1,2} Intermaxillary elastics are commonly applied for the correction of a midline, tooth interdigitation, anchorage, and the correction of Class II or Class III malocclusions.³ The elastics may be made of natural latex or alternative materials such as silicone or synthetic rubber (non-latex). Comparative studies of force degradation between latex and non-latex orthodontic elastics have been reported, but there is no unanimous agreement

concerning the results. However, when compared with polyurethane-based synthetic elastics, the force delivered by elastics made of natural rubber was considered higher.^{4,5}

The wide application of intermaxillary elastics in orthodontics is due to their high resilience, versatility and low cost. Furthermore, with instruction, the patient can easily manage the elastics as well as perform appropriate oral hygiene.

Recently, hypersensitivity reactions to latex have caused concern^{6,7} and orthodontic latex elastics have

been included in the materials that may trigger a patient allergic response.⁸ Performing appropriate anamnesis is important to check for the presence of risk factors related to a family history, spina bifida, and professional activity, among others.⁹ It is also worth highlighting a history of food allergy, especially the intake of certain fruits.^{9,10} Due to a preoccupation related to the biocompatibility of dental materials, the demand for non-latex products has increased.

Research of latex and non-latex elastics has been conducted^{11,12-16} to compare the composition and force degradation between the various brands. It has been demonstrated that non-latex elastics showed greater force loss over time compared with latex elastics,^{13,16} but further research directed at the testing of different commercial brands is required.¹⁴

The aim of the present study was to compare force degradation and deformation of $\frac{3}{16}$ " latex and non-latex elastics manufactured by Dentaurum, Orthopli, Morelli and G&H.

Materials and methods

The samples of the study comprised $\frac{3}{16}$ " medium force orthodontic non-latex and latex elastics provided by Dentaurum (Insprigen, BW, Germany), Orthopli (PA, USA), Morelli (SP, Brazil) and G&H (IN, USA). Eighty-eight test specimens were prepared and divided into two groups (latex and non-latex elastics) and four subgroups (commercial brands). Before experimentation, the elastics were sealed in commercial packaging and stored in an environment protected from light and humidity.

Special acrylic plates that contained embedded orthodontic brackets were fabricated. The elastics were attached to the brackets over their tie-wings and

stretched to a distance of approximately 20 mm.

The distance was chosen as similar to the stretch required in the application of Class II or III intermaxillary elastics. The elastics were kept stretched during the entire experimental period and were removed only to perform measurements. The internal diameter of each elastic was measured using a precision caliper (Digimess, SP, Brazil) and the force magnitude was measured by a tensiometer (Zeusan, SP, Brazil) at time intervals of 0, 24, 72 and 504 hours. The total time of the test was based on the usual time interval between each patient consultation of approximately every three weeks. Gram-force was measured because it is customarily used in orthodontics. The samples were stored in plastic receptacles containing artificial saliva produced by the Biochemical Laboratory of the School of Pharmaceutical Sciences of Ribeirão Preto, USP. The samples were stored at room temperature during the entire evaluation period.

Statistical analysis

The data were analysed using the GraphPad Prism 5 statistical software (GraphPad Software Inc., CA, USA). The means and standard deviation were calculated for each elastic and time interval. Comparisons of the diameter and force between the latex and non-latex elastics at the different experimental time intervals were performed by the two-way repeated-measures analysis of variance (ANOVA) and a Bonferroni's post-test. The level of significance adopted was 5%.

Results

Figure 1 and Table I show that for the Dentaurum, Morelli and G&H brands, the non-latex elastics delivered

Table I. Mean and standard deviation of the remaining force of the elastic latex and non-latex in evaluated periods.

Brand	Material	Time (hours)			
		0	24	72	504
Dentaurum	Latex	146,0 (6,99)	131,0 (6,99)	124,5 (5,50)	120,5 (5,50)
	Non-latex	175,0 (8,49)	125,0 (4,71)	111,0 (3,16)	93,5 (4,74)
G&H	Latex	126,8 (4,04)	101,4 (4,52)	98,18 (4,04)	95,0 (3,87)
	Non-latex	138,2 (6,03)	107,7 (4,10)	99,55 (4,15)	85,91 (3,75)
Morelli	Latex	210,9 (10,44)	183,2 (7,83)	180,9 (6,25)	174,1 (7,00)
	Non-latex	262,7 (9,04)	206,8 (6,03)	199,1 (5,39)	169,1 (3,01)
Orthopli	Latex	134,5 (10,91)	119,5 (8,64)	115,5 (6,85)	112,0 (5,37)
	Non-latex	127,2 (5,14)	94,5 (4,15)	83,1 (3,37)	65,4 (4,15)

* Values in gf

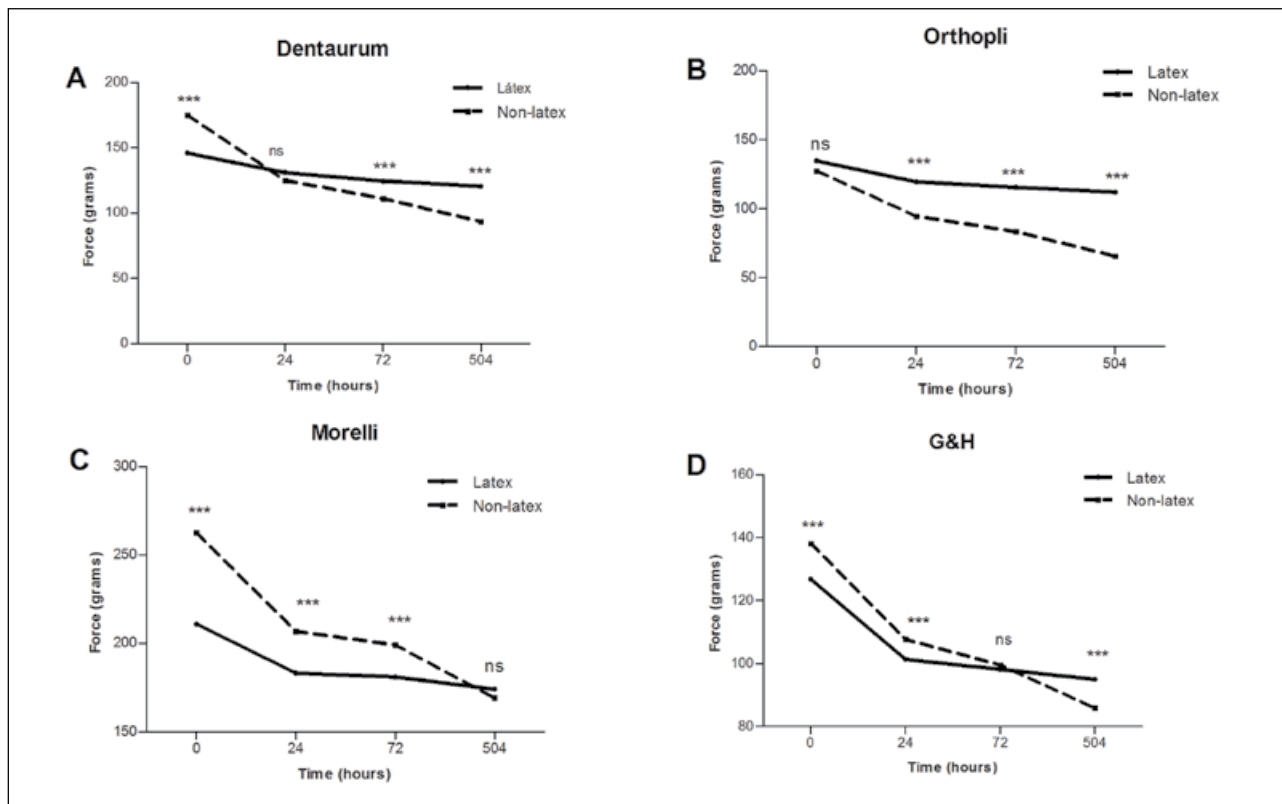


Figure 1. Comparison between the means of forces of the elastic latex and non-latex: Dentaurum, Orthopli, Morelli and G&H, in all experimental periods. *** $p < 0.001$; ns = not significant.

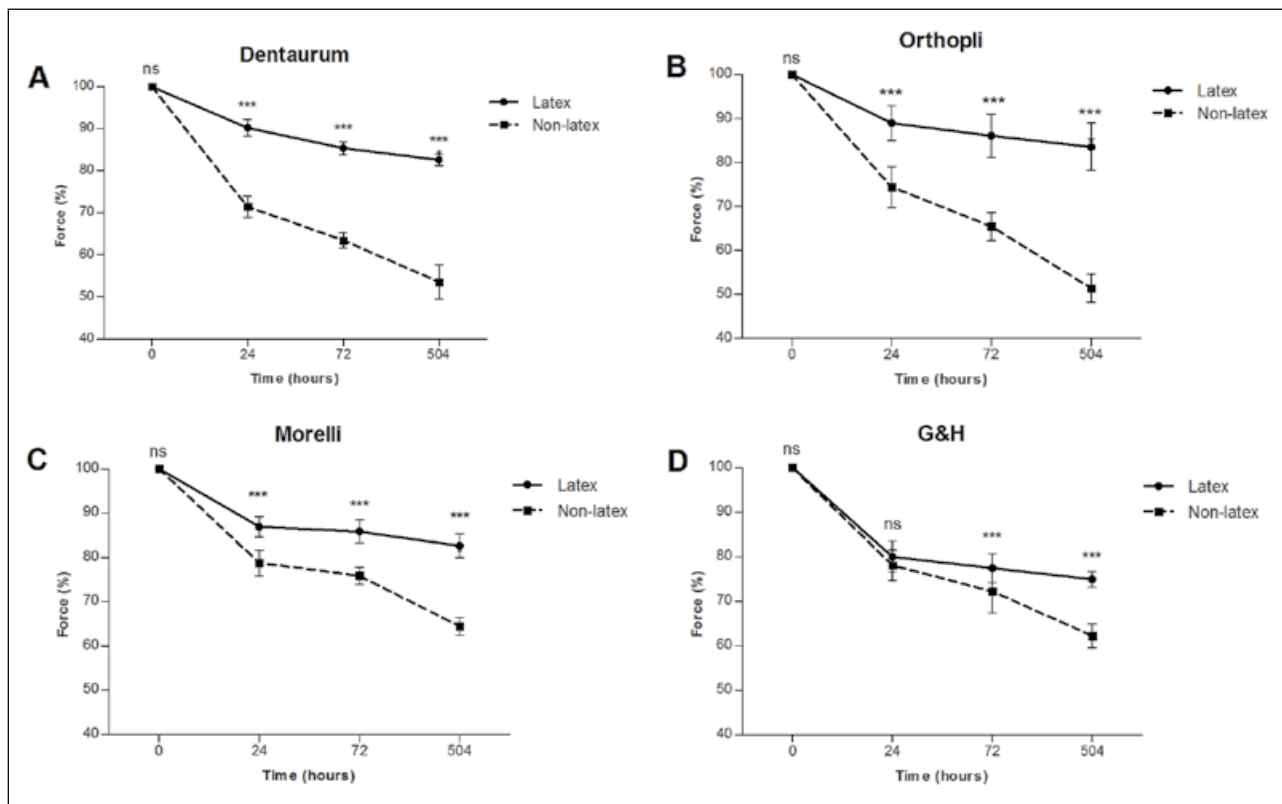


Figure 2. Comparison between the means of force degradation (%) of the elastic latex and non-latex: Dentaurum, Orthopli, Morelli and G&H, in all experimental periods. *** $p < 0.001$; ns = not significant.

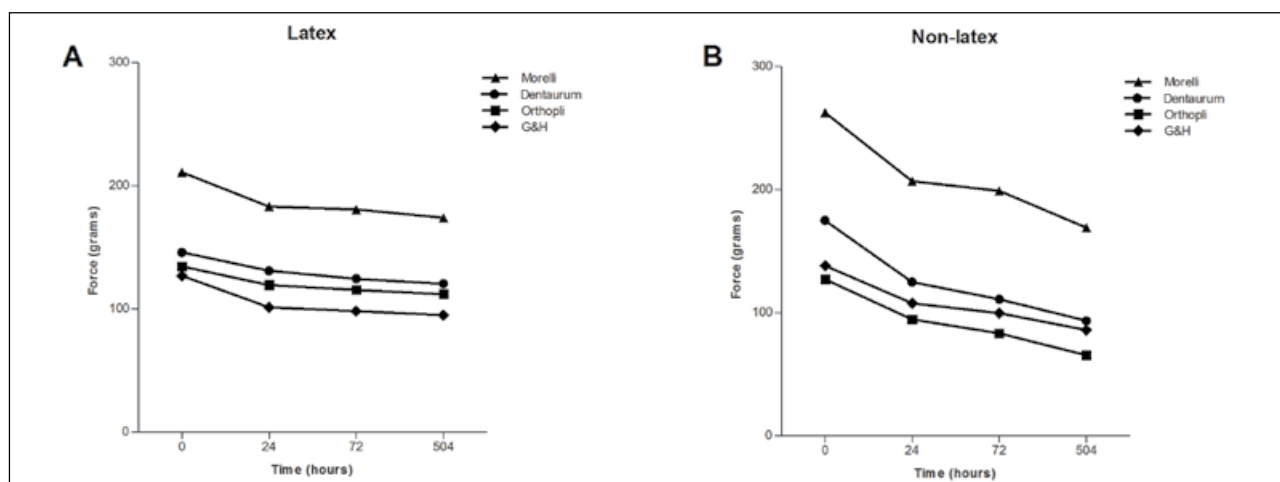


Figure 3. Comparison of the force of the latex (A) and the non-latex (B) elastics: Dentaureum, Orthopli, Morelli and G&H, in all experimental periods. $p < 0.05$.

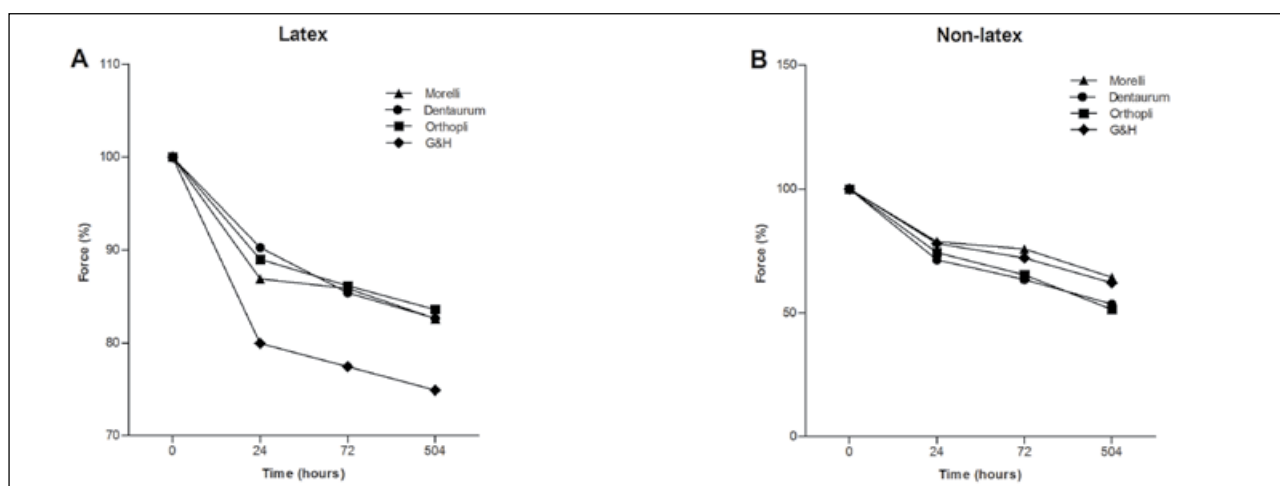


Figure 4. Comparison of the force degradation (%) of the latex (A) and the non-latex (B) elastics: Dentaureum, Orthopli, Morelli and G&H, in all experimental periods. $p < 0.05$.

greater initial force than the latex elastics ($p < 0.001$). After 24 hours, the Morelli and G&H non-latex elastics delivered greater force than the latex elastics, but the reverse was found for the Orthopli elastics ($p < 0.001$). The Dentaureum and Orthopli latex elastics showed higher values than the non-latex elastics after 72 hours and 504 hours ($p < 0.001$), while the G&H latex elastics showed higher values only after 504 hours ($p < 0.001$). The Morelli latex elastics delivered lower force values at all experimental time intervals ($p < 0.001$), except after 504 hours when a statistically significant difference was found ($p < 0.001$).

The force degradation of non-latex elastics was statistically and significantly higher at all time intervals ($p < 0.001$), except for the G&H elastics after 24 hours ($p < 0.05$). Both the latex and non-latex elastics showed greater force degradation at time intervals of

24 and 504 hours and less variation at time intervals of 24 and 72 hours (Figure 2, Table II).

The Morelli latex elastics delivered greater force, ahead of Dentaureum, Orthopli and G&H elastics. The Morelli non-latex elastics delivered greater force, followed by Dentaureum, G&H and Orthopli elastics (Figure 3, $p < 0.05$).

Presented in Figure 4, no difference in force degradation was found for Dentaureum, Morelli and Orthopli latex elastics ($p < 0.05$). The G&H elastics showed greater force degradation in comparison with the other brands ($p < 0.05$). The Morelli and G&H non-latex elastics did not show any inter-brand difference ($p < 0.05$) and their force degradation was lower than the Dentaureum and Orthopli elastics ($p < 0.05$) without any inter-brand difference.

Tables III and IV show the mean and standard deviation of the internal elastic diameters. It was found that, at commencement, there was no statistically significant difference ($p < 0.001$) between the diameter of latex and non-latex elastics for any of the brands tested (Figure 5). At all other experimental time intervals, the non-latex elastics showed higher deformation values ($p < 0.001$). This behaviour was also found with

regard to the percentage of internal diameter (Figure 6) and only the G&H elastic group showed a statistically significant difference after 24 hours ($p < 0.001$).

As shown in Figure 7A, no difference in diameter was found for the Dentaurum and G&H latex elastics at the different experimental time intervals ($p < 0.05$). The Morelli elastics showed greater internal diameter than the Dentaurum and Orthopli elastics ($p < 0.05$).

Table II. Mean and standard deviation of the remaining force percentage of the elastic latex and non-latex in evaluated periods.

Brand	Material	Time (hours)			
		0	24	72	504
Dentaurum	Latex	100,0 (0,00)	90,2 (6,32)	85,4 (4,81)	82,6 (4,41)
	Non-latex	100,0 (0,00)	71,4 (3,50)	63,4 (1,85)	53,5 (4,10)
G&H	Latex	100,0 (0,00)	79,9 (3,51)	77,4 (3,27)	74,9 (1,81)
	Non-latex	100,0 (0,00)	78,0 (3,39)	72,1 (4,90)	62,2 (2,66)
Morelli	Latex	100,0 (0,00)	86,9 (2,24)	85,8 (2,56)	82,6 (2,71)
	Non-latex	100,0 (0,00)	78,7 (2,90)	75,8 (1,97)	64,4 (2,01)
Orthopli	Latex	100,0 (0,00)	88,9 (3,92)	86,1 (4,89)	83,5 (5,37)
	Non-latex	100,0 (0,00)	74,4 (4,64)	65,4 (3,17)	51,4 (3,19)

* Values in %

Table III. Mean and standard deviation of the internal diameter of the elastic latex and non-latex in evaluated periods.

Brand	Material	Time (hours)			
		0	24	72	504
Dentaurum	Latex	4,75 (0,09)	5,01 (0,10)	5,22 (0,10)	5,37 (0,11)
	Non-latex	4,79 (0,06)	5,96 (0,07)	6,46 (0,14)	8,43 (0,45)
G&H	Latex	4,79 (0,07)	5,10 (0,08)	5,25 (0,12)	5,48 (0,13)
	Non-latex	4,78 (0,05)	5,45 (0,11)	5,86 (0,12)	6,80 (0,29)
Morelli	Latex	4,89 (0,09)	5,20 (0,12)	5,35 (0,13)	5,60 (0,10)
	Non-latex	4,78 (0,05)	5,71 (0,12)	5,94 (0,22)	6,93 (0,27)
Orthopli	Latex	4,72 (0,07)	4,88 (0,10)	5,07 (0,13)	5,27 (0,10)
	Non-latex	4,77 (0,06)	5,94 (0,12)	6,40 (0,16)	8,36 (0,36)

* Values in mm

Table IV. Mean and standard deviation of the internal diameter percentage of the elastic latex and non-latex in evaluated periods.

Brand	Material	Time (hours)			
		0	24	72	504
Dentaurum	Latex	100,0 (0,00)	105,4 (1,44)	110,0 (2,21)	112,9 (2,15)
	Non-latex	100,0 (0,00)	124,3 (2,02)	134,8 (3,59)	175,7 (8,58)
G&H	Latex	100,0 (0,00)	106,4 (1,11)	109,7 (2,27)	114,5 (3,11)
	Non-latex	100,0 (0,00)	114,1 (2,68)	122,2 (3,22)	141,2 (5,15)
Morelli	Latex	100,0 (0,00)	106,2 (1,91)	109,6 (2,48)	114,4 (1,77)
	Non-latex	100,0 (0,00)	120,0 (3,04)	125,0 (3,98)	144,2 (5,04)
Orthopli	Latex	100,0 (0,00)	103,2 (1,57)	107,5 (2,05)	112,0 (1,33)
	Non-latex	100,0 (0,00)	124,3 (2,90)	133,9 (4,58)	175,0 (8,15)

* Values in %

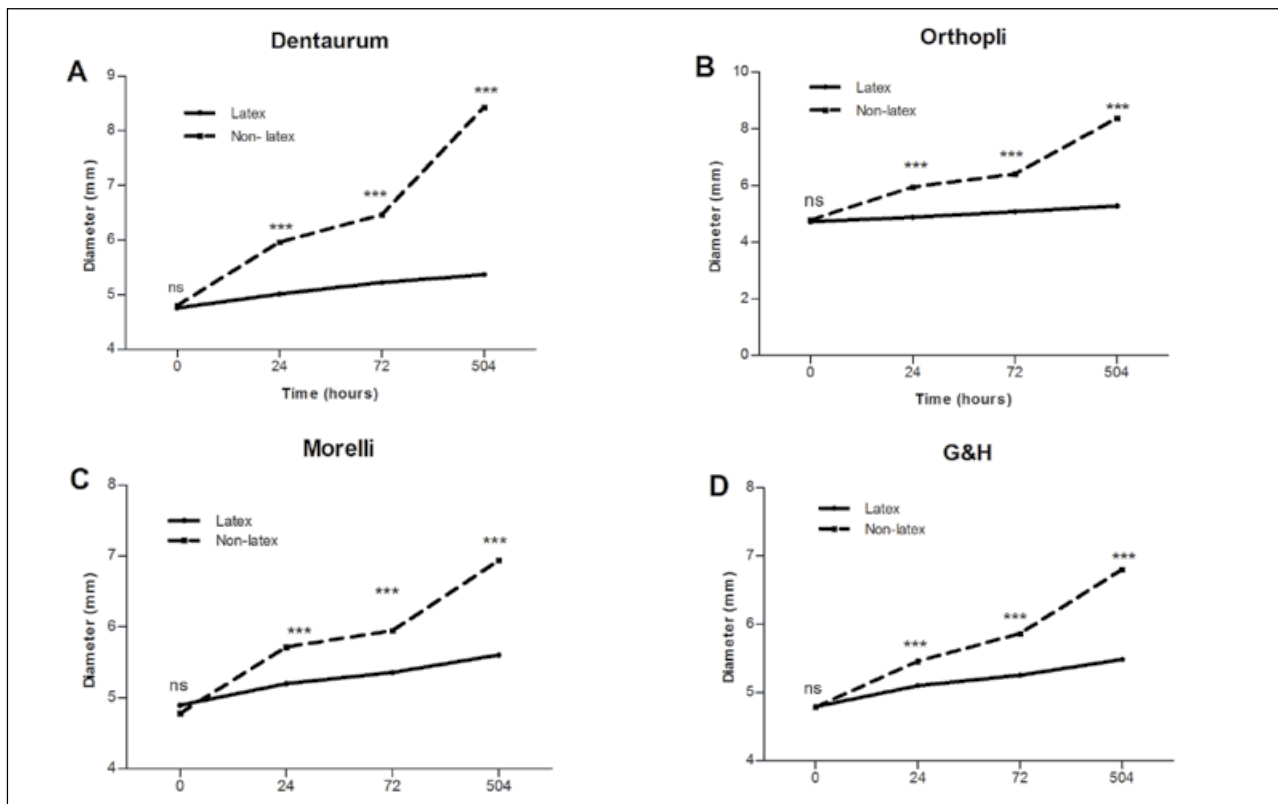


Figure 5. Comparison between the means of internal diameter of the elastic latex and non-latex: Dentaurum, Orthopli, Morelli and G&H, in all experimental periods. *** $p < 0.001$; ns = not significant.

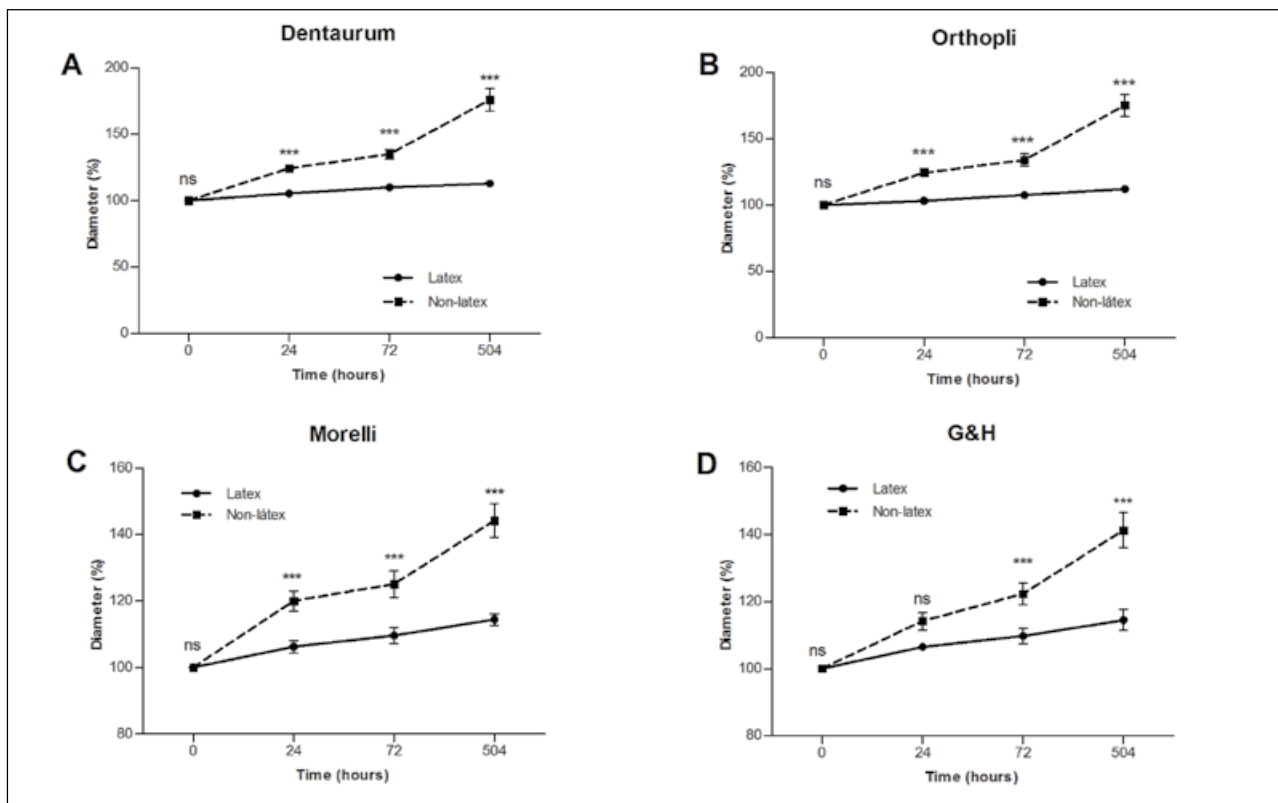


Figure 6. Comparison between the means of internal diameter deformation (%) of the elastic latex and non-latex: Dentaurum, Orthopli, Morelli and G&H, in all experimental periods. *** $p < 0.001$; ns = not significant.

The Morelli and G&H elastics revealed no differences ($p < 0.05$), except after 504 hours, at which time the diameter of the Morelli elastics was greater ($p < 0.05$). The diameter of the G&H elastics was greater than the Orthopli elastics ($p < 0.05$), except at the starting time interval ($p < 0.05$).

The Dentaureum and Orthopli non-latex elastics (Figure 7B) did not exhibit any inter-brand difference ($p < 0.05$) and showed greater diameter than the Morelli and G&H elastics ($p < 0.05$), except at the starting time interval ($p < 0.05$). The Morelli and G&H elastics did not show any inter-brand differences ($p < 0.05$), except after 24 hours, at which time the Morelli elastics showed a greater diameter ($p < 0.05$).

As presented in Figure 8, no difference in the percentage increase in diameter between the latex Dentaureum,

Morelli and G&H elastics was found ($p < 0.05$) and a higher percentage increase in diameter was shown compared with the Orthopli elastics ($p < 0.05$), except at the starting time interval ($p < 0.05$). At the 504 hour time interval the percentage in diameter of the Orthopli elastic was similar to the Dentaureum elastics ($p < 0.05$).

No difference in the percentage increase in diameter of the Dentaureum and Orthopli non-latex elastics was found ($p < 0.05$) and a higher percentage of diameter increase was shown compared with the Morelli and G&H brands ($p < 0.05$) at the 504 hour time interval. The Dentaureum and Orthopli elastics showed a higher percentage of diameter increase than the G&H elastics at the 24 hour time interval ($p < 0.05$). No difference was found between the Morelli and G&H elastics ($p < 0.05$) at the same time interval.

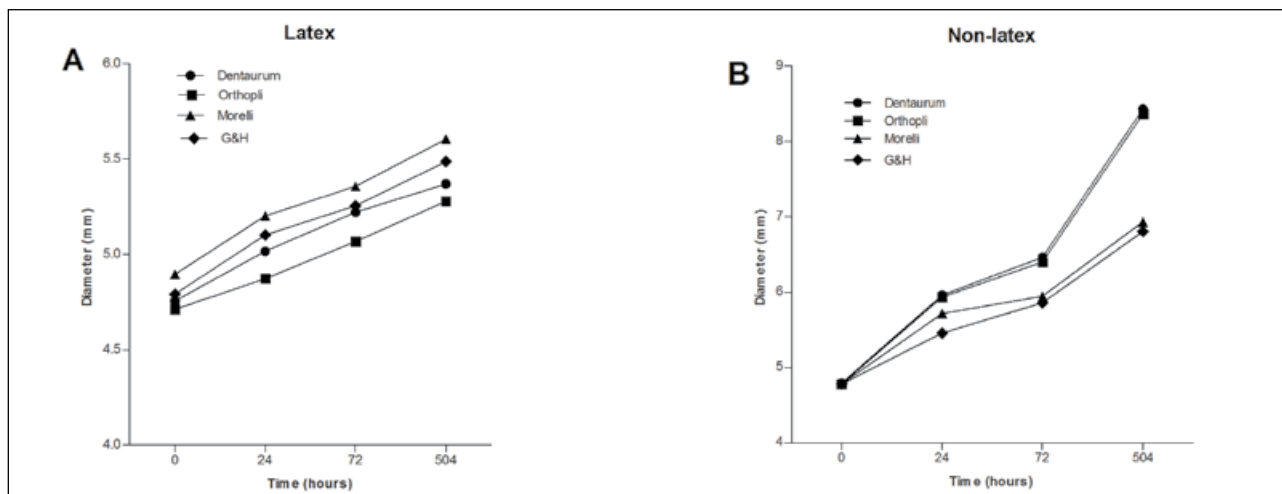


Figure 7. Comparison of the internal diameter of the latex (A) and the non-latex (B) elastics: Dentaureum, Orthopli, Morelli and G&H, in all experimental periods. $p < 0.05$.

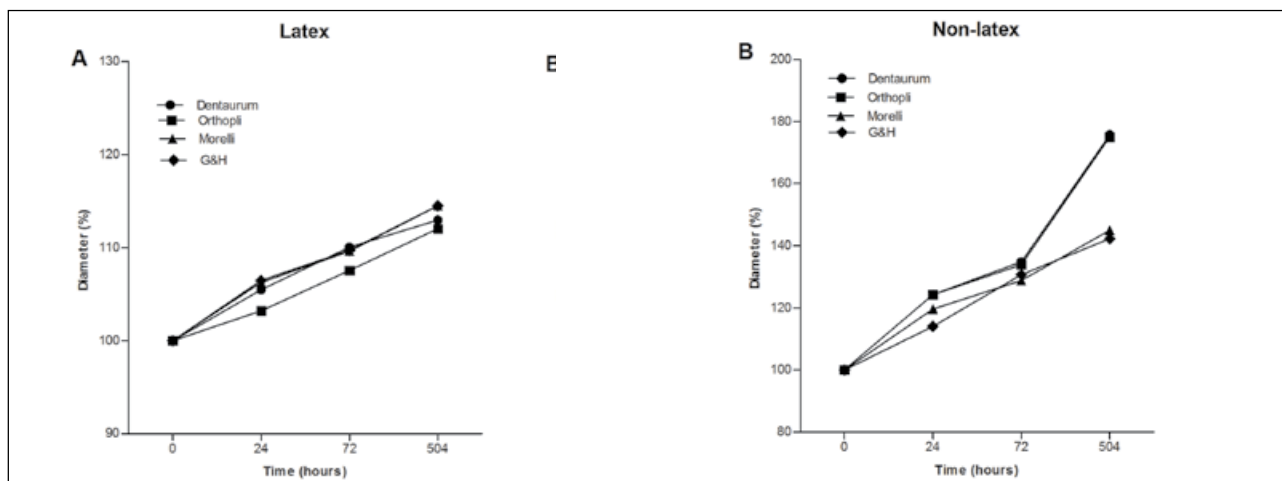


Figure 8. Comparison of the internal diameter deformation (%) of the latex (A) and the non-latex (B) elastics: Dentaureum, Orthopli, Morelli and G&H, in all experimental periods. $p < 0.05$.

Discussion

It is known that light and continuous forces are needed to promote orthodontic tooth movement. When applying mechanics using intermaxillary elastics, it is important to use a tensiometer to obtain an exact reading of the applied forces. However, it is a clinical challenge to determine the loss of the initial force over time. Studies investigated the *in vitro* mechanical behaviour of elastic material using static¹⁶⁻²⁰ and dynamic^{12,13,15} experimental models. The latter model stretched the elastics in cyclical movements in order to simulate a patient's jaw movements during oral function. Cyclic tests showed greater force loss than static tests, but the rate of force degradation was similar by either method.¹³ The tests performed in the present study were conducted in artificial saliva in order to methodologically replicate studies that used dry and aqueous conditions.^{11,16-19} In previous investigations, it was determined that elastic force loss was less in dry conditions.^{16,17}

In the present study, it was determined that the mean reduction in elastic force was significant after the first 24 hours, irrespective of the composition of the elastic and commercial brand. Previous studies have further divided the 24 hour period, and indicated a greater degradation after the first three to five hours,²⁰ three hours,¹⁹ one hour¹⁸ and one-half hour,^{15,17} respectively.

Intermaxillary forces delivered by elastics made of latex have been applied since Baker anchorage in 1862,² and previous research has studied the physical properties of this material.¹⁷⁻²² The study of Kanchana et al.¹⁸ found a force degradation pattern for latex elastics of 29.9% after one hour, 32.3% after 24 hours and 36.2% after 72 hours. In the present study, the latex elastics exhibiting the greatest degradation were the G&H brand, which reduced by 20% after 24 hours and 22.5% after 72 hours. Wong²¹ found an initial force loss of 17% for the $\frac{3}{16}$ " latex elastics after 504 hours. For this same material and time interval, the present study found a force loss of 17.3% for Dentaurem, 25.1% for G&H, 17.3% for Morelli, and 16.4% for Orthopli elastics.

Additional studies¹¹⁻¹⁶ have revealed the mechanical behaviour of non-latex elastics. Kersey et al.¹³ conducted a study using $\frac{1}{4}$ " elastics produced by American Orthodontics and found force degradation of 46.7% after 24 hours using the cyclic model and 31.2% using the static model for non-latex elastics,

and 25.4% in the cyclic model and 17.2% in the static model for latex elastics. In the present study, the results were similar to those obtained in the static model of the previous study, with a mean minimum value of 21.1% after 24 hours for the G&H latex elastics and 28.6% for the Dentaurem non-latex elastics.

Force degradation between latex and non-latex orthodontic elastics differed according to the brand. In a comparative study, Kersey et al.¹³ found the degradation force of American Orthodontics latex elastics was higher than American Orthodontics non-latex elastics. In a study of other brands, Russel et al.¹⁴ found that the degradation force of GAC latex elastics was higher than for GAC non-latex elastics, Masel non-latex elastic force was higher than for Masel latex elastics and Masel non-latex elastic force was higher than for GAC non-latex elastics. In the present study, greater remaining force was found in the latex elastics for all brands (Figure 2). In the evaluation between the brands (Figure 4), greater degradation was found in the G&H elastics (latex) and Dentaurem and Orthopli elastics (non-latex). It must be noted that force degradation is unequal when different brands are compared.

Neither of the reviewed studies analysed the deformation of the internal diameter as a methodological criterion. Barrie and Spence²² assessed the changes in length of elastics under a constant load and found variable results. It has, however, been established that the greater the increase in size of the elastic lumen, the more the force decreases.²³ In the present study, it was found that non-latex elastics deformed more than latex elastics at all the time intervals for all brands (Figure 5).

An *in vitro* study is unable to accurately represent clinical reality as there is less force degradation compared with *in vivo* studies.¹⁷ It was clinically reported that the $\frac{1}{8}$ " latex diameter maintained a higher force than non-latex elastics; however, the $\frac{1}{4}$ " and $\frac{5}{16}$ " diameter elastics delivered equivalent forces after 24 hours for both types of material.²⁴ The results of the present study may offer guidance to clinicians when selecting elastics and provide an understanding of the composition and mechanical behaviour of brands. The methodology adopted likely minimised the force degradation due to the static nature of the study, which was conducted at room temperature. However, the proposed objectives were met.

Conclusion

The non-latex elastics showed greater deformation and force degradation than latex elastics for all brands. Of the latex elastics, the G&H brand showed the greatest force decay, and for the non-latex elastics, the Dentaurem and Orthopli brands exhibited greater force decay.

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