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CHANGES IN THE FORCE DECAY OF ORTHODONTIC ELASTOMERIC CHAINS AFTER IMMERSION IN DIFFERENT MOUTHRINSES

Marwa Sameh Shamaa*, Dina Samy Farahat** *and* Marwa Ali Tawfik*

ABSTRACT

Objective: To investigate the influence of the most frequently utilized mouthrinses on the force degradation of different elastomeric chains.

Methodology: Conventional and memory elastomeric chains were attained from two different manufacturers with a total of 320 specimens. Each of the 4 chain types was divided into two groups to deliver light (200g) and heavy forces (350g) (n= 40). Each group was further divided into 4 subgroups (n=10): a control one where the elastomeric chains were immersed in deionized water and three experimental groups immersed in a sodium fluoride (NaF) containing mouthrinse, a whitening mouthrinse and an alcohol containing mouthrinse. The force decay percent was measured over 5 time points.

Results: Force decay was significantly higher in alcohol containing mouthrinse group at day 1 compared to other groups followed by a marginal significance. In the whitening group; force decay was non-significantly higher than that in sodium fluoride followed by the control group**.** There was no significant difference in force degeneration between the two companies. In conventional chain group; there was a significantly higher force decay ($p<.001$) compared to memory one with the greatest decrease in the first day till the second week, then both reached a plateau and the force remained nearly constant at weeks 3 & 4. No significant difference was detected between light and heavy force application.

Conclusion: Alcohol containing mouthrinses can intensify force decay in elastomeric chains more than bleaching and NaF mouthrinses. Memory elastomeric chains are recommended as they exhibited less force decay compared to conventional ones.

KEYWORDS: Elastomeric chains; Force decay; Mouthrinses.

* Associate Professor, Orthodontic Department, Faculty of Dentistry, Mansoura University, Egypt.
** Associate Professor, Department of Dental Biomaterials, Faculty of Dentistry, Mansoura University

INTRODUCTION

The elastomeric chain represents a polyurethane synthetic polymer having elastic properties that is mostly utilized in orthodontic practice. It is an extended chain obtainable in different colors with interconnected holes. When subjected to deformation forces, it can restore the original dimensions due to its viscoelastic characteristics. [1] Elastomeric chains are utilized in orthodontics to enhance tooth movement, correct rotation and midline deviation and they enable space closure and traction of impacted teeth. [2,3]

There are two kinds of elastomers employed in orthodontics. The 1st kind is natural elastomers that are known as elastics and are utilized in interarch mechanics. The 2nd kind is synthetic elastomers that are known as alastiks and are employed in elastic threads, ligatures and elastomeric chains. Elastomeric chains are synthetized from polyurethane and can be either conventional or memory. [4] The memory elastomeric chains are assumed to preserve higher force and exhibit more gradual force loss, thus they are more favorable as they apply higher force over a longer time. [5]

Elastomeric chains have several advantages of being easy to use, inexpensive and the decreased risk of intraoral trauma, in spite of their inherited disadvantages that they undergo force decay and permanent staining. [6] Various factors affect the degree of force decay of elastomeric chains such as water absorption, salivary pH, temperature changes, ultraviolet light exposure and the repeated use of mouthwashes. [7,8]

Orthodontic patients are more exposed to the danger of plaque aggregation around their fixed attachments and therefore they are at a higher risk of microbial accumulation causing dental caries. [9] Mouthwashes are highly recommended for orthodontic patients along with tooth brushing and flossing in order to maintain proper oral hygiene. [10]

Studies on the influence of mouthrinses on force degradation of elastomeric chains are controversial. Furthermore, there is no data about their effect on memory versus conventional chains. Thus, the purpose of the current study was to evaluate the force decay of memory elastomeric chains in comparison to conventional ones (of two commercial brands) under the influence of the most frequently used mouthwashes at different time points.

MATERIAL & METHODS

To determine the effect of different mouthwashes on the force decay of elastomeric chains, a total of 320 specimens were used in this study (Figure1). Clear elastomeric chains from two orthodontic companies (American Orthodontics Sheboygan,

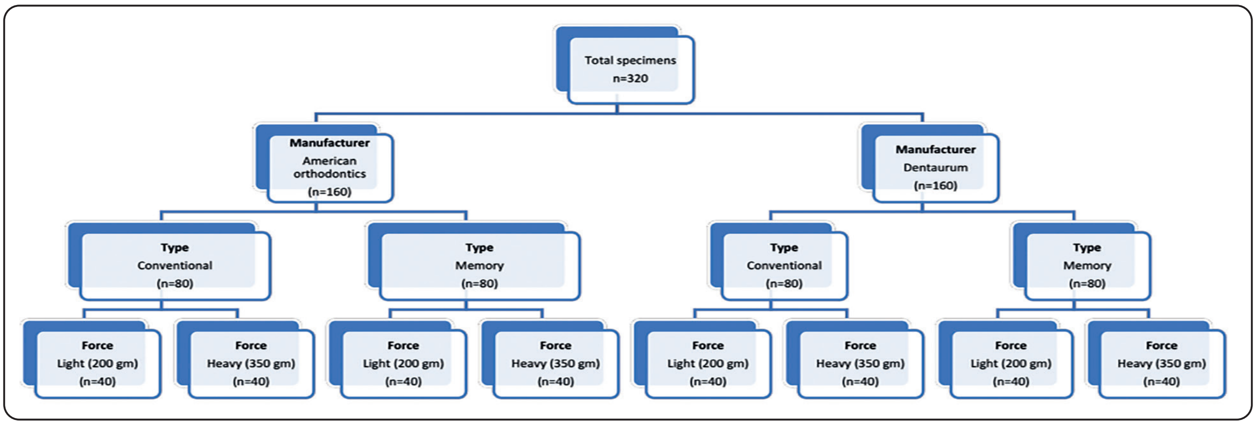

Fig (1) Grouping of specimens.

WI, USA and Dentaurum, Ispringen, Germany) were selected (160 specimens each).

Two different chain types from each manufacturer with various lot numbers were evaluated: conventional chains and memory chains (n=80). Each of the four elastomeric chain types were divided into two groups (n=40) to test two magnitudes of force, as follows: (1) light force (200 g) and (2) heavy force (350 g). Each group was divided into 4 subgroups (10 specimens each): a control group where the elastomeric chains were immersed in deionized water (DW) and three experimental groups corresponding to each mouthrinse type.

Sample size was calculated based on the results of Castelló et al. 2022 [7] by using the G*Power software (version 3.1.9.7). We hypothesized that measuring force decay percent over 5 time points in 4 subgroups (solution types) or in 2 subgroups (manufacturer, force, and power chain types) has a small effect size for Subgroup*Time interaction (f=0.1). A total sample size of 320 achieves 98.4% power for solution factor and 99.8% for each of the other three factors. The same sample size of 320 achieves 99.8% power to detect a small effect size (f=0.1) for within-subjects factor (Time) in 2 and 4 subgroups. For the between-subjects factor (solution, manufacturer, force, and power chain types), we hypothesized a medium effect size (f=0.25). The same sample size of 320 achieves 99.93% and 99.99% power to detect a medium effect size (f=0.25) for the between-subjects factor in 4 and 2 subgroups, respectively. The research protocol was approved by the Ethical Committee, Faculty of Dentistry, Mansoura University (No. A0101024OR).

Three different types of mouthrinses were used in this study, namely**:** a sodium fluoride containing mouthrinse (Oral B gum and enamel care), a whitening mouthrinse (Crest 3D white glamourous white) and an antiseptic mouthrinse containing 26.9% alcohol (Listerine ® Original).

The chains were purchased 2 months before testing and stored at room temperature away from light and humidity. Each specimen was cut to contain 6 modules and an additional module was left at both ends to aid in positioning the samples and prevent damage resulting from the cut.

To stretch the chains while supplying initial forces of either 200 or 350 g, a specially designed adjustable metallic jig was fabricated. The jig consisted of two halves connected by an adjustable jack screw with ten pins on every half (Figure 2). Several jigs were formed for simultaneous testing of the chains.

To determine how long each elastomeric chain is required to be stretched to obtain an initial force of 200 gm, specimens were cut from each type of the chains then stretched on a pin of the metallic jig and the hook of a digital force gauge (HF-30 Digital Push Pull Force Gauge, M&A Instruments inc., CA, USA) (Figure 2) so that the force recorded after allowing the chain to stretch for 15 seconds was 200 g. [4]

Fig. (2) Digital Force gauge and adjustable metal jig with stretched chains utilized in this study.

The stretch distance was determined using 20 specimens from each type of the elastic chains then the average stretch distance was calculated. The same process was repeated to determine the stretch distance needed to reach an initial force of 350 g. [4]

These samples were discarded once utilized and not re-employed. Table 1 shows the required stretching distance for each subgroup.

TABLE (1) Required stretching distance for each elastomeric chain type

Elastomeric chain type	Light force (200 gm)	Heavy force (350 gm)
Conventional (Dentaurum)	19 mm	21 mm
Memory (Dentaurum)	21 mm	25mm
Conventional (American Orthodontics)	22 mm	25 mm
Memory (American Orthodontics)	32 mm	42 mm

The samples were cut utilizing a ligature cutter (Dentaurum, Ispringen, Germany) instantly prior to testing. Then, the samples were stretched over the pins of the metallic jigs and placed in plastic containers where they were submerged in deionized water then placed in an incubator (JSGI-100T,JSR inc., Korea) at 37°C. The jigs with the stretched elastomeric chains were immersed in the respective test mouthwashes twice daily for 60 sec with a period of 12 hr between each exposure and the other.[11] Afterwards, the specimens were immersed in individual deionized water baths for 10 sec, to mimic the process of rinsing the mouthwashes from the oral cavity, and then put back into the incubator in their deionized water containers.[11] The control group was subjected to the above-mentioned procedure, but only exposed to deionized water. [4] The overall immersion period was 28 days.

Force measurements were performed in the same way using the digital force gauge and at the same vertical and horizontal distance on the jig base to assure precise assessment. Prior to the measurements, the force gauge was calibrated according to the manufacturer's instructions. Then, measurements were performed by attaching one end of the elastomeric chain to the jig and securing the other end to the force gauge.[12] Readings were registered with the elastomeric chains stretched to the same respective lengths to which they were stretched throughout the experimental periods[12]. Measurement of the force decay percent was performed after 24 hours (D1), 1 week (W1), 2 weeks (W2), 3 weeks (W3) and 4 weeks (W4).

Calculation of force decay percent at different time points:

Force decay (%) at D1 = [(Initial force – Force at D1)/ Initial force)*100]

Force decay (%) at W1 = [(Force at D1 – Force at W1)/ Force at D1)*100]

Force decay (%) at W2 = [(Force at W1 – Force at W2)/ Force at W1)*100]

Force decay (%) at W3 = [(Force at W2 – Force at W3)/ Force at W2)*100]

Force decay (%) at W4 = [(Force at W3 – Force at W4)/ Force at W3)*100]

Statistical analysis

Data were analyzed using IBM-SPSS software (version 27, 2020). Quantitative data were initially tested for normality Shapiro-Wilk's test and Q-Q plots. The presence of outliers was assessed by boxplot. Homogeneity of variances and covariances were assessed by Levene's test of homogeneity of variances and Box's M test, respectively. Mauchly's test of sphericity was utilized to estimate the assumption of sphericity. Quantitative data were expressed as mean, standard deviation (SD), and standard error (SE), when appropriate. The two-way mixed ANOVA was utilized to detect whether there are differences between independent groups over time. For a statistically significant two-way interaction, simple main effects were performed, while if there was no statistically significant two-way interaction, main effects were performed. Results were statistically significant at $p \leq 0.050$.

RESULTS

Table 2 shows the results of two-way mixed ANOVA which was run to determine whether there were differences in force decay percent between independent groups (between-subjects factor) over time.

Effect of mouthrinse type (solution):

There was a statistically significant interaction effect between solution type and time on force decay percent.

Accordingly, 'simple main effect' of solution type and time were performed.

Simple main effect of solution type:

Force decay percent (FDP) was compared between the two groups at each time point.

In D1, FDP was significantly different between 4 solution types (F [3,316] =8.861, p<.001, partial h2 =.078). Pairwise comparisons revealed that FDP was significantly different between Listerine vs. water (p<.001), NAF (p=.001), and whitening (p=.014), but not between water vs. NAF (p=1.000), water vs. whitening (p=.379), and NAF vs. whitening (p=1.000).

In W1, FDP was not significantly different between the 4 solution types (F [3,316] =2.580, p=.054, partial h2 =.024).

In W2, FDP was not significantly different between the 4 solution types (F [3,316] =1.502, p=.214, partial h2 =.014).

In W3, FDP was not significantly different in conventional vs. memory (F [1,318] =0.126, p=.945, partial h2 =.001).

In W4, FDP was not significantly different in conventional vs. memory (F [1,318] =0.024, p=.995, partial h2 =.000).

Simple main effect of time:

Force decay percent (FDP) was compared between time points in each type of solution.

In water type of solution, there was a statistically significant difference in FDP between the 5 time points (Greenhouse-Geisser test, F [1.8, 144.2] = 590.016, p<.001, partial h2 =.882). Pairwise comparisons revealed a statistically significant difference in FDP in all pairwise comparisons (p<.001 for all) not between W1 vs. W2 (p=.366) and between W3 vs. W4 (p=1.000).

In NAF type of solution, there was a statistically significant difference in FDP between the 5 time points (Greenhouse-Geisser test, F [1.6, 124] = 648.951, p<.001, partial h2 =.891). Pairwise comparisons revealed a statistically significant difference FDP in all pairwise comparisons (p<.001 for all) not between W1 vs. W2 (p=.335) and between W3 vs. W4 (p=1.000).

In Whitening type of solution, there was statistically significant difference in FDP between the 5 time points (Greenhouse-Geisser test, F [1.9, 149.5] = 575.104, p<.001, partial h2 = .879). Pairwise comparisons revealed a statistically significantly difference FDP in all pairwise comparisons (p<.001 for all) not between W1 vs. W2 (p=.469) and between W3 vs. W4 (p=1.000).

In Listerine type of solution, there was statistically significant difference in FDP between the 5 time points (Greenhouse-Geisser test, F [2.1, 167.6] = 512.265, p<.001, partial h2 = .866). Pairwise comparisons revealed a statistically significantly difference FDP in all pairwise comparisons (p<.001 for all) not between W1 vs. W2 (p=.179) and between W3 vs. W4 (p=1.000).

Effect of manufacturer:

There was no statistically significant interaction between manufacturer and time on the force decay percent. Accordingly, 'main effect' of manufacturer and time were presented. Data is (mean, SE).

TABLE (2) Interaction effect of various factors with time on force decay percent

Between-subjects factor	Within-subjects factor (time)										Factor* Time Interaction effect		
	D1		W1		W2		W3		W4		F	p-value	Partial h^2
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD			
Solution											3.903	**<.001**	.036
Deionized Water	40.750	10.4936	10.9358	3.67115	12.9006	9.16879	0.1172	4.46392	0.0614	3.73076			
	42.777	10.7333	11.3415	4.33995	13.5642	9.55262	0.1761	3.32835	0.0585	3.78366			
NAF	43.898	10.7120	11.5558	3.84795	13.5212	10.28784	0.4992	4.77149	0.0323	4.78066			
Whitening	49.089	10.7798	12.8308	5.98844	16.0801	11.90763	0.1469	5.15702	-0.129	7.76305			
Listerine													
Power chain type											384.3	**<.001**	.547
Normal	54.531	3.7656	14.3424	4.24526	23.2935	5.16300	0.1874	5.01262	-0.043	6.85817			
Memory	33.726	3.7147	8.9896	3.13059	4.7395	3.64384	0.2823	3.85323	0.0550	2.88100			
Force											0.939	.389	.003
Light (200 g)	43.250	11.0713	11.4524	5.15564	13.6318	10.59498	0.3207	4.93457	-0.064	6.30750			
Heavy (350 g)	45.007	11.0293	11.8796	3.94550	14.4012	10.02942	0.1489	3.95138	0.0754	3.94274			
Manufacturer											1.584	.207	.005
A. Orthodontics	42.969	11.1201	10.8952	3.76049	13.6259	9.90575	0.0885	5.33055	0.0368	4.49189			
Dentaurum	45.288	10.9274	12.4367	5.18676	14.4071	10.71027	0.3812	3.39418	-0.025	5.926963			

Notes: D1 = Day 1. W1, W2, W3, and W4 = weeks 1, 2, 3, and 4. A. Orthodontics = American Orthodontics. SD standard deviation. The test of significance is two-way mixed ANOVA.

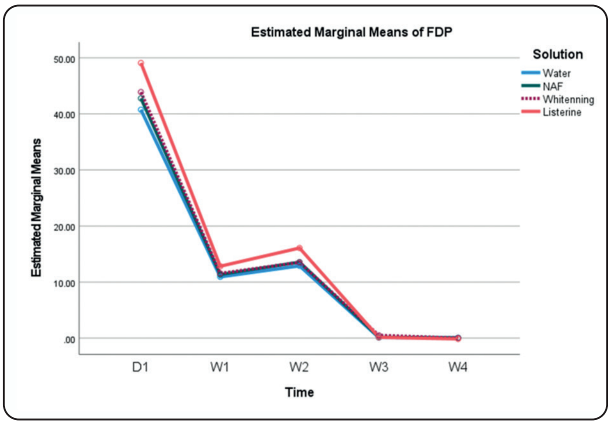

Fig (3) Multiple line graph displaying the effect of mouthrinse type on force decay.

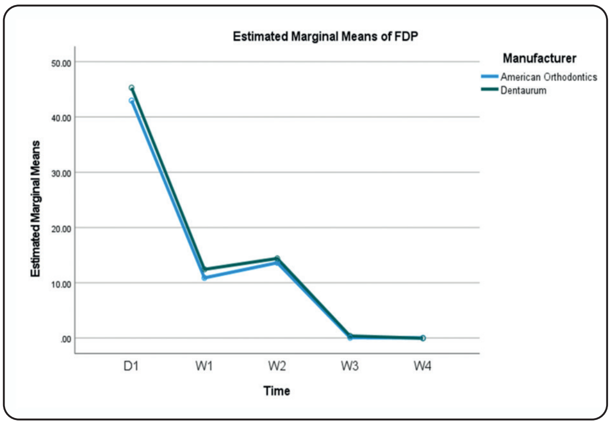

Fig (4) Multiple line graph displaying the effect of manufacturer on force decay.

Main effect of manufacturer:

FDP was 13.5, 0.369 in American Orthodontics vs. 14.5, 0.369 in Dentaurum. There was no statistically significant difference in FDP between the manufacturer types (F [1,318] =3.491, p=.063, partial h2 =.011).

Main effect of time:

However, there was a statistically significant difference in FDP between the 5 time points (Greenhouse-Geisser test, F [1.9, 614.3] =2218.561, p<.001, partial h2 =.875). FDP was 44.1, 0.62 in D1, 11.7, 0.25 in W1, 14, 0.58 in W2, 0.235, 0.25 in W3, and 0.006, 0.29 in W4. Pairwise comparisons revealed a significantly different FDP in all pairwise comparisons (p<.001 for all) but not between W3 vs. W4 (p=1.000).

Effect of power chain type:

There was a statistically significant interaction effect between power chain type and time on force decay percent.

Accordingly, 'simple main effect' of power chain type and time were performed.

Simple main effect of power chain type:

Force decay percent (FDP) was compared between the two groups at each time point.

In D1, FDP was significantly higher in conventional vs. memory (F [1,318] =2475.346, p<.001, partial h2 =.886).

In W1, FDP was significantly higher in conventional vs. memory (F [1,318] =164.774, p<.001, partial h2 =.341).

In W2, FDP was significantly higher in conventional vs. memory (F [1,318] = 1379.267, p<.001, partial h2 =.813).

In W3, FDP was not significantly different in conventional vs. memory (F [1,318] = 0.036, p=.850, partial h2 =.000).

In W4, FDP was not significantly different in conventional vs. memory (F [1,318] = 0.028, p=.867, partial h2 =.000).

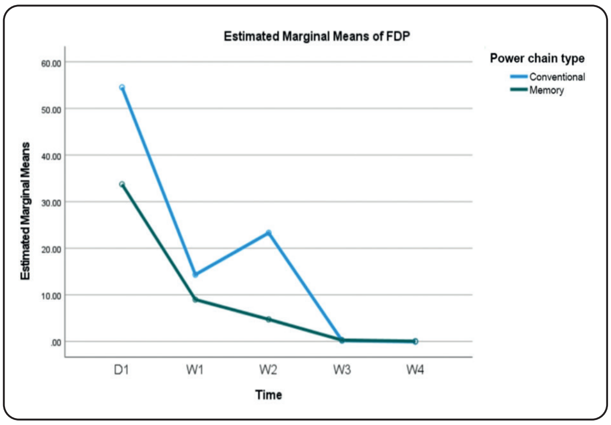

Fig (5) Multiple line graph showing the effect of power chain type on force decay.

Simple main effect of time:

Force decay percent (FDP) was compared between time points in each type of power chain.

In normal type of power chain, there was statistically significant difference in FDP between the 5 time points (Greenhouse-Geisser test, F [2.7, 431.2] = 2811.801, p<.001, partial h2 =.946). Pairwise comparisons revealed a statistically significantly difference FDP in all pairwise comparisons (p<.001 for all) not between week 3 vs. week 4 (p=1.000).

In memory type of power chain, there was statistically significant difference in FDP between the 5 time points (Greenhouse-Geisser test, F [2.9, 455.3]=2254209,p<.001,partial h2=.934). Pairwise comparisons revealed a statistically significantly difference FDP in all pairwise comparisons (p<.001 for all) not between week 3 vs. week 4 (p=1.000).

Effect of force:

There was no statistically significant interaction between force and time on FDP. Accordingly, 'main effect' of force and time were presented. Data is mean, SE.

Main effect of force:

FDP was 13.718, 0.370 in Light force vs. 14.302, 0.370 in heavy force. There was no statistically significant difference in FDP between the force types (F [1,318] =1.246, p=.265, partial h2 =.004).

Main effect of time:

However, there was statistically significant difference in FDP between the 5 time points (Greenhouse-Geisser test, F [1.9, 616.5] =2214.068, p<.001, partial h2 =.874). FDP was 44.1, 0.62 in D1, 11.7, 0.26 in W1, 14, 0.58 in W2, 0.235, 0.25 in W3, and 0.006, 0.29 in W4. Pairwise comparisons revealed a significantly different FDP in all pairwise comparisons (p<.001 for all) but not between W3 vs. W4 (p=1.000).

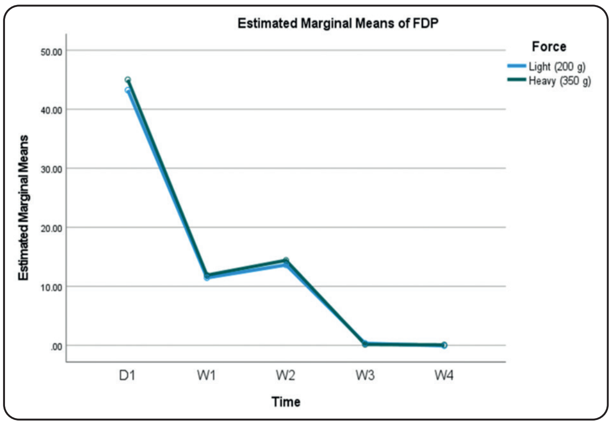

Fig (6) Multiple line graph showing the effect of initial force magnitude on force decay.

DISCUSSION

Elastomeric chains are usually utilized in orthodontics in numerous applications to enhance tooth movement and space closure as a result of their high versatility. However, their effectiveness stays debatable because of the prompt reduction in their mechanical properties and the force loss produced by the effect of several external agents.[7, 13]

Orthodontic mechanotherapy usually causes obstacles in preserving the oral cavity cleanness leading to persistent plaque accumulation and unpleasant breath. Thus, patients frequently utilize mouthwashes to preserve their oral hygiene.[14] Although many studies explored the influence of mouthrinses on force degeneration of elastomeric chains, there is lack of information about differences between memory and conventional chains. To our knowledge, this is the first study to evaluate the force decay of memory elastomeric chains in comparison to conventional ones under the effect of various types of mouthwashes (NaF, whitening, alcohol) at different time points.

NaF is frequently utilized in mouthrinse components. It is advantageous in enhancing re-mineralization and increasing the resistance of enamel to acid attacks.[10,15] Contradictory reports have been declared concerning the influence of NaF mouthrinse on the force degeneration in elastomeric chains. Omidkhoda et al. revealed that mouthrinses including fluoride produced less force decay than those without fluoride. [16] Sufarnap et al [10] concluded that NaF mouthrinse exhibited a non-significant effect on the force decay of elastomeric chains compared to saliva. These results were in contrast to those obtained by Oshagh et al [17], Behnz et al [18] and Sadeghian et al [19] who noticed significant force degradation of elastomeric chains exposed to mouthrinses containing NaF.

Nowadays, there is a great increase in esthetic demand, and accordingly for tooth whitening which led to the incorporation of peroxides in mouthrinses. Hydrogen peroxide (H_2O_2) interacts with organic compounds, breaking their ionic bonds and changing their absorption of energy, leading to alteration in the optical properties of tooth structure. [11] Behnz et al [18] revealed marked force degeneration of elastomeric chains immersed in bleaching mouthrise in day 1 and day 28. These findings disagree with Pithon et al [11] who found that the reaction of the chains with bleaching mouthrinse did not induce significant effect on force decay.

Frequently utilized antiseptic mouthrinses are alcohol-containing like Listerine that has an alcohol concentration of 26.9%. Listerine is a mixture of four active components dissolved in water-ethanol which are; eucalyptol 0.092%, thymol 0.064%, methyl salicylate 0.060% and menthol 0.042%. [20] The influence of alcohol in mouthrinses on the structural changes of elastomeric chains was suggested by Castelló et al [7] who reported that Listerine mouthrinses accelerate the rate of degeneration of the physical characteristics of power chains. Similarly, Santana et al [14] and Mirhashemi et al [21] reported that force decay of elastomeric chains can be dramatically increased by using Listerine mouthrinses.

In this study we used memory and conventional elastomeric chains of two trading companies (American Orthodontics Sheboygan, WI, USA and Dentaurum, Ispringen, Germany). Each of the 4 chain groups was divided into 2 subgroups: light and heavy force. The elastomeric chains were immersed into three types of mouthrinses: a sodium fluoride containing mouthrinse (Oral B gum and enamel care), a whitening mouthrinse (Crest 3D white glamourous white) and an antiseptic mouthrinse containing 26.9% alcohol (Listerine ® Original) and the force decay percent was measured over 5 time points.

Force decay was significantly higher in Listerine at day 1 compared to all other groups then there was marginal significance. Furthermore, force decay in whitening group was non significantly higher than that in sodium fluoride followed by the control group.

The results of the current study are in line with that obtained with Castelló et al [7] who reported that Listerine had more negative effect on the physical characteristics of elastomeric chains than mouthrinses containing bleaching agents or sodium fluoride. Also, Behnz et al [18] showed that bleaching mouthrinse is more weakening for elastomeric chains those containing NaF.

Regarding the effect of the manufacturer; force decay was slightly increased in Dentaurum compared to American Orthodontics with no significant difference between the two companies. Unlike Sadeghian et al [19] who noticed that force decay in dentaurum was less than that in American Orthodontics brand.

There was significantly higher force decay in conventional versus memory power chain with the greatest decrease in the first day till the second week, then both reached a plateau and the force remained nearly constant at week 3 & week 4. These results are in accordance with the findings of Dadgar et al. [5] who observed that memory elastomeric chains showed less force degradation and delivered a greater force than conventional ones. On the other hand, no significant difference was detected between light and heavy force application. This is in consistency with Masoud et al. [4] who revealed no difference in force degeneration when utilizing light or heavy initial forces.

CONCLUSIONS

- Alcohol containing mouthrinses can intensify force decay in elastomeric chains more than whitening and NaF mouthrinses.
- All elastomeric chain groups showed a similar general pattern of force degeneration with the greatest increase in the first day.
- Memory elastomeric chains are recommended as they exhibited less force decay compared to conventional ones.
- No difference in force degeneration was observed when utilizing either light or heavy initial forces.

REFERENCES

1. Braga E, Souza G, Barretto P, Ferraz C, Pithon M. Experimental evaluation of strength degradation of orthodontic chain elastics immersed in hot beverages. Journal of Indian Orthodontic Society. 2019 Oct; 53 (4):244-8.
2. Mude N, Chokhani D, Kharche A, Khudare P, Joteppa V, Mohani S. Changes in the force degradation of orthodontic elastomeric chains subjected to different formulations of chlorhexidine mouth rinse: an in vitro study. International Journal of Health Sciences. 2022 Jun 2(I):12572-85.
3. Proffit, William R., Henry W. Fields, and David M. Sarver. Contemporary Orthodontics-E-Book. Elsevier Health Sciences, 2014.
4. Masoud AI, Tsay TP, BeGole E, Bedran-Russo AK. Force decay evaluation of thermoplastic and thermoset elastomeric chains: A mechanical design comparison. The Angle Orthodontist. 2014 Nov 1; 84(6):1026-33.
5. Dadgar S, Sobouti F, Armin M, Ebrahiminasab P, Moosazadeh M, Rakhshan V. Effects of 6 different chemical treatments on force kinetics of memory elastic chains versus conventional chains: An in vitro study. International Orthodontics. 2020 Jun 1; 18 (2):349-58.

6. Al–Ani RA. The effect of mouth wash containing alcohol on force degradation of colored elastomeric chains. Indian Journal of Public Health Research & Development. 2019 Oct 1; 10 (10).

7. Castelló CA, Zamora-Martínez N, Paredes-Gallardo V, Tarazona-Álvarez B. Effect of Mouthwashes on the Force Decay of Orthodontic Elastomeric Chains: A Systematic Review and Meta-Analysis. 2022 Mar.

8. Ramachandraiah S, Sridharan K, Nishad A, Manjusha KK, Abraham EA, Ramees MM. Force decay characteristics of commonly used elastomeric chains on exposure to various mouth rinses with different alcohol concentration: An in vitro Study. J Contemp Dent Pract 2017;18(9):812-820.

9. Nahidh M, Abdullah NN, Hassan AF, Ghaib NH. The Effect of Herbal Mouthwashes on the Force Decay of Elastomeric Chains: An In-vitro Study. Health Sciences. 2017 Jan 1; 6 (10):45-53.

10. Sufarnap E, Harahap KI, Terry T. Effect of sodium fluoride in chlorhexidine mouthwashes on force decay and permanent deformation of orthodontic elastomeric chain. Padjadjaran Journal of Dentistry. 2021 Mar 31; 33(1):74-80.

11. Pithon MM, Rodrigues AC, Sousa ÉL, de Souza Santos LP, dos Santos Soares N. Do mouthwashes with and without bleaching agents degrade the force of elastomeric chains? The Angle Orthodontist. 2013 Jul 1; 83 (4):712-7.

12. Larrabee TM, Liu SS, Torres-Gorena A, Soto-Rojas A, Eckert GJ, Stewart KT. The effects of varying alcohol concentrations commonly found in mouth rinses on the force decay of elastomeric chain. The Angle Orthodontist. 2012 Sep 1; 82 (5):894-9.

13. Menon VV, Madhavan S, Chacko T, Gopalakrishnan S, Jacob J, Parayancode A. Comparative assessment of force decay of the elastomeric chain with the use of various mouth rinses in simulated oral environment: an in vitro study. Journal of Pharmacy & Bioallied Sciences. 2019 May; 11 (Suppl 2):S269.

14. Santana W, Thahar B, Mardiati E, Salim J. The effect of alcohol-containing mouthwash and alcohol-free mouthwash towards the power chains force decay. Padjadjaran Journal of Dentistry. 2017 Nov 30; 29 (3).

15. Shanbhag TV, Nayak V, Shenoy S. Pharmacology for Nurses-E-Book. Elsevier Health Sciences; 2016 Aug 16.

16. Omidkhoda M, Rashed R, Khodarahmi N. Evaluation of the effects of three different mouthwashes on the force decay of orthodontic chains. Dental Research Journal. 2015 Jul; 12 (4):348.

17. Oshagh M, Khajeh F, Heidari S, Torkan S, Fattahi HR. The effect of different environmental factors on force degradation of three common systems of orthodontic space closure. Dental research journal. 2015 Jan; 12 (1):50.

18. Behnaz M, Namvar F, Sohrabi S, Parishanian M. Effect of Bleaching Mouthwash on Force Decay of Orthodontic Elastomeric Chains. The Journal of Contemporary Dental Practice. 2018 Feb 1; 19 (2):221-5.

19. Sadeghian S, Heydari G, Shirvani A, Sadeghian R. The effect of sodium fluoride and listerine mouthwashes on the force decay of orthodontic elastomeric chains. Journal of Research in Medical and Dental Science. 2017; 5 (5):115-22.

20. Chen Y, Wong RW, Seneviratne CJ, Hägg U, McGrath C, Samaranayake LP. Comparison of the antimicrobial activity of Listerine and Corsodyl on orthodontic brackets in vitro. American journal of orthodontics and dentofacial orthopedics. 2011 Oct 1; 140 (4):537-42.

21. Mirhashemi AH, Khameneh NH, Shahpoorzadeh K, Shahroudi AS. Comparison of force decay pattern in orthodontic elastomeric chains and NiTi closed coil springs, affected by five different mouthwashes: An in vitro study. Dentistry 3000. 2021 Oct 28; 9 (1):95-106.