Effect of Some Carbonated Drinks on Force Decay of Elastomeric Chains: an in Vitro Study

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ABSTRACT:

The aim of this study was to evaluate the effect of some carbonated drinks on the force decay properties of commercially available elastomeric chains. 200 short elastomeric chains of two types, conventional and memory chains, were evaluated under the same conditions (150-200 gm at 25 mm). The samples were divided in five groups (40 chains for each group). The control group represented by artificial saliva and four test groups represented by orange based drinks, lemon based drinks, diet pepsi and regular pepsi. The Force was measured at five different time intervals: At initial, 24 hours and 7, 14 and 21 days by a digital force gauge. The result showed that there were significant differences among groups. Statistically significant effects of time on force decay were seen in all groups. Statistically significant difference was found between conventional and memory chains.

INTRODUCTION

Corrective orthodontic treatment consists of the transmission of mechanical forces to teeth in order to adjust them to appropriate positions.

Elastomeric chain was introduced in the 1960's and has remained the traditional method of retraction and space closure. They come in three different forms: short, long, and closed. They may be transparent, gray or other-colored.

Their main advantages include the following: ease of use, low price, reduced potential for intraoral trauma, minimal need for patient compliance and wide array of colors. Their disadvantages can be seen in inconsistency of force levels over time, absorption of fluids leading to discoloration.

Change in their force over time, leads to therapeutic control problems. Several studies have reported that chains may lose 50 to 75% of their initial force during the first day of use and retain only 30% to 40% of the original force after four weeks.

Presently the orthodontic patients are exposed to the concept of consuming popular carbonated drinks in moderate to large quantities in keeping the current trend of fast food culture. Therefore, this study was evaluated the effect of carbonated drinks on the force decay properties of commercially available elastomeric chains.

Review of literature:

The rate of space closure of 100 g and 200g nickel-titanium closed coil springs was examined. Eighteen patients requiring orthodontic treatment were examined. The springs were attached tothe hook on the first molar and a crimpablehook distal to the canine. The result showed that the 150 g and 200 g produce a faster rate of space closure than 100 g and no significant difference was found in the rates of space closure caused by the 150 g and 200 g gram springs.(1)

The forces generated by elastomeric chains and NiTi closed coil springs were compared, and their force decay Pattern was evaluated. Forty elastomeric chains and forty

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NiTi closed coil springs were evaluated. They were extended to twice their original length and stored in artificial saliva at 37ºC. Force measurements were taken at seven time points (initial, 1 day, 4, 7, 14, 21 and 28 days). Elastomeric chains released higher initial force values than those released by the coil springs. By contrast, the coil springs showed initial force values closer to the ideal, and presented slowly and gradually force decay over 28 days force decay over 28 days. At the end of the study, the elastomeric chains exhibited a significantly greater force loss than that presented by the coil springs.(2)

The effect of Light Coke, phosphoric acid, and citric acid were evaluated on the force decay of two types of elastomeric chains. One hundred sixty gray colored elastomeric chain modules were divided into four groups for immersion into Light Coke, phosphoric acid, citric acid, and artificial saliva. Elastomeric chains were kept immersed in artificial saliva at 37°C (pH 6.24) then immersed in the solutions twice a day for 15 minutes. Force was taken initially, 24 hours, 7, 14, and 21days.The greatest loss in force occurred in the first 24 hours. It was concluded that the immersion treatments caused no statistically significant difference in force for either chain module.(3)

The effect of initial force and the amount of force decay between the elastomeric chain and tie-back method over a period of time were evaluated. Twenty five-unit elastomeric chains (15 mm) stretched 100%, and twenty elastic modules in tie-back method stretched twice their original diameter. They were stored in 37 °C distilled water. The force of all samples was measured at baseline, 24 and 48 hours, and once a week thereafter for four weeks with a force gauge. The tie-back method with mean force of 577.50 g had a lower initial force than the elastomeric chain with mean force of 650g. The elastomeric chain showed a substantial force decay of 355.50 gat 24 hours, but the force decay in the tie-back method was less (mean 154 g). The force decay of the elastomeric chain and tie-back at 48 hours were 446.50 g and 209 g, respectively. It was concluded that the tie-back method of space closure, which has more appropriate initial force and slower force decay, may have a clinical value, approaching a more light and continued force.(4)

The dependence of force decay on the initial strain on elastic chains was investigated. Eight different elastic chains from eight major brands tested at 50% and 100% strain. The sample size for each brand was 20. Chains were stored in water. Force measurements were taken at six time points (0, 2, 8, and 24 hours and 7 and 21 days). The force degradation of the elastic chains at 50% strain varied from 37% to 75%. At 100% strain the varied between 39% and 67%. Most force loss between 24 hours.(5)

Force decay of elastomeric chains in different media was evaluated. Forty chains of elastomeric chain were stretched to a force 200 ± 5 g. They divided into 4 main groups according to the environment (air, distill water, Biofresh mouth wash and artificial saliva pH 6.75). The results showed that the remaining forces 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 bio fresh mouth wash more than the neutral saliva.(6)

The percentage force decay of elastomeric chain was investigated utilizing three different design mechanisms simulating canine retraction. Three acrylic resin jigs were constructed to provide a framework for three simulated space closure mechanisms. The 6-5-3, the 6-3 and the chain loop were the configuration mechanisms

used in the study. Force levels were evaluated at 13 time points. The result showed that significant difference in the mean percentage force decay for the three different mechanisms, the 6-3 mechanical design had the smallest mean percentage force decay. There was a significant difference in the mean percentage force loss for the different companies, Ormco had the smallest percentage force loss while Unitek had the highest percentage force decay.(7)

The force decay of nonlatex versus latex inter arch elastics within the normal range of salivary pH levels was evaluated. Two nonlatex groups and one latex group (American Orthodontics) were tested. Elastics were immerged in artificial saliva solutions with pH levels of 5.0, 6.0, and 7.5. Force magnitudes were measured at 25 mm at four times 10 seconds 4, 8, and12 hours. The results showed that no clinically significant correlation between pH and force decay.(8)

The behaviour of different elastomeric chains was evaluated. Three kinds of elastomeric chains, Plastic chain (PC), Memory chain (MC) and Super slick chain (SSC), (mean initial force close to 180 g). Force measurements were taken at six time points (initial, 1 hour, 24 hours, 1, 2 and 3 weeks). The result showed that all significant force decrease after the 1hour period (23% for PC and 14% for MC and SSC). At the end of the third week period, the remaining force was 57%, 67% and 71% for PC, MC and SSC, respectively. Only the enhanced chains maintained the force applied over 100 g at the end of study. It was concluded that the effect of both the material and the time factors were significant.(9)

The effect of mouthwashes with and without bleaching agents on the force of elastomeric chains was evaluated. One hundred and eight elastomeric chain specimens were divided into six groups. Two groups were exposed to two types of mouthwashes (Plax and Listerine), and two groups were exposed to mouthwashes containing bleaching agent (Plax Whitening and Listerine Whitening). One of the control groups immersed in artificial saliva throughout the entire experimental period, and the other control specimens were exposed to distilled water. Force measurements were performed at six time intervals (initial, 1, 7, 14, 21 and 28 days). The result showed that statistically significant differences between groups at the time intervals of 7, 14, and 21 days. The elastomeric chains in distilled water and Plax Whitening maintained the most force during the experimental period. It was concluded that the presence of bleaching agent has no influence on the force degradation of elastomeric chains.(10)

The effect of aerated drinks on force decay of elastomeric chains was tested. Chains were divided in four groups: distal water, lemon based drinks, orange based drinks and cola drinks groups. Elastomeric chains were stretched up to 25 mm and the given force was evaluated at the following intervals: 0 hour, 2 hours, 12 hours, 24 hours, 3 days, 5 days and 7 days after the immersion in the aerated drinks 2 hours every day. The result showed that the orange based drinks caused highest force decay followed by cola, lemon and water. The greatest reduction in force occurred in the first 24 hours.(11)

Force decay of clear and semi-clear elastomeric chain were evaluated. Chains were extended to twice their original length and immersed in artificial saliva at 37^{o}C. Force decay was evaluated at five predetermined time intervals: initial, one week, two, three and four weeks. The result showed that significant difference in the percentage of the lost initial

force between all the tested chains. AO-memory and Ormco maintained most of their initial force at the end of the four-week interval.[12]

MATERIAL AND METHODS

The sample consisted of two hundred short clear elastomeric chains of two types: Conventional chains and memory chains, 100 chains for each type (fig.1).

Grouping of the sample:

The sample was arranged into five groups, each group contain 40 chains (20 conventional & 20 memory chains).

The control group represented by artificial saliva (group A) and four test groups represented by orange based drinks(group B), lemon based drinks (group C), diet pepsi (group C) and regular pepsi (group D).

Figure 1: Elastomeric chains (conventional& memory chains)

Five plastic plates were fabricated and perforated for the insertion in each plate 80 pins with 0.1 cm diameter and 1.5 cm length arranged in four rows, distance between them 2.5 cm, each row consisted of 20 pins. (fig 2)

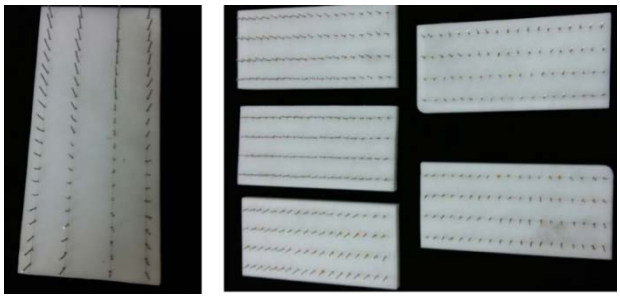

Figure2: Plastic stretch jig

The elastomeric chains were stretched onto five jigs and stored in artificial saliva, in a water bath at a temperature of 37°±1 C for 21 days.

One jig served as a control group and did not receive further treatment. Four jigs served as test groups were removed from artificial saliva and immersed in the carbonated drinks for 15 minutes, at the room temperature, once a day then removed from the carbonated drinks, washed under running water in order to eliminate residues of carbonated drinks, then they again stored in artificial saliva between the immersions time period.

Five force measurements were taken during the experimental period of the study, at the following time intervals: 0 (baseline), 24 hours 7, 14 and 21 days. Force measurements were obtained with a digital force guage. (fig 3)

Measurements were made by leaving one end of the elastomeric chain secured on the pin and fixing the other to the force tester, allowing for the measurement at 25 mm.

Figure 3: Digital force gauge.

RESULTS

1- Effect of testing solutions on forces released by memory power chains:

The result showed that the control group demonstrated the lowest force decay values, with statistically difference with testing groups over the whole study time ($p<0.05$). (Table 1)

In comparison between testing groups, after 24 hours statistically significant differences was found between group D (114.7) with group E (117.2). At 7 day statistically significant differences were found between group E (109.3) with groups B (107.0) and C (107.5). At 14 day statistically significant differences were found between group B(98.5) with groups C (97.2) and E (100.6) also there were statistically significant differences between group C (97.2) with groups D (99.6) and E (100.6). At 21 day statistically significant differences was found between group B (91) with groups C (92.5), D (93.7) and E (94.1) also there were statistically significant differences between group C (92.5) with groups E (94.1). ($p<0.05$) (Table 1).

Different letters indicate significance in mean between groups

2- Effect of testing solutions on forces released by conventional power chains:

The result showed that the control group demonstrated the lowest force decay values, with statistically difference with testing groups over the whole study time ($p<0.05$). (Table 2)

In comparison between testing groups, after 24 hours statistically significant differences was found between group C (105) with group E (107.9). At 7 day,14 day and 21 day statistically significant differences was found between groups C with group E also there were statistically significant differences between group B with groups D and E.($p<0.05$)(table 2)

Table 1: Comparison of the mean values of forces released by memory elastomeric chains in each time period of five groups.

		artificial saliva(A)		orange based drinks(B)		lemon based drinks(C)		diet pepsi(D)		regular pepsi(E)		P
		Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	
M	T(0h)	151.2	1.9	150.3	1.9	150.8	2.1	150.5	2.0	150.4	2.1	0.6
	T(24hs)	119.7^{a}	1.4	115.9^{bc}	1.8	116.0^{bc}	2.1	114.7^{bd}	1.9	117.2^{c}	1.9	<0.05*
	T(7days)	113.5^{a}	.9	107.0^{b}	2.2	107.5^{b}	1.7	108.1^{bc}	2.4	109.3^{c}	2.0	<0.05*
	T(14days)	108.0^{a}	.9	98.5^{c}	1.4	97.2^{b}	1.4	99.6_{cd}	2.1	100.6^{d}	.9	<0.05*
	T(21days)	103.3^{a}	1.2	91.0^{c}	1.1	92.5^{b}	1.7	93.7^{bd}	1.3	94.1b^{d}	1.4	<0.05*

SD: Standard deviation **P:** Probability ***:** Significance ≤0.05 **M:** Memory chains **T:** Time

Table 2: Comparison of the mean values of the forces released by conventional elastomeric chains in each time period of five groups.

		artificial saliva(A)		orange based drinks(B)		lemon based drinks(C)		diet pepsi(D)		regular pepsi(E)		P
.		Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	
C	T(0h)	180.5	2.9	180.5	3.9	180.2	2.8	180.0	4.1	180.2	2.8	0.99
	T(24hs)	112.2^{a}	1.8	106.7^{bc}	2.5	105.0^{b}	2.1	106.7^{bc}	1.7	107.9^{c}	1.8	<0.05*
	T(7days)	104.5^{a}	1.5	93.7^{b}	2.6	95.1^{bc}	2.5	96.1^{cd}	2.0	97.9^{d}	2.1	<0.05*
	T(14days)	96.1^{a}	1.6	85.0^{b}	1.4	86.1^{bc}	1.6	87.4^{cd}	2.0	88.6^{d}	1.6	<0.05*
	T(21days)	88.3^{a}	1.5	76.9^{b}	1.6	77.3^{bc}	1.4	78.3^{cd}	1.4	79.5^{d}	1.5	<0.05*

SD: Standard deviation **P:** Probability ***:** Significance ≤0.05 **C:** Conventional chains **T:** Time

Different letters indicate significance in mean between groups

3- Effect of artificial saliva on forces released by conventional and memory elastomeric chains:

The results showed that the memory elastomeric chains had significantly ($p<0.001$) more force released when compared to the conventional elastomeric chains at all the time point.

4-Comparison between force decay of memory and conventional power chains at different time intervals within orange based drinks:

The results showed that the memory elastomeric chains had significantly ($p<0.001$) more force released when compared to the conventional elastomeric chains at all the time point.

5- Comparison between force decay of memory and conventional power chains at different time intervals within lemon based drinks:

The results showed that the memory elastomeric chains had significantly ($p<0.001$) more force released when compared to the conventional elastomeric chains at all the time point.

6- Comparison between force decay of memory and conventional power chains at different time intervals within diet pepsi:

The results showed that the memory elastomeric chains had significantly ($p<0.001$) more force released when compared to the conventional elastomeric chains at all the time point.

7- Comparison between force decay of memory and conventional power chains at different time intervals within regular pepsi:

The results showed that the memory elastomeric chains had significantly ($p<0.001$) more force released when compared to the conventional elastomeric chains at all the time point.

DISCUSSION

Orthodontic elastics are widely used in Orthodontics due to their capacity to transmit force, low cost, ease of use, being relatively hygienic and because they do not need much cooperation from the patient.[5] However, they are not considered ideal materials due to the decline in force required for efficient tooth movement.[10]

There is no scientific evidence for the optimum force magnitude for orthodontic tooth movement.[13] Previous studies have recommended forces between 150 and 200 g for retracting the canine.[1,2] A mean force of 180.3g for conventional chains and 150.6 g for memory chains were considered in the present study, as it is expected to avoid hyalinization and root resorption.[9]

Almost all previous studies showed that in any test environment, the highest force loss occurred during the 1st hour or the first 24 hours and then progressed in a more steady and gradual rate.[5,9] In the present study, during the first 24 hours, the force loss was 22-24% in memory chains and 40-42% of the initial force in conventional chains had been lost, range of force loss was approximately similar to previous studies.[9,7] Other studies, however, showed a higher range of force loss (up to 75% of the initial force) in the first 24 hours.[14] This difference was found to be highly dependent on the experimental conditions.

At the end of 3rd week , 37.5-39.5% of the initial force had been lost in memory chains, this range of force loss was approximately similar to previous study.[9]The loss was 56-57.5% of the initial force in conventional chains, this range of force loss was similar to Aldrees et al.[12] Other studies, however, showed a higher range of force loss (up to 85% of the initial force) at the end of 3rd weeks.[4] This difference was found to be highly dependent on the experimental conditions as the force loss is higher in wet in vitro conditions than in the air or dry conditions.[6]

The results of this study showed that the carbonated drinks had effect more than control

group ,this result was similar to Kumaret al.[11] A controversial result was reported by Teixeira et al[3] who said that the coke caused no statistically significant difference in force decay. This difference in results may be due to using of different elastomeric chain brands. The notable difference between the results of those chains tested in artificial saliva and those stored in carbonated drinks suggest that some factors other than pH (preservative material, pigments, citric and phosphoric acids in carbonates drinks) is able to modify the physical properties of the elastomeric chains because in this study ,the orange based drinks (pH=3) had more influence on force decay compared to lemon based drinks (pH=3.3) and regular pepsi (pH=2.7) ,this may be mean that more acidity do not necessary cause higher force loss. This result was similar to the work of Sauget et al.[8] Who found no significant correlation between pH and force decay.

The difference in force decay between the memory and conventional chains after three weeks was approximately 17%. Memory Chain maintained significantly higher levels of force than conventional chain during all time intervals along the tested period, this result similar to other study.[9] This different due to various substances in the manufacturing process of the memory chains. These results confirm the claims that the elastomeric chains with memory properties can preserve the force more efficiently than other chains.

CONCLUSION

Based on the results found in this study, it may be concluded that:

- Carbonated drinks demonstrated more capacity to influence the force decay of the orthodontic elastomeric chains than was shown by the salivary medium.
- Orange based drinks caused the highest force loss followed by lemon based drinks, diet pepsi, regular pepsi and the artificial saliva, respectively.
- In both elastomeric chain types the greatest force decay occurred in the first 24 hours, followed by a gradual reduction in the subsequent 21 days.
- Compared to conventional chains, chains with memory properties were shown a lower level of force at the start; however, their rate of force decay over three weeks was slower

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