ORIGINAL PAPER

DOI: https://doi.org/10.20883/jms.316

Force decay of intermaxillary orthodontic elastics: in vitro study

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ABSTRACT

Introduction. Orthodontic elastics are widely used in orthodontic treatment. It's been proved that they have advantages such as low cost, ease of use, but also disadvantages, mainly force decay in time and increased entrapment of biofilm. Amount of the force is of extreme significance. This force can be altered by physical or chemical factors.
Material and Methods. Latex elastics in 3 different diameters were selected for this study. Each elastic was stretched and placed on hooks that are at specified distances that equal 3 times the diameter of each elastic. The forces produced by stretching was measured using tension gauge and the measurement were taken at specific time intervals of 0h, 3h, 12h, 24h. The same process was repeated for elastics in dry and artificial environment.
Results. Elastics in the dry environment showed progressive force decay cause by stretching over time. Just after 3 hours force decay between 6,07% and 8,75% was observed. The biggest loss of force between 13,61 – 16,13 % was measured after 24 hours. Compared to the dry environment, an even more significant force decay was observed in the artificial saliva. After first 3 hours force loss was between 4,99% – 9,22%. The biggest force decay was observed after 24 hours and it was 5 % higher compared to dry environment.
Conclusions. 1) The artificial saliva environment and time of exposure to it, have a negative effect on the properties of elastomeric. 2) To maintain the effective orthodontic strength of elastics, they should be replaced every 12 hours.

Keywords: force decay, orthodontic elastics, artificial saliva, elastomeric.

Introduction

As technology evolves, orthodontic elastics are being increasingly used in orthodontics when treating with the use of permanent braces. They are the source of force necessary in the biomechanics of tooth movement [1]. The idea for using elastic material started in mid 1960s [2]. In 1970 Andreasen and Bishara conducted first research on elastomeric chains. In the years that followed, more researchers have provided benefits of elastic material used in orthodontics, involving elastomeric chains and intraoral elastics, such as ease of use, low cost [3–5]. However, there are disadvantages, mainly degradation of elastic material that result in force decay in time and increased entrapment of biofilm [6–7].

The amount of orthodontic force depends on the type and size of the elastics used. The two types of elastics that are used to achieve this effect are the latex and non-latex types. Both ensure biocompatibility with the mucosa, and patient comfort. The non-latex are made of synthetic material (polyurethane) and are used in patients who are allergic to latex [8–9].

Orthodontic elastics have two defining parameters: their diameter (1/8", 3/16", 1/4", 5/16", 3/8") and the force they generate (2.5 oz, 3.5 oz, 4.5 oz, 6.5 oz). Elastics as the source of orthodontic power can be applied in orthopedic treatment e.g. extraorally in combination with a facial mask or they can be applied intraorally — stretched between the upper and lower aligners [10]. The amount of force applied is of extreme significance to the success of the treatment. This force can be altered by physical or chemical factors. Laboratory research assessing the properties of latex and non-latex elastics has shown that force decay is more significant in the non-latex [11–12].

Aim

The aim of this study was to assess the changes in force produced by orthodontic elastics in the oral cavity environment.

Material and Methods

The latex elastics chosen for the study came from one manufacturer (American Orthodontics) and in three different diameters (3/16", 4/16", 5/16"), all generating the same force (4.5 oz). According to the manufacturer, at three times the inner lumen stretch, the elastomer should produce a force of 4.5 oz. All the elastics used in the study were delivered on the same day, checked for use by dates and stored according to the instruction manual. 500 elastics of each size were submitted to the presellection process of the study. Torn or deformed pieces were discarded. This process was repeated for each of the diameters. 50 elastics of each diameter (3/16", 4/16", 5/16") were selected for the study in which the force they generate at different time intervals (0.3h, 12h, 24h) and in two different environments (dry and with artificial saliva) was observed. To observe the behavior of elastomers in vitro in the environment of the oral cavity, an artificial saliva solution has been prepared according to the data in **Table 1** [13].

Table 1. Artificial saliva components

Chemical component	g/l
NaCl	0,7
KCl	1,2
KH_2PO_4	0,2
$NaHCO_3$	1,5
Na_2HPO_4	0,26
KSCN	0,33

In order to carry out the study, plexiglass tiles with metal hooks placed at set distances (14.4 mm, 19.2 mm, 23.7 mm) that equal three times the diameter of each elastic were prepared. The elastics remained stretched on those hooks for the entirety of the study. The force produced by stretching the elastic three times, was measured in g/pound using a Haag-Streit Diagnostics Correx 250 g tension gauge (**Figure 1**) and the measurements were taken at specific time intervals of 0h, 3h, 12h, 24h — separately for each size of elastic. All those measurements were recorded by the same researcher. The same process was repeat-

Figure 1. Correx tension gauge

ed for the elastics submerged in room-temperature artificial saliva.

The results were analyzed using the Mann-Whitney test in order to assess the statistical differences between the effect of force produced by each size of the elastics in both dry and artificial saliva environments. The Dunn test was used to compare paired results (0–3h, 0–12h, 0–24h, 3–12h, 3–24h, 12–24h). The statistical significance threshold was set at p = 0.05.

Results

The average amount of force generated by orthodontic elastics in the dry and artificial saliva environments at different time intervals is presented in **Table 2**. The force decay of orthodontic elastics expressed in % at given time intervals (t1 = 0–3h, t2 = 0–12h, t3 = 0–24h) is pictured in **Figures 2, 3** and **4**.

The elastics in the dry environment showed progressive force decay caused by stretching over time and the differences were statistically significant. Just after 3 hours of stretching, a force decay between 6,07% and 8,75% was observed. After 12 hours the force decay was at 11,39–11,94%. The biggest force decay of 13,61–16,13% was observed after 24 hours.

Compared to the dry environment, an even more significant force decay caused by stretching over time was observed in the artificial saliva environment. In the first three hours of stretching the force decay was at 4,99–9,22%. After 12 hours the force decay was at 10,60–14,64%. The biggest force decay was observed after 24 hours and it was 5% higher than in the elastics placed in the dry environment.

While conducting the study, it has been observed that the oral cavity environment and particularly the saliva solution, influence the mechanical properties of the elastic elements

Table 2. Elastics mean force values (g/pound + SD)

		t=0	SD	t=3	SD	t=12	SD	t=24	SD
Dry enviroment	3/16	122	10,35	114,6	8,32	108,1	9,94	102,5	6,80
	4/16	121,2	6,82	110,6	7,60	107	6,14	104,7	6,58
	5/16	114,7	7,38	105,7	8,86	101	8,33	96,2	6,19
Artificial saliva	3/16	114,2	9,60	108,5	8,10	102,1	7,36	92,4	6,72
	4/16	116,1	7,65	105,4	8,32	99,1	7,54	91	5,62
	5/16	104,1	9,73	98,7	8,13	91,5	9,22	86,7	5,94

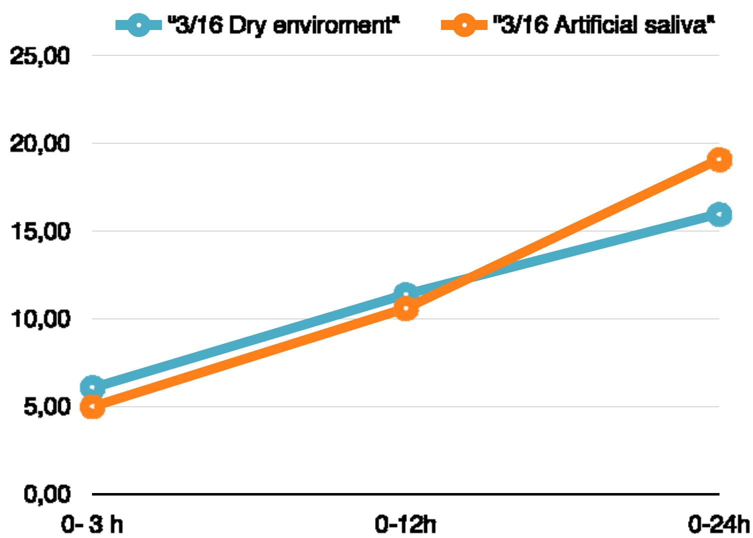

Figure 2. Force decay percentage comparison of 3/16 elastics in two enviroments

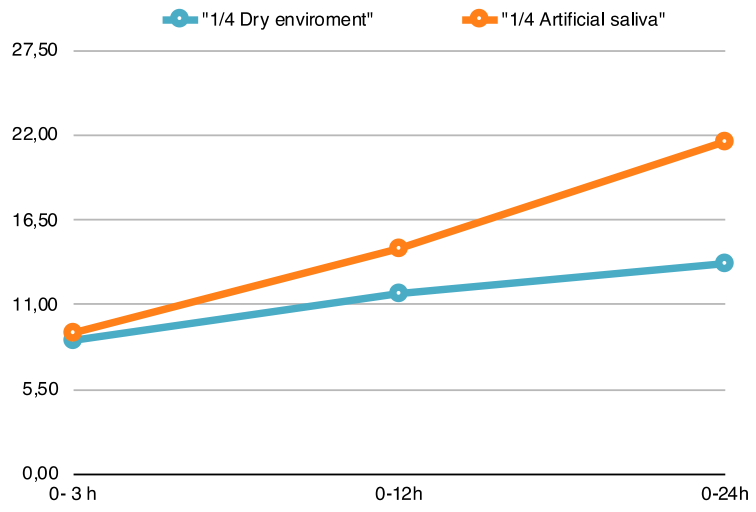

Figure 3. Force decay percentage comparison of 4/16 elastics in two enviroments

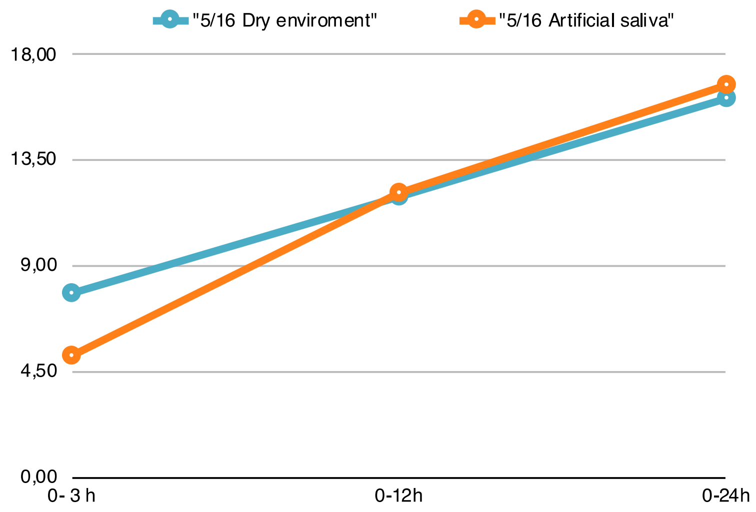

Figure 4. Force decay percentage comparison of 5/16 elastics in two enviroments

used in orthodontics. Kumar et al. came to similar conclusions when studying force decay of another type of orthodontic elastic elements — elastomeric chains. The researchers have observed a force decay of almost 50% after exposure to tea solutions and a 22% force decay after exposure to Coca-Cola [14]. In their in vivo study of mechanical properties of orthodontic elastics, Pithon et al. have compared force decay of latex and non-latex elastics. After 12 hours of usage by the patient, the 1/4" and 5/16" non-latex elastics have produced more orthodontic force then their latex counterparts. After 24 hours of wear, the 1/8" diameter latex elastics recorded the smallest force decay of those observed [15].

During orthodontic treatment, the elastic elements are exposed to the influence of many different factors such as solutions, individual composition of a patients saliva which includes a changing pH, dental hygiene treatments, various types and temperatures of ingested food, or the muscle force of the stomatognathic system during speaking and chewing. When analysing the force required in the biomechanics of orthodontic treatment, it is necessary to take into account the physical, mechanical and chemical factors that influence the elastic elements.

Conclusions

1. The orthodontic elastics have shown a progressive force decay.
2. The artificial saliva environment and time of exposure to it, have a negative effect on the properties of elastomers.

3. To maintain the effective orthodontic strength of elastics, they should be replaced every 12 hours

Acknowledgements

Conflict of interest statement
The authors declare no conflict of interest.

Funding sources
There are no sources of funding to declare.

Author contributions
HK, BB — conception and design, data analysis, interpretation; HK, AO, EF, AB — article drafting or critical advice; HK, BB — final approval.

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Acceptance for editing: 2019-05-09
Acceptance for publication: 2019-06-29

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