ORIGINAL RESEARCH PAPER | Volume - 14 | Issue - 02 | February - 2025 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

A COMPARATIVE EVALUATION OF FORCE DECAY OF LATEX AND NON-LATEX ELASTOMERIC CHAIN AND INTRA-ORAL ELASTICS IN DRY CONDITION AND ARTIFICIAL SALIVA – AN IN- VITRO STUDY

Orthodontics

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ABSTRACT

Aim: The aim of this in vitro study is to evaluate the force decay of latex and non- latex elastomeric chain and elastics at 8 hours and 24 hours after having been subjected to constant stretching in both dry condition and artificial saliva. **Materials and Methods:** Latex and non-latex elastomeric chain and latex and non-latex intra- oral elastics was obtained. Each subgroup had 10 samples of each type of intra-oral elastics and elastomeric chain. The intra-oral elastics were stretched to three times their internal diameter on a stainless-steel plate and the elastomeric chain was stretched to 25 mm. Two types of tests was carried out, Dry testing and in Artificial saliva. A universal testing machine was used for force evaluation with a load cell of 1 kN/100 KgF and crosshead speed of 30 mm/minute. **Results:** At 24 hrs, E-Chain group showed significantly highest mean Force Decay as compared to Elastics group and the mean difference was statistically significant at $p<0.001$. Similarly, at 48 hrs also, E-Chain group showed significantly highest mean Force Decay as compared to Elastics group and the mean difference was statistically significant at $p<0.001$. At 24 hrs, E-Chain group showed significantly highest mean Force Decay as compared to Elastics group and the mean difference was statistically significant at $p<0.001$. Similarly, at 48 hrs also, E-Chain group showed significantly highest mean Force Decay as compared to Elastics group and the mean difference was statistically significant at $p<0.001$. **Conclusion:** In this study, when compared to the Elastics group, we found that the E-Chain group had the substantially greatest mean Force Decay after 24 hours. E-Chain group demonstrated a considerably higher mean Force Decay at 48 hours in comparison to the Elastics group. Non-Latex type in the Elastics group demonstrated a considerably higher mean Force Decay at 24 hours as compared to the Latex type. Latex type demonstrated a considerably higher mean Force Decay in the E-Chain group when compared to other Latex types.

KEYWORDS

Elastics, E-chain, Latex, Non-latex, Orthodontic Force, Force Decay.

INTRODUCTION

An optimal level of force is required to achieve the desired orthodontic tooth movement[1] The use of elastomeric materials in orthodontics has made modern orthodontic practice less complicated[2] Elastics and elastomerics are commonly employed as active components of force in orthodontic therapy.

Elastics can be classified in several ways based on their material, availability, application, and force. Elastics can be of two types: natural and synthetic. [3] In the Begg and Tip Egde procedures, naturally generated latex elastics are more frequently employed to provide intermaxillary traction and forces[4]

Synthetic elastics are amorphous polymers derived from polyurethane ingredients. Polymers are not ideal elastic materials since their mechanical characteristics fluctuate over time and at various temperatures.[5]

Elastomeric chains are indispensable tools. They generate some amount of the force required to move teeth. Elastomeric chains come in two varieties: closed and open (short and long). The main disadvantage of elastomeric chains is their irreversible distortion, which can cause surface rupture, colour changes, and mechanical characteristics changes.[6]

For orthodontists, force degradation is still the primary problem since tooth movement requires appropriate and constant force. A light, consistent force is required to move teeth in a normal manner[7] The force depreciation of orthodontic elastics during clinical usage is believed to be primarily caused by mechanical degradation effects.[8]

Thus, the aim of this study is to evaluate in vitro the force decay of latex and non- latex elastomeric chain and elastics at 8 hours and 24 hours after having been subjected to constant stretching in both dry condition and artificial saliva.

MATERIALS AND METHODS

This in vitro study was designed and conducted to evaluate the force decay of both latex and non - latex elastomeric chain and intra-oral elastics. Ethical clearance was obtained by the Institutional Ethics Committee bearing a registration number IEC/MRADC&H/EC-049/2022.

Sample Size

The sample size has been estimated using the GPower software v. 3.1.9.4 [(Franz Faul, Universität Kiel, Germany)

Considering the effect size to be measured (f) at 48% [Based on the results from previous literature by Noelia López et al, 2012], power of the study at 80% and the alpha error at 5%, the sample size needed is 80. The total sample size will be divided into 2 groups of 40 each and will be further sub-divided into 20 samples based on the condition to be tested & time of testing [10 samples x 2 types x 2 conditions (dry & wet) x 2 time intervals = 80 samples].

The above sample size is estimated for elastics, and a similar sample size will be considered for elastomeric chains. So, the total sample size for the present study will be 160 samples. [40 latex elastics & 40 elastomeric chains and 40 non-elastic elastics and 40 elastomeric chains].

Table 1: Distribution of sample

Groups	Subgroups	Sample
Group I- Intra-Oral Elastics	I a-Latex	N=80
	I b-Non- Latex	
Group II-Elastomeric Chain	II a-Latex	N=80
	II b-Non- Latex	

Group I -Intra-oral Elastics:
Latex and non-latex intraoral elastics were obtained from American orthodontics. All the elastics had the same internal diameter and weight. 80 samples were taken and each subgroup had 10 samples of each elastic type. The elastics come in sealed packaging and were stored in a cool dark place until the moment of use when they were stretched to three times their Internal diameter on a stainless steel plate, that had 25 pairs of pins separated by a distance of three times the internal diameter of elastics. Two types of tests were carried out:
Dry testing in which the elastics were stretched to three times their Internal diameter at room temperature, measuring force at T0 and T1.

Artificial Saliva: Elastics stretched on stainless steel plate was submerged in artificial saliva and stored in an incubator at $37 \pm 0.5\,^0$C to assess the effect of saliva on the force behavior and to simulate the oral environment. The artificial saliva was prepared with 1 L of distilled water, 0.4 g of sodium chloride, 0.4 g of potassium chloride, 0.906 g calcium chloride dihydrate, 0.69 g sodium dihydrogen phosphate dehydrate, 0.005 g sodium sulfide nano hydrate and 1 g urea.[14] The specimens were measured after storage in artificial saliva at $37 \pm 0.5\,^0$C, at T0 and T1.

Force evaluations was carried out using a UTM with a load cell of 1 kN/100 KgF and crosshead speed of 30 mm/minute. The elastics were stretched between two hooks, one on the fixed base and the other on the machine head, both with a calibre of 1.5 mm and Internal diameter measuring 8 mm. The machine head will stop when the elastic is stretched to three times its Internal diameter. Its peak force was measured in Newtons.

Group II- Elastomeric Chain
Latex and non-latex elastomeric chain (closed and clear) was obtained from two manufacturers: latex from Morelli and non-latex from American Orthodontics. 80 samples were taken and each subgroup had 10 samples of each elastomeric chain type. E-chains were stretched on a stainless steel plate, that had 25 pairs of pins separated by a distance of 25 mm to fix the elastomeric chains at a constant distance during the study. Two types of tests were carried out:
Dry testing in which the E-chain was stretched to 25 mm, measuring force at T0 and T1.

Artificial Saliva: E-chain stretched on stainless steel plate was submerged in artificial saliva and stored in an incubator at $37 \pm 0.5\,^0$C to assess the effect of saliva on the force behavior and to simulate the oral environment. The specimens were measured after storage in artificial saliva at $37 \pm 0.5\,^0$C, at T0 and T1.

Force evaluations were carried out using a UTM with a load cell of 1 kN/100 KgF and a crosshead speed of 30 mm/minute. The elastomeric chain was stretched between two hooks, one on the fixed base and the other on the machine head, both with a caliber of 1.5 mm and Internal diameter measuring 8 mm. The machine head stops when the elastomeric chain is stretched to 25mm. Its peak force was measured in Newtons.

Statistical Analysis
Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 Released 2013. Armonk, NY: IBM Corp., will be used to perform statistical analyses.

RESULTS
In this current study, Force decay of latex and non-latex intra oral elastics and E-chain were evaluated. The Yield strength, Ultimate Tensile Strength, Modulus of elasticity were evaluated using UTM in the department of nanotechnology, Indian institute of Science, Bangalore.

The mean Force Decay showed a significant difference between materials at p<0.001, with 100% of the variation in the Force Decay was attributable to the difference in materials.

Similarly, the type of the materials also showed a significant difference in the mean Force Decay at p<0.001, with 79% of the variation in the Force Decay was attributable to the difference in the type of materials.

The conditions of the materials to which they were exposed, also showed a significant difference in the mean Force Decay at p<0.001, with 35% of the variation in the Force Decay was attributable to the difference in the condition of materials.

There was significant interaction of the materials and type of materials, that together contributed for a significant difference in the Force Decay with 89% of the variation in the Force Decay at 24 hrs with p<0.001.

Similarly, there was significant interaction of the materials and conditions in which the materials were exposed, that together contributed for a significant difference in the Force Decay with 43% of the variation in the Force Decay at 24 hrs with p<0.001.

With all the three factors being considered, there was significant interaction of the materials, types and conditions in which the materials were exposed, which altogether contributed for a significant difference in the Force Decay with 7% of the variation in the Force Decay at 24 hrs with p=0.03.

However, the interaction between the condition exposed and the type of the material did show any significant contribution to the variation in the Force Decay at 24 hrs time interval [p=0.13].

Similarly, the type of the materials also showed a significant difference in the mean Force Decay at p<0.001, with 76% of the variation in the Force Decay was attributable to the difference in the type of materials.

The conditions of the materials to which they were exposed, also showed borderline significant difference in the mean Force Decay at p=0.07, with 7% of the variation in the Force Decay was attributable to the difference in the condition of materials.

There was significant interaction of the materials and type of materials, that together contributed for a significant difference in the Force Decay with 86% of the variation in the Force Decay at 48 hrs with p<0.001.

Similarly, there was significant interaction of the materials and conditions in which the materials were exposed, that together contributed for a significant difference in the Force Decay with 17% of the variation in the Force Decay at 48 hrs with p<0.001.

With all the three factors being considered, there was no significant interaction of the materials, types and conditions in which the materials were exposed, which altogether contributed for a mere difference in the Force Decay with 1% of the variation in the Force Decay at 48 hrs [p=0.53].

However, the interaction between the condition exposed and the type of the material did show any significant contribution to the variation in the Force Decay at 48 hrs time interval [p=0.51].

At 24 hrs, E-Chain group showed significantly highest mean Force Decay as compared to Elastics group and the mean difference was statistically significant at p<0.001. Similarly, at 48 hrs also, E-Chain group showed significantly highest mean Force Decay as compared to Elastics group and the mean difference was statistically significant at p<0.001.

At 24 hrs, in Elastics group, Latex type showed significantly highest mean Force Decay as compared to Non-Latex type and the mean difference was statistically significant at p<0.001. Contrastingly, in E-Chain group, Non-Latex type showed significantly highest mean Force Decay as compared to Latex type and the mean difference was statistically significant at p<0.001.

Table 2: Comparison of mean Force Decay (in N) b/w Latex & Non-latex type at 24 hrs time interval

Material	Type	Mean	SD	Mean Diff	p-value
Elastics	Latex	1.526	0.068	0.527	<0.001*
	Non-Latex	0.999	0.080		
E-Chain	Latex	7.807	0.503	-2.796	<0.001*
	Non-Latex	10.603	0.776		

At 48 hrs, in Elastics group, Latex type showed significantly highest mean Force Decay as compared to Non-Latex type and the mean difference was statistically significant at p<0.001. Contrastingly, in E-Chain group, Non-Latex type showed significantly highest mean Force Decay as compared to Latex type and the mean difference was statistically significant at p<0.001

Table 3: Comparison of mean Force Decay (in N) b/w Latex & Non-latex types at 48 hrs time interval

Material	Type	Mean	SD	Mean Diff	p-value

Elastics	Latex	1.425	0.109	0.498	<0.001*
	Non-Latex	0.928	0.077		
E-Chain	Latex	7.560	0.471	-2.969	<0.001*
	Non-Latex	10.529	0.648		

At 24 hrs, in Latex type, E-Chain group showed significantly highest mean Force Decay as compared to Elastics group and the mean difference was statistically significant at p<0.001. Similarly, in Non-Latex type, E-Chain group showed significantly highest mean Force Decay as compared to Elastics group and the mean difference was statistically significant at p<0.001.

Table 4: Comparison of mean Force Decay (in N) b/w Dry & Art. Saliva Condition at 24 hrs time interval

Material	Condition	Mean	SD	Mean Diff	p-value
Elastics	Dry	1.301	0.250	0.075	0.40
	Art. Saliva	1.225	0.303		
E-Chain	Dry	8.735	1.355	-0.940	0.07
	Art. Saliva	9.675	1.634		

At 48 hrs, in Latex type, E-Chain group showed significantly highest mean Force Decay as compared to Elastics group and the mean difference was statistically significant at p<0.001. Similarly, in Non-Latex type, E-Chain group showed significantly highest mean Force Decay as compared to Elastics group and the mean difference was statistically significant at p<0.001.

Table 5: Comparison of mean Force Decay (in N) b/w Dry & Art. Saliva Condition at 48 hrs time interval

Material	Condition	Mean	SD	Mean Diff	p-value
Elastics	Dry	1.237	0.269	0.122	0.16
	Art. Saliva	1.116	0.261		
E-Chain	Dry	8.791	1.531	-0.506	0.32
	Art. Saliva	9.298	1.673		

At 24 hrs, in Dry Condition, E-Chain group showed significantly highest mean Force Decay as compared to Elastics group and the mean difference was statistically significant at p<0.001. Similarly, when exposed to Artificial Saliva, E-Chain group showed significantly highest mean Force Decay as compared to Elastics group and the mean difference was statistically significant at p<0.001 .

Table 6: Comparison of mean Force Decay (in N) b/w 2 materials at 24 hrs time interval

Type	Material	Mean	SD	Mean Diff	p-value
Latex	Elastics	1.526	0.068	-6.280	<0.001*
	E-Chain	7.807	0.503		
Non-Latex	Elastics	0.999	0.080	-9.603	<0.001*
	E-Chain	10.603	0.776		

At 48 hrs, in Dry Condition, E-Chain group showed significantly highest mean Force Decay as compared to Elastics group and the mean difference was statistically significant at p<0.001. Similarly, when exposed to Artificial Saliva, E-Chain group showed significantly highest mean Force Decay as compared to Elastics group and the mean difference was statistically significant at p<0.001

Table 7 : Comparison of mean Force Decay (in N) b/w 2 materials at 48 hrs time interval

Type	Material	Mean	SD	Mean Diff	p-value
Latex	Elastics	1.425	0.109	-6.135	<0.001*
	E-Chain	7.560	0.471		
Non-Latex	Elastics	0.928	0.077	-9.601	<0.001*
	E-Chain	10.529	0.648		

At 24 hrs, considering both the type of material and the condition, the E-Chain group showed significantly higher mean Force Decay as compared to Elastics group and the mean differences were statistically significant at p<0.001.

Table 8: Comparison of mean Force Decay (in N) b/w 2 materials at 24 hrs time

Condition	Material	Mean	SD	Mean Diff	p-value
Dry	Elastics	1.301	0.250	-7.434	<0.001*
	E-Chain	8.735	1.355		
Art. Saliva	Elastics	1.225	0.303	-8.450	<0.001*
	E-Chain	9.675	1.634		

Table 9: Comparison of mean Force Decay (in N) between Elastics and E-Chain based on the type and condition at 24 hrs.

Type	Condition	Material	Mean	SD	Mean Diff	p-value
Latex	Dry	Elastics	1.540	0.027	-5.928	<0.001*
		E-Chain	7.467	0.468		
	Art. Saliva	Elastics	1.513	0.093	-6.633	<0.001*
		E-Chain	8.146	0.243		
Non-Latex	Dry	Elastics	1.062	0.063	-8.941	<0.001*
		E-Chain	10.002	0.293		
	Art. Saliva	Elastics	0.937	0.032	-10.266	<0.001*
		E-Chain	11.203	0.621		

At 48 hrs also, considering both the type of material and the condition, the E-Chain group showed significantly higher mean Force Decay as compared to Elastics group and the mean differences were statistically significant at p<0.001.

Table 10: Comparison of mean Force Decay (in N) between Elastics and E-Chain based on the type and condition at 48 hrs.

Type & (Condition)	Material	Mean	SD	Mean Diff	p-value
Latex (Dry)	Elastics	1.487	0.108	-5.873	<0.001*
	E-Chain	7.360	0.486		
Latex (Art. Saliva)	Elastics	1.363	0.069	-6.397	<0.001*
	E-Chain	7.760	0.379		
Non-Latex (Dry)	Elastics	0.987	0.047	-9.235	<0.001*
	E-Chain	10.222	0.405		
Non-Latex (Art. Saliva)	Elastics	0.868	0.049	-9.967	<0.001*
	E-Chain	10.835	0.717		

At 24 hrs, the mean force decay in Non-latex elastics when exposed to artificial saliva showed significantly lesser values as compared to Dry condition and the mean difference was statistically significant at p=0.001. Contrastingly, the mean force decay in both Latex and Non-Latex E-chains showed significantly higher values when exposed to artificial saliva as compared to Dry condition and the mean differences were statistically significant at p<0.001. However, the mean Force decay in the Latex Elastics group did not vary significantly dry condition and after exposure to artificial saliva.

Table 11: Comparison of mean Force decay (in N) in Elastics and E-chains based on diff. types and conditions at 24 hrs time interval

Material	Type	Condition	Mean	SD	Mean Diff	p-value
Elastics	Latex	Dry	1.540	0.027	0.027	0.40
		Art. Saliva	1.513	0.093		
	Non-Latex	Dry	1.061	0.063	0.124	0.001*
		Art. Saliva	0.937	0.032		
E-Chain	Latex	Dry	7.467	0.468	-0.679	<0.001*
		Art. Saliva	8.146	0.243		
	Non-Latex	Dry	10.002	0.293	-1.201	<0.001*
		Art. Saliva	11.203	0.621		

At 48 hrs, the mean force decay in Latex and Non-latex elastics when exposed to artificial saliva showed significantly lesser values as compared to Dry condition and the mean differences were statistically significant at p=0.007 & p<0.001 respectively. Contrastingly, the mean force decay in both Latex and Non- Latex E-chains showed significantly higher values when exposed to artificial saliva as compared to Dry condition and the mean differences were statistically significant at p=0.04 & p=0.03 respectively .

Table 12: Comparison of mean Force decay (in N) in Elastics and E-chains based on diff. types & conditions at 48 hrs time interval

Material	Type	Condition	Mean	SD	Mean Diff	p-value
Elastics	Latex	Dry	1.487	0.108	0.12	0.007*
		Art. Saliva	1.363	0.069		
	Non-Latex	Dry	0.987	0.047	0.12	<0.001*
		Art. Saliva	0.868	0.049		
E-Chain	Latex	Dry	7.360	0.486	-0.40	0.04*
		Art. Saliva	7.760	0.379		
	Non-Latex	Dry	10.222	0.405	-0.61	0.03*
		Art. Saliva	10.835	0.717		

The mean force decay in Latex and Non-Latex Elastics group in Dry condition or when exposed to artificial saliva did not show significant difference between 24 and 48 hours .

Table 13: Comparison of mean Force Decay (in N) between 24 & 48 hrs. in Elastics group based on the type and condition using Independent Student t Test

Type	Condition	Time	N	Mean	SD	Mean Diff	p-value
Latex	Dry	24 hrs	10	1.540	0.027	0.053	0.14

PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

		48 hrs	10	1.487	0.108		
	Art. Saliva	24 hrs	10	1.513	0.093	0.150	0.09
		48 hrs	10	1.363	0.069		
Non-Latex	Dry	24 hrs	10	1.062	0.063	0.075	0.40
		48 hrs	10	0.987	0.047		
	Art. Saliva	24 hrs	10	0.937	0.032	0.069	0.48
		48 hrs	10	0.868	0.049		

Similarly, the mean force decay in Latex and Non-Latex E-Chains group in Dry condition or when exposed to artificial saliva did not show significant difference between 24 and 48 hours.

Table 14: Comparison of mean Force Decay (in N) between 24 & 48 hrs. in E-Chain group based on the type and condition

Type (Condition)	Time	Mean	SD	Mean Diff	p-value
Latex (Dry)	24 hrs	7.467	0.468	0.107	0.23
	48 hrs	7.360	0.486		
Latex (Art. Saliva)	24 hrs	8.146	0.243	0.386	0.47
	48 hrs	7.760	0.379		
Non-Latex (Dry)	24 hrs	10.002	0.293	-0.220	0.16
	48 hrs	10.222	0.405		
Non-Latex (Art. Saliva)	24 hrs	11.203	0.621	0.368	0.30
	48 hrs	10.835	0.717		

DISCUSSION

The purpose of this study was to evaluate the force decay of intraoral elastics, latex, and non-latex elastomeric chains. The elastomeric chain was extended to 25 mm in length, while the intra-oral elastics were stretched three times their internal diameter on a stainless-steel plate. Two types of tests were performed: one involved stretching elastics to three times their internal diameter for 24 and 48 hours, in which case elastomeric chains were stretched to 25 mm at room temperature; and the other involved stretching elastics to three times their internal diameter for 24 and 48 hours, in which case elastomeric chains for both groups were stretched to 25 mm while submerged in artificial saliva.

In contrast to 100% and 200%, some studies have suggested that a pre-stretching of 50% may be beneficial in reducing force loss over time. In contrast, Yagura and Adreasen discovered a direct relationship between the amount of stretching and the persistent distortion of elastomeric chains [9].

Many writers, however, reached the inconsistent and non-clinically relevant conclusion that pre-stretching has little benefit on force decay, despite the fact that a precise evaluation of force is required for a healthy and functional tooth. Numerous investigations on the force exerted by intermaxillary elastics have been published in the literature.

Numerous studies have compared the forces released by latex and non-latex elastics. According to research, non-latex elastics lose force faster than latex elastics. It has also been proposed that because synthetic elastics differ physically from natural elastics, certain environmental factors, such as heat and moisture, may effect them differently and presumably more negatively. [10]

When compared to their initial force, the types and sizes of elastics in our study showed a decrease in force with time. When compared to the Elastics group, we discovered that the E-Chain group had much greater mean Force Decay after 24 hours. Similarly, the E-Chain group revealed a much higher mean Force Decay at 48 hours than the Elastics group. Other writers reported similar performances (Bishara and Andreasen, 1970; Brantley et al., 1979). When compared to their initial force, the types and sizes of elastics in our study showed a decrease in force over time [11].

According to our findings, the non-latex type in the Elastics group demonstrated a considerably higher mean Force Decay at 24 hours as compared to the Latex type. In contrast, the Latex type demonstrated a considerably higher mean Force Decay in the E-Chain group when compared to other Latex types.

In our investigation, the mean Force Decay under dry conditions and when exposed to artificial saliva did not exhibit any significant differences between the Elastics and E-chain groups after 24 hours.

Furthermore, after 48 hours, there was no noticeable difference in the Elastics and E-Chain groups' mean Force Decay in dry conditions or when exposed to artificial saliva. In a 2003 investigation on non-latex elastics manufactured of JEPE, Hwang and Cha discovered that the force lost after 24 hours in dry media was 24% of the initial force and 73% in wet media. According to a 2011 study by Noelia López et al., there were greater force losses in wet circumstances when there were considerable differences between wet and dry surroundings [12].

Numerous studies on the use of elastomers in dentistry and their force loss over time have produced significantly varying results. It is difficult to compare the different commodities featured due to disagreements about the many brands, materials, and testing methodologies used in these investigations.

To facilitate reliable comparisons between studies, we believe that a standardized technique for this type of testing is essential. To be explicit, this study looked at the force decay of intraoral elastics, as well as latex and non-latex elastomeric chains. Only one trademark was analyzed to ensure that the findings were accurately interpreted. It is vital to test; alternative brands and in vivo studies may respond differently.

CONCLUSION

Non-Latex type in the Elastics group had significantly higher mean Force Decay at 24 hours than Latex types. When compared to other Latex types, the E-Chain group had significantly higher mean Force Decay. The E-Chain group showed the much higher mean Force Decay after 24 hours. The E-Chain group had significantly higher mean Force Decay at 48 hours than the Elastics group.

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