ISSN: 1812–1217

The Force Degradation of Elastic Chain in Different Environments and for Different Intervals (An In Vitro Study)

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ABSTRACT

Aims: This study designed to determine the force degradation of elastomeric chains (Dentaurum) at different time intervals in different media (air, distill water, Biofresh mouth wash and artificial saliva) and to compare the effect of wet and dry conditions on the force relaxation. **Materials and methods:** forty new modules of elastomeric chain of sex loops length divided into 4 main groups according to the environment (air, distill water, Biofresh mouth wash "F" and artificial saliva pH 6.75)and stored in an incubator at 37°C, Mean load were recorded for the samples at each time interval zero,1, 24 hour and 1 and 3 weeks respectively, the load measurement were done by tensile testing machine with use of special fixture to hold the samples and stretched over special framework. **Results:** The results showed that the mean percent force remaining of elastics is affected by stretching, water absorption, chemicals and times and the amount of loss in dry is less than in wet environments and especially in biofresh mouth wash more than the neutral saliva. **Conclusions:** the elastomeric chains are greatly affected by stretching, moisture and time.

Key wards: force degradation, elastic chain, mouth rinse.

Al-Kassar SS. The Force Degradation Of Elastic Chain In Different Environments And For Different Intervals (An In Vitro Study). *Al–Rafidain Dent J.* 2011; 11(2):231-237.
Received: 12/11/2008 ***Sent to Referees:*** 13/11/2008 ***Accepted for Publication:*** 5/4/2009

INTRODUCTION

The orthodontist must plan how to close any space that is not devoted to relief of crowding; whether anterior retraction, posterior protraction, or a combination of both.[1,2] Closure of spaces in the dental arch can be done with a variety of traction aids, like closed coil springs, elastomeric chain and other methods. However, force loss over time has been documented among most types of traction aids currently available3 In oral cavity, many factors can affect on force production and force degradation of traction aids, such as saliva, temperature fluctuation,[1] pH variation, [3],fluoride ions and rinses,[3] oxygen content[4],free radicals,[5] salivary enzymes and masticatory forces.[6] This force loss makes it difficult for orthodontists to determine the actual force transmitted to dentition.[7, 10, 27] From many years ago since about 1800s and elastomeric materials used in dental practices, they are used to produce force form many uses may be dental or skeletal.[5] Elastomeric chains were introduced to the orthodontic profession in the 1960s, and are now an integral part of many practices, and largely replaced latex elastics for intra-arch tooth movement.[5] The elastomers are amorphous, cross-linked polymers that have number of bridges between the linear molecules that form a three-dimensional network which at rest tend to be distributed at random, irregular pattern of folded linear molecular chain which holed each other by van der waals (secondary bonds).[6] Elastomeric chain are economical and easy to use though they absorb water and saliva, permanently stain and suffer of breakdown of internal bonds, that lead to permanent deformation. Also, elastomeric chain undergoes stress relaxation (degradation), which is a decrease in the magnitude of force transmitted while held at a fix strain. This relaxation is in part due to rearrangement within the polymer structure.[34] Eliades *et al* [16] state that the mechanism of permanent deformation of polymeric materials include molecular chain stretching, slippage between adjacent molecular chain, and molecular chain scission. During stretching, the material is subject to an instantaneous elastic deformation. As the

load is maintained, there is retarded elastic deformation, as well as an irreversible viscous deformation, producing permanent elongation (depending on the load). During unloading, the instantaneous elastic strain is immediately recovered, followed by a decay of the retarded elastic strain. The term "creep compliance"encompasses all three aspects, the instantaneous elastic deformation, the retarded elastic deformation, and the permanent deformation.[13] The use of chlorhexidine mouth rinse has become more popular especially at the first four to eight weeks of orthodontic therapy. Because plaque control in the early stages of orthodontic appliance therapy may be compromised and chlorhexidine can be prescribed for that reason.[36] The aims of this study is to determine the force produced and force degradation of elastomeric chains (Dentaurum) at different time intervals in different media (air, distilled water, Biofresh mouth wash and artificial saliva) and to compare the effect of wet and dry conditions on the force relaxation.

MATERIALS AND METHODS

The samples were forty new modules of elastomeric chain of six loops length with an extra-half loop was allowed at the two ends of the sample to prevent distortion while cutting of the chain. These samples were divided into four main groups according to the media (air, distilled water, Biofresh mouth wash "F" and artificial saliva), 10 samples for each, pH of artificial saliva was 6.75 ± 0.15. The water and artificial saliva were changed every two days throughout study and were kept in covered glass containers to prevent evaporation and consequent pH changes. All samples were stored in an incubator at 37°C to resemble body temperature and held in air at room temperature (30-35°C) throughout measuring period. Mean load were recorded for the samples at each time interval zero, 1, 24 hour and 1 and 3 weeks respectively for a total of 200 measurements. Every chain was stretched between two hooks from the u-beams were prepared according to Ferriter *et al*[19] as showed in the figure.

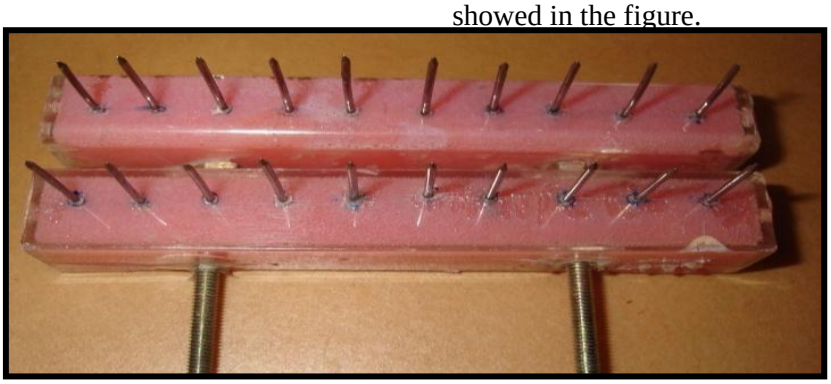


Figure : The U Shape Acrylic Block

The lengths of extensions of traction aids samples are chosen so that each sample will produce a (200 ±5)gm force at that extension, this force used by study of Bousquet et al, this force range are considered a force within physiological limit.[3, 31] The method of determining the sample extension length in a relation to a specific force value produced by that extension, was used by Ferriter *et al*. Each fixture consists of metallic ruler (with milimeter graduation), the ruler was cut in (L) shape. A stainless steel pin was soldered to the middle of the (L) shaped ruler in a horizontal direction. This ruler was attached in an upper clamp in the universal tensile testing machine. A similar ruler was prepared in the same manner and attached in the lower clamp in the machine. The purpose of these fixtures was for attachment of samples in the tensile testing machine to measure force production. After that, the sample returns back to its place in channels with the aid of tucker and this procedure was repeated for all samples and at every time intervals. Channels were initially adjusted to permit stretching of elastic chains to the predetermined distance including air, Distall water, biofresh mouth wash 'F' and artificial saliva but later were reduced (simulating tooth movement) at rate of 0.5mm per two weeks by a screw threaded mechanism (studs) to simulate tooth movement. The

blocks removed from saliva solution and immersed inside mouthwash solution (Biofresh 'F') which present inside glass containers and stored inside the same incubator at 37°C. The immersion period inside mouthwash solution was for two minutes [11] twice daily for three weeks. After the end of two minute immersion period; the loaded blocks were returned to artificial saliva container (at 37°C) until next mouth wash immersion period. The term "initial force" was reserved for the force values recorded during the first stretch of the material when taken from the manufacturer's envelopes, i.e., the material was not manipulated before being stretched.[11] From the initial force (IF) value the percentage of force degradation (FD) can be obtained according to the following equation[21]:

% FD = 100 × [(IF-Ft) / IF]…Where:

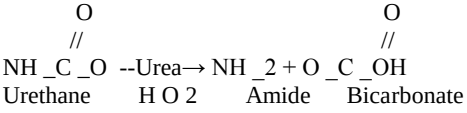
IF = initial force.

Ft = force at specific period of time.

Descriptive Statistics, one way ANOVA tests and Duncan multiple range tests are used to measure the amounts of force Production and Force Degradation of Elastic Chain in All Incubation Media And At four Time Intervals.

RESULTS AND DISCUSSIONS

It is clear from Table 1; the force decay was increased with respect to time intervals for the elastic chain and at different environments, and illustrated a higher percentage of force loss in elastics incubated in biofresh and artificial saliva than those in air. This finding in agreement with Al-Ghazi[1]. ANOVA test (Table 1) showed statistical significant differences in mean percent force remaining at each time interval of follow up from one media to another in each company. Then Duncan's multiple analysis range test was done for each media in mean percent force remaining at each time interval of follow up and showed statistical significant differences for all groups (Table 2) The force decay in distilled water, biofresh and artificial saliva was more than in dry media due to stretching effect and water sorption by leaching out of some element from elastic after immersion in water due to its susceptibility to hydrolysis[29] also water molecules may act as plasticizers and negatively affect the intermolecular attraction forces of the chains of elastomers[22] .The water cause swelling of elastic due to filling of the voids in the rubber matrix by fluids lead to microstructure cracks with consequent breakdown in the intermolecular bond leads to loss of force delivered.[17] Further more, force decay in artificial saliva was more than in distilled water because it contains many chemicals that probably change properties of elastomeric chain and associated with deformation, force degradation and relaxation behavior. Urea which is present in artificial saliva has a great negative effect on polyurethane cross linkage because it has the ability to attack bond between the NH and C which lead to weaken the elastomers.[9]



While in dry media, the force decay was due to the of stretching only because this make uncoiled chain to slip past each other and these chains held by secondary bonds which are weak and can not withstand the stretching so rupture of these bonds lead to decrease in force delivered since only stretched chain can carry load. The number of the ruptured chain increased with time and end with broken of the primary bonds and appearance of permanent deformation which manifested as a decrease in the constancy of the force. Since, long duration storage of elastomeric chains in water was found to be substantially increased in force decay rate.[1, 6, 20] The force degradation of elastic chain in biofresh solution more than others this could be due to fluoride ions which present in mouthwash solution may have role in degradation process, Von Frounhofer *et al* [34] state that exposure of Elastic Chain to topical fluoride affect the elastic properties of EC and increase the distraction of EC required to deliver initial force. Chlorhexidin present in mouthwash solution may also play a role in increasing the degradation of elastomers, Evangelista *et al* [18] suggest that the aqueous component or the chemical substance in the disinfectant solution may plasticize or cause disruption of the intermolecular bonds and

degradation of the elastomers. They also mentioned that in the process of storing elastomers in solution, water gets incorporated into the polymer, both water and detergents have a plasticizing effect on most polymers, which causes the polymeric chains to slip past each other, especially under load. The combination of the detergent and water would be an especially potent plasticizer. The non significance difference between effect of mouth wash solution and artificial saliva of normal pH may be due to short period of immersion in mouth wash (two minutes) that was not enough to show different effect from artificial saliva of normal pH. The smallest Force Degradation percent among all media and time experienced was shown in Elastic Chain samples present in dry condition and tested after 1 hour after extension. The mechanism of permanent deformation and rearrangement within the polymer structure, effect of air and effects of free radical generating systems (ozone and ultraviolet light) might be the cause of Force Degradation in dry condition after 1 hour. [7, 10, 13, 15, 20, 23, 30, 34, 35]

Table (1): Descriptive Statistics and Duncan's Test Of Force Production And Force Degradation Of Elastic Chain In All Incubation Media And At four Time Intervals.

Type Of Media	Time	N	Mean FP**	% of FD	SE	Min.	Max.	Duncan's Groups***
Dry	**0 Hour**	10	201.70	0%	0.597	198	204	P
Dry	**1 Hour**	10	174.20	13.63%	1.172	168	179	N
Dry	**24 Hour**	10	149.20	26.02%	0.854	145	154	L
Dry	**1 Week**	10	126.80	37.13%	0.533	124	129	J
Dry	**3 Weeks**	10	117.30	41.84%	0.597	114	120	G
Artificial Saliva	**0 Hour**	10	200.70	0%	0.746	196	203	P
Artificial Saliva	**1 Hour**	10	147.90	26.3%	0.737	145	151	KL
Artificial Saliva	**24 Hour**	10	111.50	44.44%	0.898	107	115	H
Artificial Saliva	**1 Week**	10	76.10	62.08%	0.690	73	80	D
Artificial Saliva	**3 Weeks**	10	63.80	68.21%	0.800	59	68	B
Distill Water	**0 Hour**	10	200.40	0%	0.653	196	203	P
Distill Water	**1 Hour**	10	153.80	23.25%	0.952	149	159	M
Distill Water	**24 Hour**	10	121.30	39.47%	0.803	118	126	H
Distill Water	**1 Week**	10	91.20	54.49%	0.593	88	94	E
Distill Water	**3 Weeks**	10	79.70	60.22%	0.597	77	82	C
Biofresh m. w.	**0 Hour**	10	200.20	0%	0.573	197	203	O
Biofresh m.w.	**1 Hour**	10	147.00	26.57%	0.830	143	151	K
Biofresh m. w.	**24 Hour**	10	108.70	45.7%	0.684	105	113	F
Biofresh m. w.	**1 Week**	10	70.90	64.58%	0.567	69	74	C
Biofresh m. w.	**3 Weeks**	10	60.20	69.93%	0.593	57	63	A

* Methods used for initial force determination. **The mean was in grams measurement, *** Different letters mean significant different at $p \leq 0.005$. m. w.= mouth wash

Table (2): One – Way ANOVA Analysis For Amount Of Force Production Of Elastic Chain In all Incubation Media And At four Immersion Periods.

Media		SS	DF	MS	F-test	Sig.
Dry	**Between Groups**	47929.72	3	11982.430	1932.65	< 0.001
	Within Groups	279.000	45	6.200		
	Total	48208.72	49			
Artificial Saliva	**Between Groups**	124488.0	3	31122.000	5148.860	< 0.001
	Within Groups	272.000	45	6.044		
	Total	124760	49			
Distall Water	**Between Groups**	117277.080	3	29319.270	5385.172	< 0.001
	Within Groups	245.000	45	5.444		
	Total	117522.080	49			
Biofresh mouth wash 'F'	**Between Groups**	132417.8	3	33104.450	7670.959	< 0.001
	Within Groups	194.200	45	4.316		
	Total	132612.0	49			

SS: sum of squares, Df: Degree of freedom, MS: Mean square

CONCLUSIONS

The elastomeric chains are greatly affected by stretching, moisture and time; exhibit rapid force loss comparing with dry condition, and the biofresh mouth wash cause more force degradation than in artificial saliva.

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