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# Assessment of the force decay and the influence of pH levels on three different brands of latex and non-latex orthodontic elastics: An *in vitro* study

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**Abstract**
Elastics are one of the most versatile material available to the orthodontist. Its an invaluable tool of the orthodontist armamentarium. The effects of salivary pH levels on viscoelastic force relaxation of nonlatex interarch elastics. Great individual pH variability is noted within the oral cavity, and this can fluctuate with diet. Aim of this study was to assess the force decay and the influence of pH levels on three different brands of latex and non-latex orthodontic elastics.
**Materials And Methods:** Three stainless steel jigs with 8 sets of predetermined inter post distance of 14.8mm, 19.0 mm and 28.4 mm were fabricated to measure force degradation for 3 brands of latex and non latex elastic brands at 225%,300% and 450% and at pH 5,pH 6 and pH 7.5. An i universal testing machine (Mecmesin 10 i) is used to measure the force in grams exerted by the elastics for required percentage of stretching. Incubator (GE Electronics) was used in this study to regulate the temperature at 37 degree centigrade to simulate oral environment. Results: The percentage of force decay is less for non-latex elastics at various percentages of stretching at various time intervals and different Ph levels compared to latex group of elastics. The force degradation was observed during 3hrs-12 hrs period compared to 12hrs-24hrs irrespective of the latex and non latex elastic brands. The various levels of Ph had no significant influence in force degradation compared to time interval.
**Conclusion:** The force decay was significantly different for latex and non latex group of elastics over the time period of 24 hrs irrespective of the pH of artificial saliva.

**Keywords:** Force degradation, latex, non-latex, pH

## Introduction

Orthodontics is that branch of dentistry which deals with various force systems capable of influencing the desired response on the dentition. Ideally these force systems should provide optimal tooth-moving forces, be comfortable and hygienic to the patient, require minimal operator manipulation and chair time, require minimal patient cooperation, and be economical [1]. Elastics and elastomerics are routinely used as active component of force in orthodontic treatment. Their use combined with patient compliance provides the clinician with the ability to correct both antero-posterior and vertical discrepancies [2].

The use of latex elastics in clinical practice is mainly estimated on force extension values given by the various manufacturers for various sizes of elastics. The standard force index utilized by suppliers imply that at three times the original lumen size, elastics will exert the force mentioned on the package [3].

Elastics can be of two types namely natural and synthetic. Natural rubber may be extracted from various plants, the chief source being the rubber tree (Hevea brasiliensis) [4]. Natural rubber is a type of elastomer that forms a three-dimensional reticulate structure by cross-links of irregular twisted arrangements of long molecular chains linked together at certain points by covalent bonds [5]. Synthetic Rubber is a polyurethane rubber containing urethane linkage. This is synthesized by stretching a polyester or a polyether glycol or poly hydrocarbondiol with a di isocyanate [6].

Elastomeric chains were launched to dental profession in the 1960's and have become essential part of orthodontic practice [7]. Basically elastics of both Natural and synthetic have their greatest application in orthodontic treatment.

While naturally produced latex elastics are mainly used in the Begg technique to deliver intramaxillary elastic forces [4], synthetic elastomeric materials in the form of chains find their highest implementation in edgewise mechanics [8].
It has been discovered that rubber elastics lose a part of their initial force after they are used for oral activities such as mastication, speaking and after being exposed to various oral environments that include different salivary pH, oral temperature, foods and drinks [9].
Because of presence of allergens in latex elastics, reactions to latex carry with them a wide range of risk factors [9]. During early 90s, non-latex elastics have been made available for orthodontic use but the guidelines for the clinical application of latex elastics are not necessarily applied to non-latex elastics. For this reason, the properties of these materials need to be assessed experimentally [10].

**Aim and Objectives**

The Aim of this study was to assess the force decay and the influence of pH levels on three different brands of latex and non-latex orthodontic elastics. The objectives were: (1) To assess the influence of pH levels on force decay of three different brands of latex and non-latex orthodontic elastics. (2) To compare force decay in three different brands of orthodontic elastics subjected to different percentage of stretching in different time intervals in artificially simulated oral environment

**Materials and Methods**

This study was designed to observe the effects of pH levels on force decay among two groups of orthodontic elastics i.e. Group I latex elastics and Group II non-latex elastics. During the experiment, factors such as temperature of artificial saliva, time in solution and deformation during handling on jig board should be kept as consistent as possible.

**Materials**

**Group I -** Latex elastics

a) American orthodontics - 20 elastics
b) Dentaurum -20 elastics
c) GAC -20 elastics

**Group II-** Non -latex elastics

a) American orthodontics - 20 elastics
b) Dentaurum -20 elastics
c) GAC -20 elastics

**All brands of 1/4 of inch size interarch elastics**

1) Three stainless steel jigs with 8 sets of predetermined inter post distance of 14.8mm, 19.0 mm and 28.4 mm were fabricated to simulate 225%, 300% and 450% of stretching respectively.
2) An instron universal testing machine is used to measure the force in grams exerted by the elastics for required percentage of stretching.
3) Artificial saliva was prepared to simulate oral environment set at prescribed pH levels of 5.0, 6.0, and 7.5.

| **Inorganic constituents** | **Concentration g/ltr** | |
|---|---|---|
| potassium chloride | 1.3g/l | |
| Calcium chloride dehydrate | 0.1g/l | |
| Magnesium chloride | 0.05g/l | |
| 5 | Sodium chloride | 0.1g/l |
| 6 | Sodium fluoride | $2.5 \times 10^{-5}$ g/l |
| 7 | Potassium di hydrogen phosphate | 0.035 g/l |
| 8 | Zinc sulphate | 0.162g/l |
| 9 | Distilled water | 1000 ml |
| 10 | pH | 7 |

**Preparation of artificial saliva-** Artificial saliva solutions set at prescribed pH levels of 5.0, 6.0, and 7.5. pH levels were measured 3,12 and 24 hour using a calibrated pH/ion meter (and were adjusted accordingly with 1 M citric acid or 1 M sodium hydroxide. Solutions were incubated at approximately 37 $^{0}$C [6].
4. Incubator (GE Electronics) was used in this study to regulate the temperature at 37 degree centigrade to simulate oral environment. Air sealed plastic bags were used to prevent moisture contamination during storage.

**Methodology**

The present study was conducted on 360 elastics which were divided into two groups latex and non-latex to test the force decay at pH 5, 6, 7.5 respectively.
Using 20 elastics per treatment combination allowed two groups of all three brands to be tested simultaneously at the pH level of 5.0 6.0 and 7.5 respectively at the time interval of 3hr, 12hrs and 24hr were incubated at 37 degrees to simulate oral environment and elastics were subjected to 225%, 300% and 450% of stretching of lumen size to study force degradation, and then measured using Instron machine.
All the elastics were engaged on stainless steel jigs which expanded the internal diameter of elastics to 225%, 300% and 450%. The stainless steel jigs were immersed in artificial saliva with various pH levels of 5, 6 and 7.5 and incubated at 37 c to simulate oral environment.
Measurements are taken after the incubation of 3, 12 and 24 hrs
The data was analysed using ANOVA and results were tabulate and graphical representations were made. SPSS version 16 was used for analysis of the data.

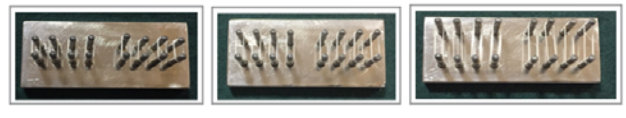


**Fig 1:** Jigs with Post Distance of 14.8mm, 19mm, 28.4mm with Elastics

**Fig 2:** Glass Petridish with Stainless Steel Jigs Immersed In Saliva of PH 5, 6, 7.5 Respectively


**Fig 3(a):** Universal Testing Machine

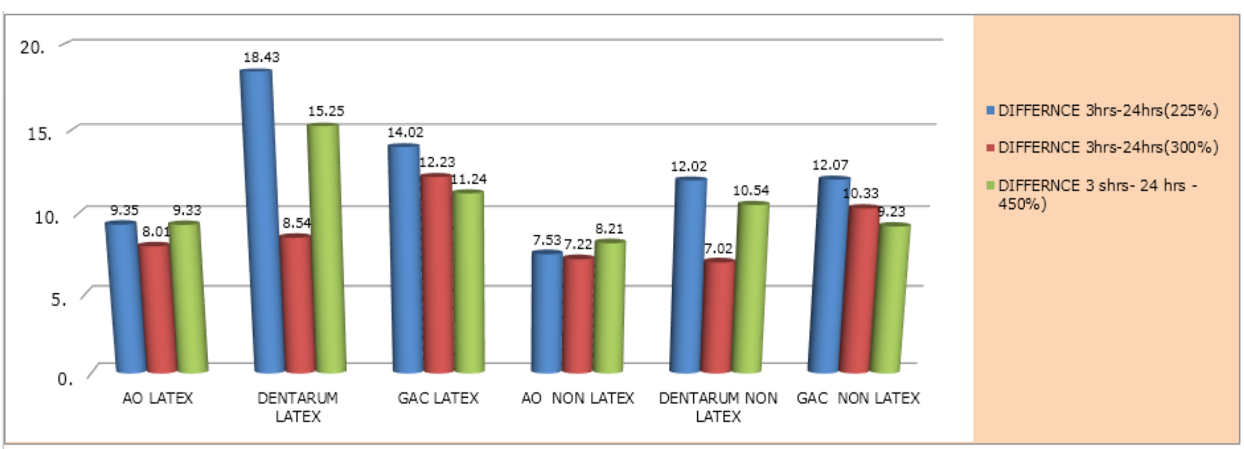
**Fig 3(b):** Jig Mounted On Machine

## Results

**Table 1:** The percentage of force decay at different time interval at pH 5

| | 3-12HRS/ pH5/225 | 12-24 HRS/ pH5/225% | Difference 3hrs-24 hrs (225%) | 3-12HRS/ pH7.5/300 | 12-24 HRS/ pH7.5/300 | Difference 3hrs-24 hrs 300%) | 3-12HRS/ pH7.5/450 | 12-24 HRS/ pH7.5/450 | Difference 3hrs-24 hrs450%) |
|---|---|---|---|---|---|---|---|---|---|
| Ao Latex | 3% | 8% | 9.35 | 1% | 5% | 8.01 | 3% | 6% | 9.33 |
| Dentaurum Latex | 8 % | 13% | 18.43 | 5% | 6% | 8.54 | 4% | 9% | 15.25 |
| Gac Latex | 7% | 14% | 14.02 | 4% | 11% | 12.23 | 2% | 6% | 11.24 |
| Ao Non Latex | 5% | 6% | 7.53 | 1% | 4% | 7.22 | 1% | 5% | 8.21 |
| Dentaurum Non Latex | 3% | 6% | 12.02 | 4% | 5% | 7.02 | 3% | 6% | 10.54 |
| Gac Non Latex | 4% | 11% | 12.07 | 3% | 9% | 10.33 | 2% | 5% | 9.23 |

Table 1 – Describes the percentage of force degradation at different time interval at pH 5 of various brands of latex and non latex elastics. For 225% of stretching the amount of force decay observed over a period of 3hr to 24 hrs in AO latex group is 9.37g and AO non latex is 7.53g, Dentaurum latex group is 18.43 g and non latex is 12.02 g and GAC latex group is 14.02 g and non latex is 12.07 g. At 300% of stretching AO latex group undergo force decay of 8.01 g and non latex is 7.22 g, dentaurum latex is 8.54 g and non latex is 7.02 g and GAC latex group is 12.23 g and non latex is 10.33 g and at 450% of stretching AO latex is 9.33 g and non latex is 8.21 g, dentaurum latex is 15.25 g and non latex is 10.54 g and GAC latex is 11.24 g and non latex is 9.23 g.

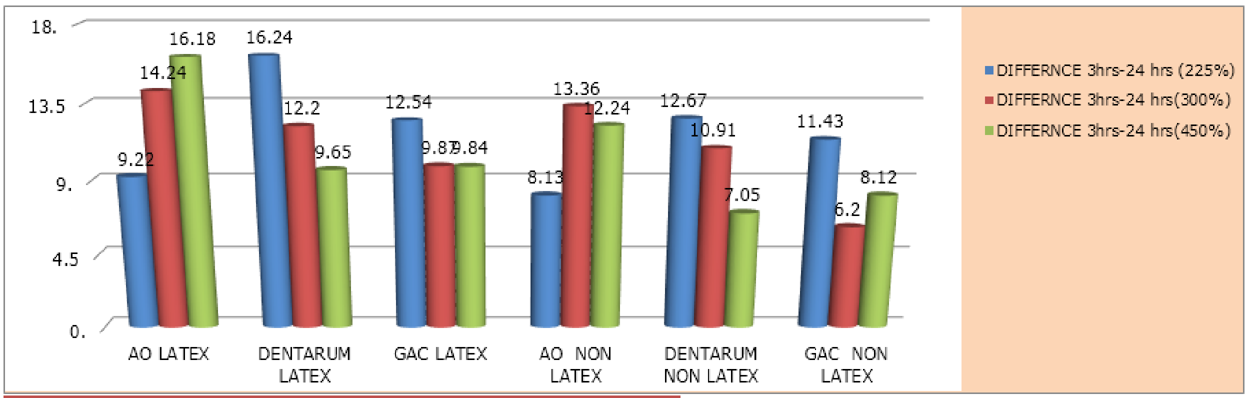



**Graph 10- force decay difference at ph 5**

**Table 2:** The percentage of force decay at different time interval at pH 6

| | 3-12HR/pH 6/ 225% | 12-24 HR pH6/ 225% | Difference 3hrs-24 hrs (225%) | 3-12HRpH6 300% | 12-24 HRS/pH6/300% | Difference 3hrs-24 hrs 300%) | 3-12HR/pH6/450% | 12-24 HRS/pH6 450% | Difference 3hrs-24 hrs 450% |
|---|---|---|---|---|---|---|---|---|---|
| Ao Latex | 4% | 7% | 9.22 | 6% | 10% | 14.24 | 2% | 8% | 16.18 |
| Dentaurum Latex | 6% | 9% | 16.24 | 7% | 9% | 12.20 | 3% | 4% | 9.65 |
| Gac Latex | 5% | 7% | 12.54 | 2% | 6% | 9.87 | 5% | 6% | 9.84 |
| Ao Non Latex | 2% | 6% | 8.13 | 6% | 9% | 13.36 | 2% | 7% | 12.24 |
| Dentaurum Non Latex | 7% | 12% | 12.67 | 4% | 8% | 10.91 | 3% | 3% | 7.05 |
| Gac Non Latex | 7% | 9% | 11.43 | 4% | 4% | 6.20 | 3% | 5% | 8.12 |

Table 2 – Describes the percentage of force degradation at different time interval at pH 5 of various brands of latex and non latex elastics. For 225% of stretching the amount of force decay observed over a period of 3hr to 24 hrs in AO latex group is 9.22g and AO non latex is 8.13g, Dentaurum latex group is 16.24g and non latex is 12.67g and GAC latex group is 12.54g and non latex is 11.437g. At 300% of stretching AO latex group undergo force decay of 14.24g and non latex is 12.24g, dentaurum latex is 12.20g and non latex is 10.91g and GAC latex group is 9.87g and non latex is 6.20g and at 450g of stretching AO latex is 16.18g and non latex is 12.24g, dentaurum latex is 9.65g and non latex is 7.05g and GAC latex is 9.84g and non latex is 8.12g.

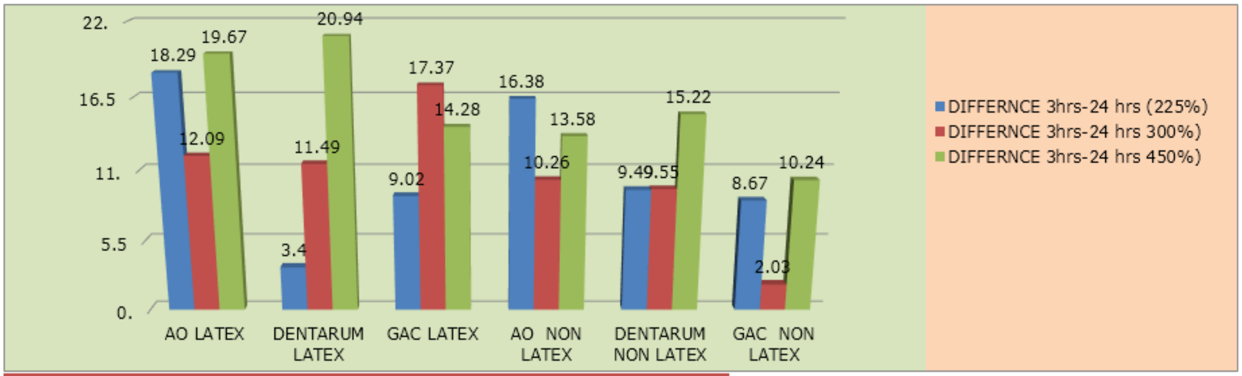



**Graph 11- force decay difference at ph 6.5**

**Table 3:** The percentage of force decay at different time interval at pH 7.5

| | 3-12HRPH7.5225% | 12-24 HRS/ PH7.5225% | Difference 3hrs-24 hrs (225%) | 3-12HRS/ PH7.5/300% | 12-24 HR/ pH7.5 /300% | Difference 3hrs-24 hrs 300%) | 3-12HR pH7.5 450% | 12-24 HRS/ PH7.5450% | Difference 3hrs-24 hrs 450%) |
|---|---|---|---|---|---|---|---|---|---|
| Ao Latex | 2% | 8% | 18.29 | 7% | 13% | 12.09 | 7% | 14% | 19.67 |
| Dentaurum Latex | 3% | 4% | 3.40 | 6% | 10% | 11.49 | 6% | 10% | 20.94 |
| Gac Latex | 5% | 6% | 9.02 | 7% | 14% | 17.37 | 7% | 12% | 14.28 |
| Ao Non Latex | 2% | 7% | 16.38 | 6% | 11% | 10.26 | 6% | 13% | 13.58 |
| Dentaurum Non Latex | 3% | 3% | 9.49 | 4% | 8% | 9.55 | 4% | 8% | 15.22 |
| Gac Non Latex | 3% | 5% | 8.67 | 6% | 11% | 2.03 | 6% | 10% | 10.24 |

Table 3 – Describes the percentage of force degradation at different time interval at pH 5 of various brands of latex and non latex elastics. For 225% of stretching the amount of force decay observed over a period of 3hr to 24 hrs in AO latex group is 18.29g and AO non latex is 10.26g, Dentaurum latex group is 3.40g and non latex is 9.49g and GAC latex group is 9.02g and non latex is 8.67g. At 300% of stretching AO latex group undergo force decay of 12.09g and non latex is 13.58g, dentaurum latex is 11.49g and non latex is 9.55g and GAC latex group is 14.28g and non latex is 10.24g and at 450% of stretching AO latex is 19.67g and non latex is 13.58g, dentaurum latex is 20.94g and non latex is 15.22g and GAC latex is 14.28g and non latex is 10.24g.




**Graph 12- force decay difference at ph 7.5**

**Discussion**

In orthodontics many materials such as arch wire loops, coil springs, latex elastics and synthetic elastomers are used to apply force to move the teeth. Elastics and elastomerics are used as an active component of orthodontic treatment such as retraction, cross-bite correction, space closure [7].

Force degradation happens over time among most types of traction aids are currently available. In oral cavity various factors can influence on force generation and force degradation of traction aids, such as saliva, temperature fluctuation, pH variation, fluoride ions release, oxygen content, free radicals, salivary enzymes and masticatory forces [11].

In the mouth, elastics experience constant force expression, with considerable force decay through the first day of use. Most of it being in the first hour of the use. Lumen size influences force decay with smaller size needing to be renewed more often to maintain planned force application [12].

It is reported in many literature about the potential importance of relaxation of elastics, there is an factual rule - that is rule of 3, which denotes that the elastics exert the certain force at an extension of 300% of their diameter [13].

Some studies found that rubber elastics will lose a part of their initial force after they are used in the mouth for the various oral activities. Few in vitro studies have been designed to simulate different kinds of saliva, stretching and even the daily diet in order to assess the changes of elastics [27]. Elastics elicit constant force expression with certain amount of force decay through the first day of use. Most of the force decay is in the first hour [14, 15].

So the purpose of this study was to assess the force degradation at stretching level of 225%, 300% and 450% and also at various pH levels such as 5, 6 and 7.5 between the various latex and non latex groups.

The present in-vitro study was conducted at Analytical Research Metallurgical Laboratories Pvt Ltd using Universal testing machine (Mecmesin–Multitest 10zi), Load cell used: 10 kg, Cross head speed of Indenter: 25mm per minute to check the force values and different stretching levels in an artificial salivary medium with different pH levels using 3 different latex and non- latex elastic brands.

The present study showed the force degradation at 225% stretching and pH 5 between 3hrs and 24 hrs was least for AO non latex group of elastics (degradation of 7.5g) indicating better quality compared to the highest force degradation of 18.43g among DENTAURUM latex elastics groups. The percentage of force degradation highest was observed for GAC (14%) over a period of 24 hrs. As shown in (table 1 and graph1)

Force extension relaxation was evaluated at 3hrs, 12 hrs and 24 hrs and not longer than 24 hrs because of clinical trends reported in many studies [16, 17, 12]. Patients usually are required to discard the elastics after 1 day use. Most frequent changes could be seen in dolicofacial patients, in whom any kind of elastics relaxation could lead to increased vertical forces and unwanted extrusion results. Few Authors suggested that the force relaxation was remarkably constant after 1 day of elastic usage because structural changes caused by repeated stretching were not cumulative [18]. Further more the stretching force reduction was relative less averaging 2 to 6% over the second day of clinical use, and remained relatively constant for a few days. Many studies suggest that after 24 hours force degradation could be considered insignificant [16, 15, 19].

The force measurement system in the present study is similar to that used by Russel *et al*. [8] A significant advantage of the system was the ability to test over time without removing the samples for hand measurement.

When the elastics were stretched to 300% with pH 5 between 3hrs and 24 hrs, DENTAURUM non latex groups showed minimum force degradation (7.02g) and AO non latex group reported a lowest of 4% degradation during 24 hrs. Highest force decay was observed with GAC latex and non latex groups respectively over 24 hrs (11% and 9%). As shown in (table 1 and graph 1)

Stretching of elastics at 450% with similar pH 5 showed force degradation was highest was for DENTAURUM latex groups over 24 hrs period (9% and 15.25g) Lowest force degradation was observed for AO non latex (5% and 8.21). As shown in (table 1 and graph 1)

The present study reported the force degradation highest for DENTAURUM non latex (12%) and lowest for AO non latex groups (6% and 8.13g) when the elastics were stretched to 225% and immersed at a pH 6 which is more alkaline compared to previous artificial saliva pH.). As shown in (table 2 and graph 2)

When the elastics were stretched to 300% at a pH 6 highest loss of force was observed among the AO latex groups (10% and 14.24g) and lowest force was seen among GAC non latex group (4% and 6.20g) over a 24 hrs period. As shown in (table 2 and graph 2)

Similarly the stretching of elastics to 450% at pH 6 showed highest force degradation for AO latex (8%) and lowest for DENTAURUM latex elastics (3%).As shown in (table 2 and graph 2)

At pH 7.5, Stretching of elastics to a force of 225% showed highest degradation for AO LATEX elastics (8%) and lowest was seen for DENTAURUM non latex group (4%). At 300% highest was seen for GAC latex (14%) and lowest force degradation was for DENTAURUM non latex (8%) and at 450% stretching highest was seen among AMERICAN ORTHODONTICS LATEX (14%) and lowest was reported for DENTAURUM non latex group of elastics (8%) As shown in (table 3 and graph 3).

In the present study comparison of latex and non latex groups at various stretching and pH levels showed latex elastics were shown more force decay than non latex groups over the time. Similar results were reported by Russel KA *et al*. [2] and Keresy ML *et al*. [14]

Kersey ML [20] reported that the difference in percentage of force decay decreased from initial to 24 hrs period was 15.6% in non latex elastics groups and 8.2% for the latex elastics is similar to the present study.

Because of the variability in initial force values, force decay was compared by using percentage of initial force rather than actual force generated. many studies show the rates of force degradation were higher, the type of force degradation for nonlatex elastics in the present study were similar to the results for immersed latex elastics of Kanchana P. [17] who reported 10% to 20% force degradation at 3hour and relatively less further degradation at 24 hours.

In the present study pH is not a significant contributor to force decay. Over the 24 hours span of the experiment, time appeared to be influential, with latex group of elastics exhibiting a marked decrease in force within the first 3 hours, regardless of pH. The rapid decrease in force is consistent with many studies in the literature.

## Summary

The present study was done to assess the force decay and the influence of pH levels on three different brands of latex and non-latex orthodontic elastics. i.e. Group I latex elastics and Group II non-latex elastics. The elastic brands were 1) American orthodontics 2) Dentaurum and 3) GAC.

The present study was conducted on 360 elastics which were divided into two groups latex and non latex to test the force decay at pH 5, 6, 7.5 respectively.

Using 20 elastics per treatment combination allowed two groups of all three brands to be tested simultaneously at the pH level of 5.0, 6.0 and 7.5 respectively at the time interval of 3hr, 12hrs and 24 hr are incubated at 37 degrees to simulate oral environment and elastics are subjected to 225%, 300% and 450% of stretching of lumen size to study force degradation, and then measured using universal testing machine (Mecmesin-Multi test 10-i). Measurements were taken after the incubation of 3, 12 and 24 hrs. At pH 5 the observed force decay was as follows at different levels of stretching, AO < DENTAURUM < GAC In non latex and LATEX group. At pH 6 observed force decay was as follows at different level of stretching, AO < GAC < DENTAURUM. In non latex and LATEX group. At pH 7.5 observed force decay was as follows at different level of stretching DENTAURUM < AO < GAC In non latex and LATEX group.

## Conclusion

The present study concluded as follows.

1. The percentage of force decay is less for non-latex elastics at various percentages of stretching at various time intervals and different Ph levels compared to latex group of elastics.
2. The force degradation was observed during 3hrs-12hrs period compared to 12hrs-24hrs irrespective of the latex and non latex elastic brands.
3. The various levels of pH had no significant influence in force degradation compared to time interval.
4. The amount of force was higher observed for larger amount of stretching.
5. At pH 5 the observed force decay was as follows at different level of stretching,
   AO < DENTAURUM < GAC In non latex and LATEX group.
6. At pH 6 observed force decay was as follows at different level of stretching,
   AO < GAC < DENTAURUM In non latex and LATEX group.
7. At pH 7.5 observed force decay was as follows at different level of stretching DENTAURUM < AO < GAC In non latex AND LATEX group Further in-vivo studies may be advocated to know the effects of various pH level on force decay for different elastic brands.

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