EVALUATION OF THE FORCE DEGRADATION OF DIFFERENT TYPES OF ORTHODONTIC INTERMAXILLARY ELASTICS AT DIFFERENT TIME INTERVALS – IN VITRO STUDY

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Abstract: Correct selection of the dimension of orthodontic elastics, knowledge of their characteristics, monitoring of released forces at different time intervals, and good cooperation with patients are required for successful orthodontic treatment. During orthodontic therapy, elastics lose their initial strength due to various physical and chemical factors that change their structure. The purpose of this study is to determine, through the analysis different types of elastics (latex and non-latex) and different brands to get information which types of elastics and which brands offer better stability during the different times of the force degradation.
Material and method: To realize the set goals, a selection of three brands of elastics was chosen (Forestadent , American Orthodontics and Dentaurum) and two types of elastics from each brand (latex and non-latex). All elastics were the same diameter 4.8mm and medium force of 128g. Every group (24 groups) is consisted of 10 samples for every time interval of 0h , 12h, 24h and 48h (total of 240 elastics). The elastics were stretched to a 3D printed custom board with pins in distance of 15mm which later the elastics were taken out after the time interval to measure their force on Shimadzu Autograph AGS-X universal tester machine with pins in distance of 15mm. The degradation force was compared in the four different time intervals with repetitive measure tests (Post hoc / Bonferroni test).
Results: there was significant difference of force degradation between the latex and non latex groups, between the three type of brands and between the different time intervals of every cross examination of the groups. Latex elastics are clearly more stable overtime than non-latex elastics in every brand, Dentaurum showed higher value results in both latex and non-latex elastics.
Conclusion: It is recommended to change the latex elastics every 24h and the non-latex elastics every 12h of use.
Keywords: latex orthodontic elastics, non-latex orthodontic elastics, intermaxillary elastics, force degradation, Dentaurum, American Orthodontics , Forestadent.

1. INTRODUCTION

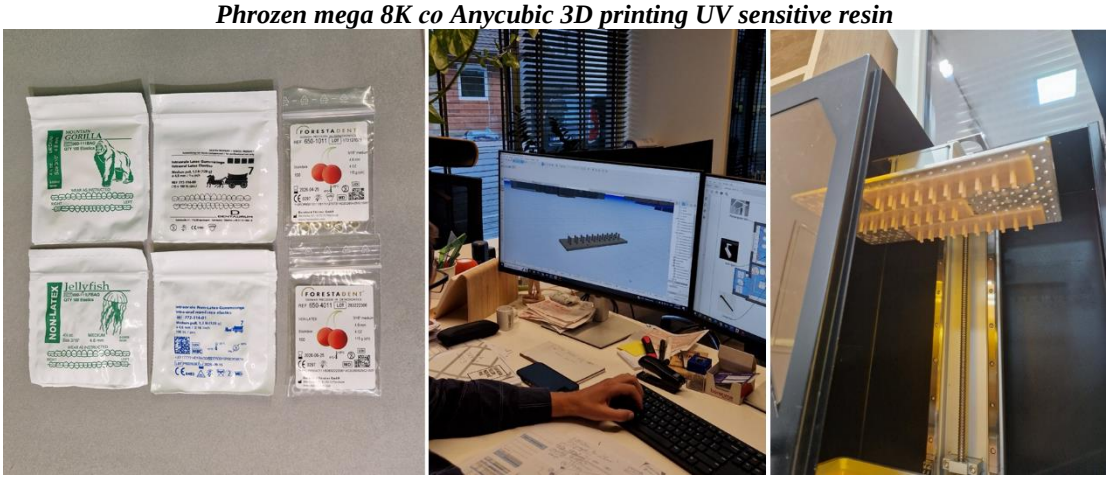
Orthodontic extraoral and intraoral elastics for intermaxillary tooth traction are an integral part of orthodontic therapy and represent a source of force that serves to correct jaw relationships, close the spaces between teeth and correct the interdental environment. (Kardach 2019, Notaroberto 2018, Dubovská 2023, Rahpeyma 2014 & Oliveira 2017). The correct choice of the dimension, the knowledge of their characteristics, monitoring the amount of released force in different time intervals, as well as good cooperation with patients, are a requirement for successful orthodontic treatment. (Pithon 2016 & Singh 2012).
Two parameters define orthodontic bands: the diameter (3.2 mm, 4.8 mm, 6.4 mm, 8 mm, 9.5 mm, 13 mm, 16 mm and 19 mm) and the force they release (70.9 gr, 127.6 gr, 184.2 gr, 226.8 gr and 397 gr). In everyday orthodontic practice, intraoral elastics with a diameter of 4.8 mm are the most used and a force strength of 127.6 g. (Kanchana, P.,Godfrey,K. (2000)determined that this type of intraoral elastics are more homogeneous and show less variation in the sample compared to the other dimensions of the elastics.
According to the material from which they are made, there are two types of orthodontic elastics: latex elastics made of natural rubber and latex-free elastics made of synthetic rubber, which is an artificial polymer and reproduces to a higher or lower degree the physical properties of natural rubber. According to the American Dental Association,

approximately 0.12%–6% of the general population and 6.2% of dental health professionals are hypersensitive to latex. The effects of hypersensitivity vary from dermatitis to anaphylactic shock. (Alavi 2014, Ardani 2018, López 2012, Vieira 2013, Montenegro 2018 & Kersey 2003).
During orthodontic therapy, elastics lose their initial strength as a result of various physical and chemical factors that lead to a change in their structure. In the oral cavity, elastic bands are subject to constant forces. A significant decrease in their strength occurs during the first day of use and the greatest loss in the first hour of their application according to Kanchana,P.,Godfrey,K. (2000).Diameter size affects force degradation, with smaller size elastics needing to be replaced more frequently to maintain intended force action as per the study of Patel, RA., Khonde, SK., Mehta, FN., Raval, KK. (2018).
After being placed in the oral cavity, the elastics lose part of their initial strength due to oral activities (chewing and talking) but also due to their exposure toenvironmental factors (saliva, food and drinks with different acidity and alkalinity, intraoral pH and temperature variations, enzymatic and microbial action, as well as the patient's dental hygiene). The normal stretching of the elastics during speaking and chewing (dynamic environment) is between 20 and 50 mm. Pithon 2016 & Wang 2007).The rate of degradation of the elastic force consists of two curves: an initial rapid degradation of forces that occurs in the first 3-4 hours after stretching the material and a latent degradation, which follows this period. In the literature there is an empirical rule (rule of "3") which shows that elastics have 300% greater tensile strength in relation to their diameter. Ajami 2017 & Gioka 2006).

2. MATERIAL AND METHODS

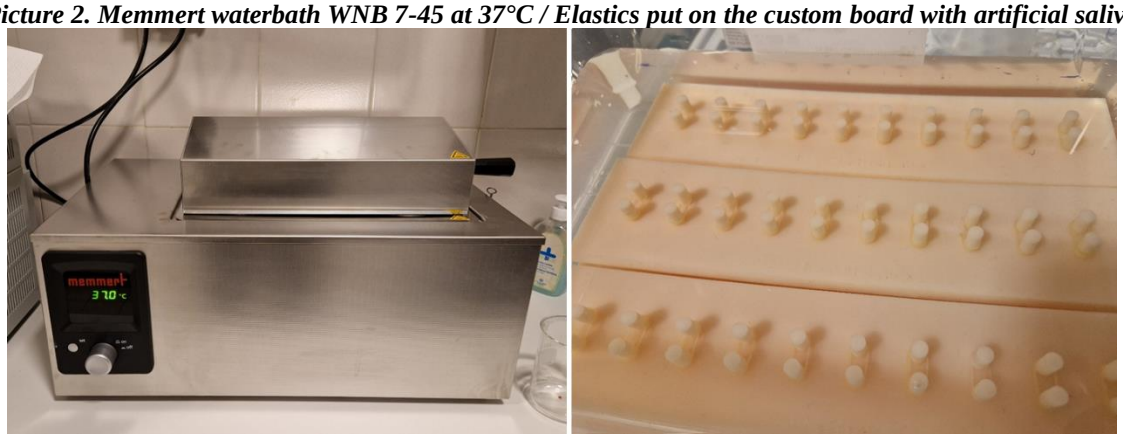
To realize the set goals, a selection of three brands of elastics was chosen (Forestadent , American Orthodontics and Dentaurum) and two types of elastics from each brand (latex and non-latex). All elastics were the same diameter 4.8mm and medium force of 128g. Every group (24 groups) is consisted of 10 samples for every time interval of 0h , 12h, 24h and 48h (total of 240 elastics). The elastics were stretched to a 3D printed custom designed board with pins in distance of 15mm in a artificial saliva bath with a constant temperature of 37°C with a 6.5 pH which later the elastics were taken out of the bath after the time interval to measure their force on Shimadzu Autograph AGS-X universal tester machine with pins in distance of 15mm.
In the series with numerical marks (strength of latex and non-latex intermaxillary elastics / brands) descriptive statistics was made (Mean; Std.Deviation; ±95,00%CI; Median; Minimum; Maximum). The differences in relation: Forestadent Non Latex (1), American Orthodontics Non Latex (2), Dentaurum Non Latex (3), Forestadent Latex (4), American Orthodontics Latex (5), Dentaurum Latex (6), were analyzed using of Repeated measures ANOVA (F / p) / Post Hoc / Bonferroni test. In the series with numerical marks (strength of orthodontic intermaxillary elastics / at the 0th hour and 12 hours, 24 hours, 48 hours from placement, in different manufacturers) the Mean±Std,Err was analyzed. ±95.00%CI. Significance was determined at $p<0.05$.

Picture 1. Orthodontic elastics / Custom board designing in Autocad / 3D printing of the custom board with Phrozen mega 8K co Anycubic 3D printing UV sensitive resin



Source: Author

Picture 2. Memmert waterbath WNB 7-45 at 37°C / Elastics put on the custom board with artificial saliva



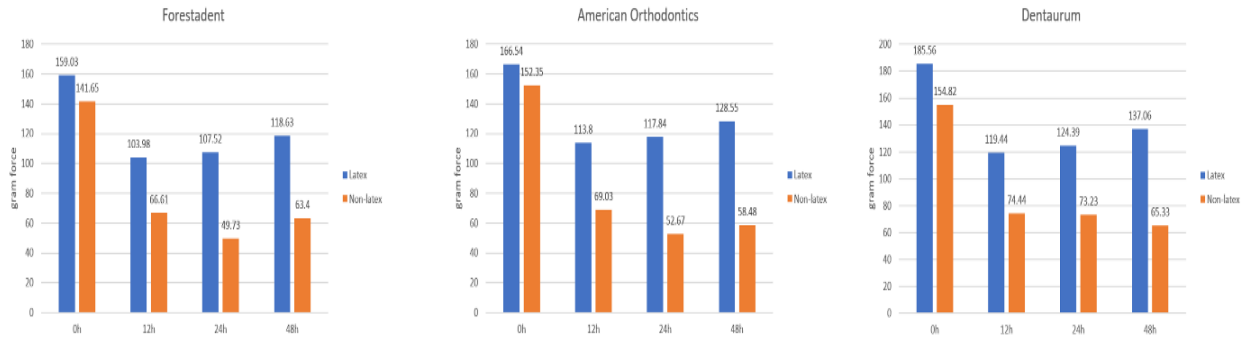
Source: Author

Picture 3. Shimadzu Autograph AGS-X with integrated program for measuring Trapezium X / Measuring of the distal parts of the custom board pins with digital schubler / Measuring the distal parts of the pins in the measuring machine with digital schubler

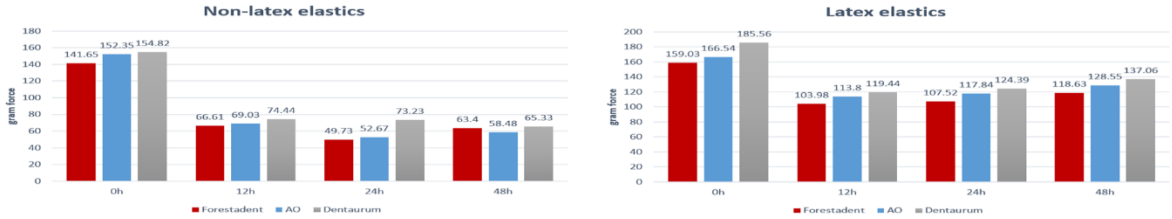
Source: Author

3. RESULTS

Graphic 1. Mean value measurements of latex and non-latex elastics of Forestadent , American Orthodontics and Dentaurum brands in different time intervals



Graphic 2. Same results as above graphic grouped in latex and non-latex graphs



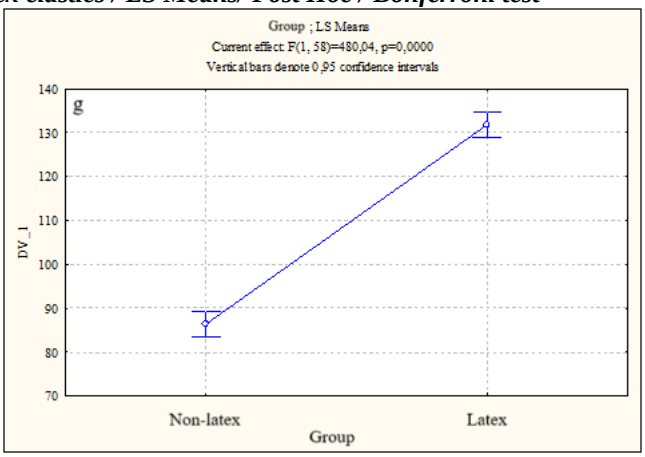
Source: Author

Graphic 3. Strength of non-latex and latex elastics / LS Means/ Post Hoc / Bonferroni test

Group; LS Means: F(1, 58)=480,04, p=**0,0000**

Cell No.	Group	DV_1 Mean	DV_1 Std.Err.	DV_1 -95,00%	DV_1 +95,00%	N
1	Non-latex	86,41	1,47	83,48	89,35	30
2	Latex	131,86	1,47	128,93	134,80	30

Cell No.	Group	{1} 86,41	{2} 131,86
1	Non-latex		**0,00**
2	Latex	**0,00**	



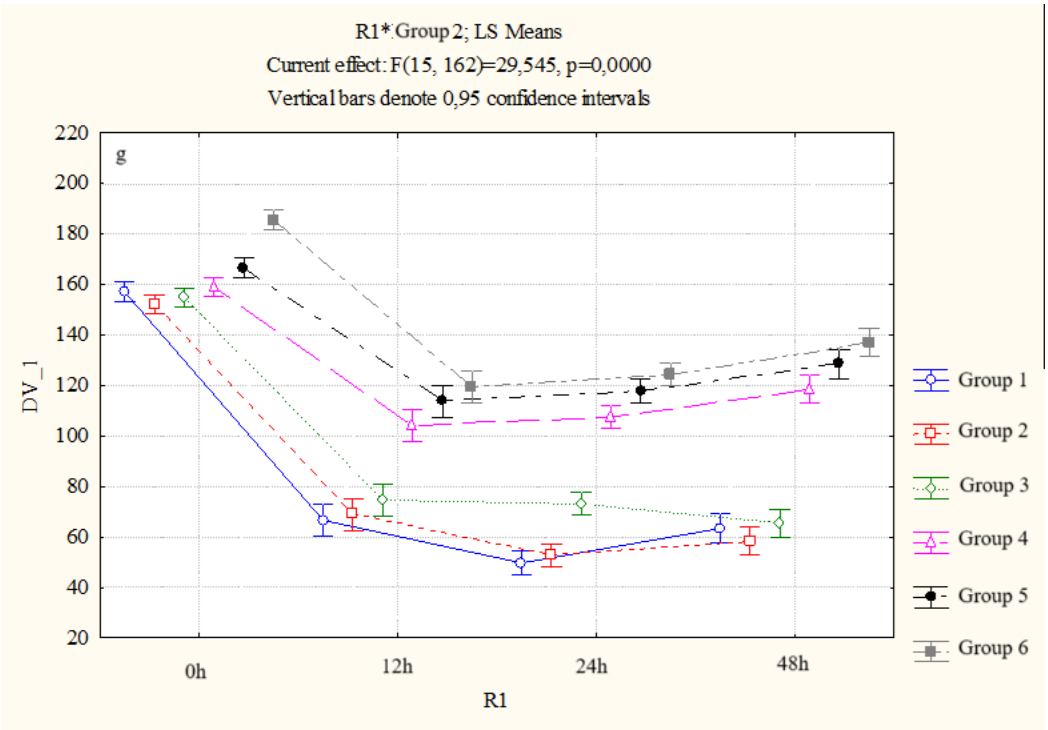
Source: Author

For F = 480.04 and p<0.001(p=0.000) there is a significant difference in the strength of orthodontic intermaxillary non-latex elastics and latex elastics at 0 hour and 12 hours, 24 hours, 48 hours after placement. The strength of orthodontic intermaxillary latex elastics (2) is significantly higher than the strength of orthodontic intermaxillary non-latex elastics (1) by p<0.01(p=0.00).

Graphic 4. Strength of orthodontic intermaxillary non-latex elastics and latex elastics at 0 hour and 12 hours, 24 hours, 48 hours

R1*Group; LS Means: F(15, 162)=29,55, p=**0,0000**

Cell No.	Group	R1	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	Forestadent Non Latex 1	0h	157,10	1,95	153,20	161,00	10
2	Forestadent Non Latex 1	12h	66,61	3,15	60,29	72,93	10
3	Forestadent Non Latex 1	24h	49,73	2,29	45,13	54,33	10
4	Forestadent Non Latex 1	48h	63,40	2,86	57,67	69,13	10
5	American Orthodontics Non Latex 2	0h	152,10	1,95	148,20	156,00	10
6	American Orthodontics Non Latex 2	12h	69,03	3,15	62,71	75,35	10
7	American Orthodontics Non Latex 2	24h	52,67	2,29	48,07	57,27	10
8	American Orthodontics Non Latex 2	48h	58,48	2,86	52,75	64,21	10
9	Dentaurum Non Latex 3	0h	154,82	1,95	150,92	158,72	10
10	Dentaurum Non Latex 3	12h	74,44	3,15	68,12	80,76	10
11	Dentaurum Non Latex 3	24h	73,23	2,29	68,63	77,83	10
12	Dentaurum Non Latex 3	48h	65,33	2,86	59,60	71,06	10
13	Forestadent Latex 4	0h	159,03	1,95	155,13	162,93	10
14	Forestadent Latex 4	12h	103,98	3,15	97,66	110,30	10
15	Forestadent Latex 4	24h	107,52	2,29	102,92	112,12	10
16	Forestadent Latex 4	48h	118,63	2,86	112,90	124,36	10
17	American Orthodontics Latex 5	0h	166,54	1,95	162,64	170,44	10
18	American Orthodontics Latex 5	12h	113,80	3,15	107,48	120,12	10
19	American Orthodontics Latex 5	24h	117,84	2,29	113,24	122,44	10
20	American Orthodontics Latex 5	48h	128,55	2,86	122,82	134,28	10
21	Dentaurum Latex 6	0h	185,56	1,95	181,66	189,46	10
22	Dentaurum Latex 6	12h	119,44	3,15	113,12	125,76	10
23	Dentaurum Latex 6	24h	124,39	2,29	119,79	128,99	10
24	Dentaurum Latex 6	48h	137,06	2,86	131,33	142,76	10



Source: Author

For F = 29.55 and p<0.001(p=0.000) there is a significant difference in the strength of orthodontic intermaxillary non-latex elastics and latex elastics at the 0th hour and 12 hours, 24 hours, 48 hours after placement, among different manufacturers .
The minimum force (49.73 grams) of the orthodontic intermaxillary elastics was registered 24 hours after placement in the group of Forestadent Non Latex elastics.
The maximum force (185.56 grams) of the orthodontic intermaxillary elastics was registered at time 0 in the group of Dentaurum Latex elastics.

4. DISCUSIONS

Nitrini et al. 2019, examining the degradation of the strength of intermaxillary elastics in different periods of time, concluded that they should be changed every 24 hours to achieve successful results of orthodontic therapy. In contrast, Kardach et al. 2019 suggest changing the elastics at 12 hour interval, at the same time stating that the artificial and wet environment have a negative effect on their characteristics, which contradicts the findings of LeaoFilho et al. 2013, who determined that the different chemical composition of drinks has no significant influence on the degradation of their strength. Several authors in their studies concluded that intraoral latex elastics have greater stability in the first 24 hours compared to non-latex elastics, which should be changed every 6-8 hours to achieve successful results. (Oliveira 2017, Patel 2018 & Sanaz 2019). Gioka et al. 2006 examining the strength degradation of latex elastics over a period of 24 hours determined a loss of the initial strength of the elastics of 25%, with the greatest loss occurring in the first 3-5 hours of extension of the elastics regardless of the dimension. ,the manufacturer or their force. Similar findings were reached by Dubovská et al. 2023 who examined the values of the initial force of latex elastics with a diameter of 4.8 mm and a force of 127.6 g, from five different manufacturers and five different packages from different series. Strength degradation was measured after 2, 8, 24 and 48 hours of their extension. The results showed a strength loss of approximately 25% within 24 hours. The greatest degradation of strength occurred during the first two hours, while the degradation of strength in 24 hours ranged from 20% to 33% for all manufacturers.

5. CONCLUSIONS

From our study we can conclude that there is a clear difference between the strength of the latex and non-latex intermaxillary orthodontic elastics after use. The biggest loss of strength occurs during the first 12 hours for both

latex and non-latex elastics, but with more force loss in the non-latex group. In almost all brands and types of elastics, in the 48 hour group all elastics showed a slight increase in their strength but that occurs because of the increased hardening of the elastics and loss of elasticity. This parameter shows us that elastics should be changed every 24h for optimal results. For optimal results with non-latex elastics they should be changed every 12h. In terms of brands, Dentaurum showed slightly better results in both latex and non-latex elastics but the pattern of force loss is the same in all of the brands.

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