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Research Article

A CLINICAL EVALUATION AND COMPARISON OF FORCE DEGRADATION OF LATEX AND NON-LATEX ORTHODONTIC ELASTICS

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ABSTRACT

The aim was to evaluate and compare force degradation of Latex and Non-Latex elastics in intramaxillary and intermaxillary traction with same extension at various time intervals in Vivo study. 30 subjects with split mouth design- Latex elastics on right side and Non-Latex elastics on left side of size 3/16 inch, 4.5 oz-medium force, 4.8 mm diameter of intramaxillary and intermaxillary traction at the same extension (25mm) were taken, instructed to remove elastics while eating to avoid repeated stretching. Force measurements were taken with push pull gauge at 11 intervals (0,1,2,3,6,9,12,24,27,30,33,36 hours). Post Hoc Tuckey HSD test was used. There was significant difference between Latex and Non-Latex elastics. Force degradation of Latex and Non-Latex elastics in intramaxillary traction started at 9 hours ($p \leq 0.0001$) with 7% more force loss in Non-Latex elastics and for intermaxillary traction at 6 hours ($p \leq 0.0001$) with 8% more force loss in Non-Latex elastics. There was nonsignificant difference between intramaxillary and intermaxillary elastics. Non-Latex elastics showed more force loss than Latex. But the difference inforce magnitude was to a lesser extent between intramaxillary and intermaxillary traction. Salivary PH and enzymes, swallowing and speaking may be contributing factors for force degradation.

INTRODUCTION

The latex elastics have become integral part of orthodontics after being first discussed by Calvin. S. case in 1893 at the Columbia dental congress but the credit goes to Henry A. Baker for the use of these elastics in clinical practice to exert a class II intermaxillary forces. Elastics have been a valuable adjunct of any orthodontic treatment for many years and are the most frequently used auxiliary force systems in modern day orthodontics. There is hardly any phase of fixed orthodontic treatment which is completed without their use. They provide the reliable force delivery and are cheapest. They can be latex or non-latex that is polyurethane based.

These auxiliaries, made from natural rubber, are replaced, but concern associated with their use pertains to the force relaxation of these materials. In the 1960s an alternative synthetic material, or latex-free, was disseminated in Orthodontics. Since the early 1990s synthetic products have been offered on the market for latex-sensitive patients and are sold as non-latex elastics. K.A.Russel[1] in 2001- with the use of orthodontic elastics is more likely to induce a rapid systemic reaction such as anaphylactic shock. As the incidence of latex allergic reactions increases, the use of non-elastic products within the orthodontic specialty as well as assessment of material properties of non-latex elastics, will become clinically more important.

It has been a common finding that rubber elastics will lose a part of their initial force after they are applied in the mouth for oral activities (eg chewing, speaking) and after they are exposed to different oral environments (eg saliva, oral temperature, foods and drinks with different acidity and alkalinity). All these factors could change the structure of elastics affect their properties.

In the present study, efforts have focused on assessing the force time characteristics of elastics mainly because these are expected to function in the oral cavity for longer periods, which may exceed 24 hours. Force decay occurred within the first 3-5 hours after extension, regardless of size, manufacturer, type of elastic –latex and non-latex, or force level of elastics[2]. Some studies suggest that the elastics do not need to be replace frequently because after the extreme rate of force degradation on the 1st day the force would remain relatively constant for the 2nd day. Clinician using orthodontic elastics need to know the forces applied to teeth at a given extension and how this force declines over time.

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MATERIALS AND METHOD

30 subjects (18-24 years age) who undergone fixed orthodontic treatment with PEA appliance were selected for the study. This study was approved by the ethical committee and informed consents were taken. The subjects in vivo study with split mouth design were categorized in to two groups and required to participate twelve times for force measurement over 36 hours. Care was taken to keep fixed distance of 25mm from crimpable hook to molar hook in intermaxillary (class II pattern) and intramaxillary arch traction while the subjects were in dental interdigitation. Every subject was instructed to remove elastics while eating food[3] (3 times per day) so to prevent breakage of the elastic bands and to avoid effects of repeated stretching on force degradation[1,2,4,5].

Armamentarium

Latex and Non-latex elastic of size 3/16 inch, 4.5 oz-medium force, 4.8 mm diameter (American Orthodontics)[6].
Push-pull meter with load cell capacity of 300gm (YUYUTSU). The maximum permissible tolerance was ±0.2gms.

Distribution of Samples in Vivo Study

Group A Latex elastics (on right side):
Subgroup A1: Intramaxillary elastics
Subgroups A2: Intermaxillary elastics
Group B Non-latex elastics (on left side):
Subgroup B1: Intramaxillary elastics
Subgroups B2: Intermaxillary elastics
Elastics on both sides were included in the statistical analysis. When the elastic broke or obvious flaws were seen in the elastics was eliminated from the samples. Subjects in all groups started to wear elastic at 9am (After breakfast)

The subjects were required to wear the elastics for 36 hours without exchanging them. Force measurements were taken at 11 intervals:0,1,2,3,6,9,12,24,27,30,33 and 36 hours.

As shown in figure no 1 and figure 2 with the help of tweezer, each elastic was carefully transferred to the hook of push- pull meter. Force magnitudes of the elastics when stretched at the distance of 25 mm along the Vernier Caliper were recorded immediately after they transferred on hook of push-pull meter. The tensile readings were recorded in grams. The direction of the hook of the push-pull meter was kept along the long axis of the elastics in the subject's mouth.

To ensure the consistency of the tests, all measurements were performed by one observer[7].

For each group, different elastic material and different observational intervals, statistical analysis was done.
Time schedule for force measurement are given in Table 1.

Statistical Analysis

The standard deviation was tested confirming to the Centre Ultimate Theorem, showing that the means of the force magnitudes were representative. There was statistically difference among different materials and different observation intervals. Post hoc tukey test was used to determine statistically significant differences among various testing materials, type of traction and different time intervals.

Statistical methods that were employed in present study are (Table 2):
Mean (average)
Standard deviation
Standard error
Post Hoc Tukey's HSD test

DISCUSSION

This study was designed to evaluate and compare the force degradation of latex and non-latex orthodontic elastics in different pattern of traction at same extension of 25mm for intermaxillary and intramaxillary over different time interval in vivo.

For ease of clinical evaluation time interval was categorized as:
1st daytime (from 9 AM to 9PM) elastics removed while eating for 3 times for 15 minutes each time.
Night time (from 9PM to 9 AM) elastics not removed for measurement.

2nd daytime (from 9AM to 9PM) elastics removed while eating for 3 times for 15 minutes each time.

Samples were collected from 30 subjects. Split mouth design latex elastics (A), Non-latex elastics(B) with subgroups: intramaxillary and intermaxillary traction respectively at 25 mm distance between molar hook and crimpable hook. Subjects were instructed to remove elastics while eating to avoid breakage and effects of repeated stretching in dynamic extension on force characteristics, same elastics were continued during night and subject was asked to follow same protocol on 2nd day.

Table 1 Mean, Percentage and Standard Deviation of Force Degradation of Various Subgroups of In Vivo Elastics At Different Time Interval: (Descriptive Statistics)

Time Interval	Latex Class I-A1				Latex Class II-A2				Non-Latex Class I-B1				Non-Latex Class II-B2			
	N	Mean	% of mean	SD	N	Mean	% of mean	SD	N	Mean	% of mean	SD	N	Mean	% of mean	SD
Baseline 0 hr	30	160.25	100%	5.184	30	160.33	100%	4.8572	30	160.08	100%	4.9342	30	160.66	100%	5.1249
1 Hr	30	153.08	95.52%	5.86	30	152.25	94.96%	4.9284	30	148	92.46%	7.1739	30	148.25	92.28%	5.5379
2 Hr	30	147.58	92.09%	6.07	30	146.08	91.11%	5.2392	30	142.08	88.76%	6.3342	30	141.83	88.27%	5.721
3 Hr	30	142.83	89.12%	7.27339	30	141.58	88.30%	6.742919	30	137	85.59%	6.803904	30	136.03	84.67%	6.13
6 Hr	30	136.66	85.27%	7.777	30	136.58	85.18%	7.0247	30	130.67	81.63%	6.4	30	129.5	80.60%	6.6436
9 Hr	30	132.25	82.52%	7.6943	30	132.33	82.53%	6.8837	30	125.16	78.19%	7.1599	30	124.75	77.65%	6.7387
12 Hr	30	129.08	80.54%	7.67	30	128.25	79.99%	6.6355	30	120.83	75.49%	7.35	30	120.08	74.75%	6.3817
24 Hr	30	121	75.50%	7.922	30	120.83	75.36%	6.3765	30	111.25	69.50%	8.7036	30	110	68.47%	7.846915
27 Hr	30	116.25	72.54%	7.2442	30	115.58	72.08%	6.3546	30	105.41	65.85%	8.9318	30	103.99	64.73%	8.9494
30 Hr	30	112.84	70.41%	7.4319	30	112.58	70.21%	7.0246	30	100.33	62.68%	9.439	30	99.58	61.99%	9.805948
33 Hr	30	109.25	68.17%	9.3806	30	108.5	67.67%	8.3975	30	96.6	60.35%	9.6082	30	95.83	59.65%	9.9424
36 Hr	30	106.33	66.35%	9.4853	30	104.9	65.42%	8.8886	30	93.33	58.31%	10.028	30	92.66	57.68%	10.2329

Table 2 Comparison of Force Degradation Latex and Non-Latex Elastics In Intramaxillary Tractions

Time Interval	N		Mean Difference	SD	p - value
	A1	B1			
Baseline (0 hour)	30	30	-0.1667	0.19	1
1 hour	30	30	5.1667	1.1	0.016
2 hour	30	30	7.4167	0.87	0
3 hour	30	30	9.106322	0.49	1
6 hour	30	30	10.6667	0.37	0.999
9 hour	30	30	13.5	0.61	0
12 hour	30	30	13.3333	1.54	0
24 hour	30	30	14.083333	0.32	0
27 hour	30	30	13.3333	0.74	0.0001
30 hour	30	30	13.75	0.14	0
33 hour	30	30	14.8833	0.19	0
36 hour	30	30	15.2167	0.14	0

Table 3 Comparison of Force Degradation Latex and Non-Latex Elastics in Intermaxillary Tractions

Time Interval	N		Mean Difference (A2-B2)	SD	p - value
	A2	B2			
Baseline (0 hour)	30	30	-0.5	0.48	1
1 hour	30	30	-5.4167	0.64	0.009
2 hour	30	30	8.5	1.1	0
3 hour	30	30	10.083333	0.74	0.004
6 hour	30	30	12.75	0.05	0
9 hour	30	30	16.3333	0.09	0
12 hour	30	30	15.8333	1.71	0
24 hour	30	30	16.666667	2.18	0
27 hour	30	30	14.6667	2.14	0
30 hour	30	30	14.75	0.023	0
33 hour	30	30	15.4833	0.87	0
36 hour	30	30	15.75	2.12	0

Table 4 Comparison of Force Degradation of Latex Elastics in Intramaxillary and Intermaxillary Tractions

Time Interval	N		Mean Difference(A1-A2)	SD	p - value
	A1	A2			
Baseline (0 hour)	30	30	0.333	0.94	1
1 hour	30	30	0.1667	0.65	1
2 hour	30	30	0.6667	0.45	1
3 hour	30	30	-0.25	0.76	1
6 hour	30	30	-1.25	0.2	1
9 hour	30	30	-1.167	0.45	0.998
12 hour	30	30	-1.4167	0.36	0.993
24 hour	30	30	-1.4167	0.56	0.993
27 hour	30	30	0.1833	0.45	1
30 hour	30	30	0.1667	0.65	1
33 hour	30	30	0.4833	0.2	1
36 hour	30	30	0.55	0.52	1

This study compared only one company's latex elastic with its non-latex elastic of size 3/16 inch, 4.5 oz medium force, 4.8 mm diameter only one size and force level of elastics (American Orthodontics).

The force measurement system we used was push-pull meter with load cell capacity of 300 gms with maximum permissible tolerance ±2 gms that used by Tong Wang *et al*[8], a significant advantage of the systems used in this study.

Force degradation was compared by using percentage of initial force rather than actual force generated in grams.

Force degradation of different pattern of traction in different elastic material in vivo showed differences during 0-36 hours-progressive drop of force, but there was remarkably more force loss within first hour in all groups. There was significant difference in force magnitude in all the groups.

Figure 1 Push-pull meter measuring force in intramaxillary elastics.

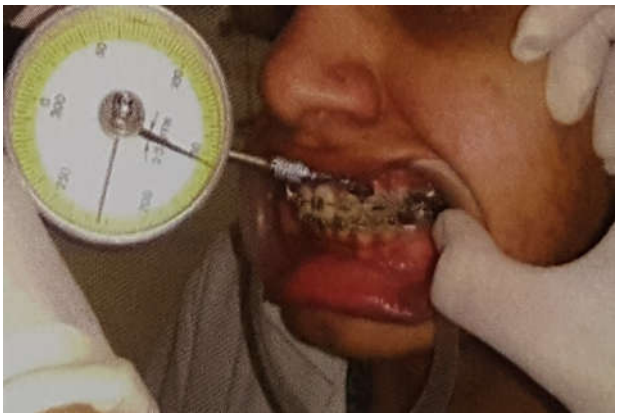

Figure 2 Push-pull meter measuring force in intermaxillary elastics.

Table 5 Comparison of Force Degradation of Non-Latex Elastics in Intramaxillary And Intermaxillary Tractions

Time Interval	N		Mean Difference(B1-B2)	SD	p - value
	B1	B2			
Baseline (0 hour)	30	30	0	0	1
1 hour	30	30	0.5833	0.88	1
2 hour	30	30	0.4167	0.73	1
3 hour	30	30	0.727011	0.99	1
6 hour	30	30	0.8333	0.3	1
9 hour	30	30	1.667	0.64	0.986
12 hour	30	30	1.0833	0.04	0.999
24 hour	30	30	1.5	1.94	0.994
27 hour	30	30	1.5167	1.02	0.992
30 hour	30	30	1.16667	1.02	0.999
33 hour	30	30	1.0833	1.02	1
36 hour	30	30	1.166667	1.74	0.999

Table 2 shows comparison of force degradation of latex and non- latex elastics in intramaxillary traction at various time interval between subgroup A1 and B1 which is highly significant at 1st day, night time and 2nd day ($p \leq 0.0001$).

Significant difference in force degradation was observed after 9 hours of initial time for non-latex elastics. The initial force remaining was 68.35% for A1 and 59.86% for B1, there was a more force loss of 8.49% in B1 at 1st day after 12 hours. After a period of 1st day at night, same elastics were continued during night time and the force for the same elastics was measured on the 2nd day at 9 AM. The force was 61.98% for A1 and 53.35% for B1, there was a more force loss of 8.63% in B1 at night time after 24 hours. For the next day, on the 2nd day after 36

hours interval the force was 51.15% for A1 and 41.81% for B1, there was a more force loss of 9.34% in B1, which is slightly higher than 1st day and night time intervals. The results of this study indicate the differences in force magnitude of latex and non-latex intramaxillary elastics, there was more force loss in B1 than A1. The rates of force degradation of intramaxillary elastics at 1st day, night time and 2nd day was 31.65%, 38.02% and 48.85% for latex elastics and 40.14%, 46.65%,58.19% for non-latex elastics respectively[9].

Different environments have different effects on the properties of elastics because oral environment has a potential to plasticize such polymers. In the oral cavity, the characteristics of elastics are affected by oral temperature, enzymes, acidic and alkaline PH, salivary stimuli caused by various types of food and drinks etc.

Table 3 Comparison of force degradation of latex and non-latex elastics in intermaxillary traction at various time interval between subgroup A2 and B2, which is highly significant at 1st day after 12 hours, during night time after 24 hours and on 2nd day after 36 hours ($p \leq 0.0001$). Force degradation was significant for non-latex elastics after 6 hours of initial time ($p \leq 0.0001$). The initial force remaining at 1st that after 12 hours was 69.36% for A2 and 59.18% for B2, there was a more force loss of 10.18% in B2 at 1st day after 12 hours. After a period of 12 hours at night without exchanging the elastics the force was measured on 2nd day for 24 hours the force was 63.10% for A2 and 52.41% for B2, there was a more force loss of 10.69% in B2 at 24 hours and for the 2nd day at the 36hours interval the force was 51.20% for A2 and 41.13% for B2, there was a more force loss of 10.07% in B2. The results of this study indicate that there was more force loss in B2 than A2. The rates of force degradation of intermaxillary elastics at 1st day after 12 hours, during night time after 24 hours and on 2nd day after 36 hours was 30.64%,36.90% and 48.80% for latex elastics and 40.82%, 47.59% and 58.87% for non-latex elastics respectively.

Force is a dynamic extension when accompanied by oral activities, stretching in an oral environment causes more fatigue. Creep and force relaxation and with the increase temperature- fatigue longevity of the natural rubber (latex) decreases.

One of the conclusions by Russell *et al*[1]was that the mechanical properties of non-latex elastics cannot be assumed to be and indeed are not the same as those of latex, which varied concededly with the type of material that can be applied to our findings.

Table 4 shows comparison of force degradation of latex elastics in intramaxillary and in intermaxillary traction at various time intervals between subgroups A1 and A2. There was no significant difference at various time intervals between A1 and A2 as the p=1. The rates of force degradation of latex elastics at 1st day after 12 hours 31.65%,for the night time force evaluation after 24 hours 38.02% and on 2nd day after 36 hours was 48.85% for intramaxillary elastics and 30.64%, 36.90%, 48.80% for intermaxillary elastics respectively[8,10].

Liu *et al*[4] confirm the force decay was remarkably stable because structural changes caused by repeated stretching were not cumulative. In the present study, structural changes of latex elastics with dynamic and static extension may not be contributing factor for force degradation of different patterns of traction.

Table 5 shows comparison of force degradation of non-latex elastics in intramaxillary and in intermaxillary traction at various time intervals between subgroup B1 and B2 in vivo study. There was no significant difference between them ($p \geq 1$). The rates of force degradation of non-latex elastics at 1st day after 12 hours was 40.14%,during night time after 24hours 47.59% and for the 2nd day after 36hours was 58.19% for intramaxillary elastics and for the intermaxillary elastics force loss was 40.82%,47.59%,58.87% respectively.

However, flaws occurred in groups (B1 and B2) so if necessary check the edges of non-latex elastics carefully to ensure enough force.

Study by Bertoncini *et al* indicated that non-latex elastic become more deformed with use than latex.

Paul S. *et al*[11]evaluated nonsignificant correlation between pH and force decay for latex Vs non-latex interarch elastics.

The oral environment exerts greater effects on the elastics which includes variable eg - pH fluctuations, temperature, enzymes and microbial, stretching etc study similar to Daniel J. Fernandes *et al*[9].

The oral environment exerts greater effects on the elastics which includes variables- pH fluctuations[11,12], temperature, enzymes and microbial, stretching in physiological activities (speaking, swallowing), different foods and drinks along with some other indefinite factors- which vary in different individuals are also contributing factors for force degradation and greater influence on non-latex elastics. Static extension in intramaxillary traction and dynamic extension in intermaxillary traction pattern does not affect the force degradation of latex and non-latex elastics.

According to the findings of force degradation, the clinician is suggested to choose an initial force much higher than desired, along with type of elastic material must also be taken into consideration for the desired effect.

It is not only important for the practitioners to know the properties of elastics well, but necessary for the manufacturers to show the properties of force degradation of their products because of the difference for different brands of elastics.

The latex and non-latex elastics were not similar in their behavior. Furthermore, force delivery over a time may vary with the manufacturer.

CONCLUSION

There is significant difference between latex and non-latex elastics. The force degradation is more obvious in non-latex orthodontic elastics than in latex elastics.

Non-latex intramaxillary elastics shows more force loss than the latex group, there is a more force loss of 8.99% at 12hours, 8.63% at 24hours and 9.34% at 36hours.

For Non-latex intermaxillary elastics there is a remarkably more force loss than the latex group, more force loss of 10.18% at 12 hours, 10.69% at 24hours and 10.07% at 36hours. There is nonsignificant difference in force degradation between intramaxillary and intermaxillary traction for latex as well as

non-latex elastics. But there is difference in magnitude of force degradation in all groups.

Various oral environment in individuals such as PH of saliva, oral temperature, activities (speaking and swallowing), structural changes of latex and non-latex elastics with static and dynamic extension may be contributing factors for force degradation of latex and non-latex elastics.

However, after the clinical observation for 36 hours in the present vivo study indicate that non-latex elastics can replace latex elastics if they are changed frequently and it is recommended that non-latex elastics cannot be continued for more than 12 hours.

According to the findings of force degradation, clinician is suggested to choose between an initial force much higher than that the desired and force near the desired amount that will decay to below the level required for the desired effects. This emphasizes the importance of choosing elastics based on the clinical situations as well as the mechanical properties of the elastics that have been shown to vary with type of material.

Further study is needed using different brands of latex and non-latex elastics along with different size and force level. This would help to determine whether the results of this study are comparable to what might be seen on a larger scale among different manufacturer.

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