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The Effect of Herbal Mouthwashes on the Force Decay of Elastomeric Chains: An *In-vitro* Study

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ABSTRACT

Background: *This in vitro study aimed to evaluate the effect of four herbal mouthwashes on the force decay of two types of clear short elastomeric chains (Regular and Extreme) at various time intervals.* ***Materials and methods:*** *Four hundred forty pieces of both types of elastomeric chains with 19 mm length were utilized in this study. The force was measured, using digital scale immediately, after one-day immersion in distilled water and after 1, 2, 3 and 4 weeks immersion in the specific mouthwash for one minute twice daily then washed and kept in distilled water at 37°C. Force decay was calculated and compared among different elastic types, mouthwashes and time intervals using t-test and one-way ANOVA then Tukey's tests.* ***Results:*** *The force degradation of regular type was significantly higher than extreme one. With time, the force decay increased significantly in both types. There was non-significant difference among the mouthwashes in the first and second weeks while the opposite in the third and fourth especially with the control group.* ***Conclusions:*** *The extreme type is preferred over the regular one because of its low force decay and the tested mouthwashes have no clinical significant effect on the force degradation over time in comparison with distilled water.*

Keywords: Elastomeric chains, Force decay, Herbal mouthwash

INRODUCTION

Space closing in the dental arches can be performed with several traction aids like closed coil springs and elastomeric chain. Nevertheless, force loss over time has been documented among the majority types of traction aids presently used [1].

Polyurethane elastomeric chains are utilized widely as a tooth moving mechanism. They are used for: closing diastemas, correction of rotations, retraction of canines, generalized space closure and midline shift correction [2].

In the normal condition of the oral cavity, numerous factors can affect the force production and degradation of traction aids, such as pH variation, fluoride ions and rinses [1], saliva, temperature fluctuation [3], oxygen content [4], free radicals [5], salivary enzymes and masticatory forces [6]. This force loss made it thorny for orthodontists to decide the real force transmitted to the teeth [2,7,8].

Mouthwashes are prescribed widely for patients with fixed orthodontic appliance in addition to tooth brush and interdental aids. These mouthwashes mainly contain chlorhexidine and some contain sodium fluoride. Chlorhexidine is considered the superior mouthwash although it has many side effects like tooth discoloration, taste disturbance, desquamation of the mucosa and augmentation of calculus deposition [9].

Nowadays, herbal mouthwashes are available in the markets. They are free from alcohol, chlorhexidine, sugar, cetylpyridinum chloride that causes staining and produced from natural plants like green tea, Percica, *Punica granatum*, Cinnamon, Aloe-Vera, black seeds, and others.

In the literatures, many studies had been conducted to test the effect of the different mouthwashes on the force degradation of different traction aids.

Al-Jumaili and Ali [10] investigated the effect of artificial saliva and Zac™ mouthwash on the force degradation of different traction aids namely; elastomeric chain, nickel titanium and stainless steel closed coil springs at different time intervals. After completion of the immersion periods (three weeks), they found a higher percentage of force decay of NiTi closed coil spring and elastomeric chain incubated in Zac™ mouthwash in comparison to that incubated in artificial saliva. On the other hand, non-significant difference in the percentage of force decay was presented in stainless steel closed coil spring samples incubated in artificial saliva and Zac™ mouthwash.

Al-Kassar [11] found that Biofresh mouthwash increased the force decay of elastomeric chains due to the effect of fluoride ions that increased the distraction of the elastic chain and chlorhexidine that may cause disruption of the intermolecular bonds and degradation of the power chains. Contrary results were reported by Ramazanzadeh, et al. [12] who found that daily use of sodium fluoride mouthwash did not cause significant change in the force decay of elastomeric chain.

Larrabee, et al. [13] found higher force degradation of elastomeric chains exposed to a mouthwash containing alcohol compared to those exposed to water. The same was reported by Mahajan, et al. [14] and Abdullah [15] when they compared the force decay between alcohol and alcohol-free mouthwashes. Pithon, et al. [16] study revealed that the bleaching-containing mouthwash did not have an effect on force decay of elastomeric chains.

Kumar, et al. [17] premeditated the effect of tea, Coca-Cola and Listerine mouth rinse on the force decay of elastomeric chains and concluded that the utmost force degradation was presented in the tea group followed by Listerine and the lowest one in the Coca-Cola group in comparison to the control.

Javanmardi and Salehi [18] used three mouthwashes namely Orthokin, Sensikin and Percica to test their effect on the elastic chains and NiTi coil spring degradation and their findings revealed that these agents did not cause significant increase in force degradation.

Mirhashemi, et al. [19] reported no significant effect of Persica, chlorhexidine (alcohol-free), sodium fluoride and the combination of chlorhexidine and sodium fluoride on the force decay of elastomeric chains. On the other hand, Omidkhoda, et al. [20] thermocycled their sample and use chlorhexidine with 13.65% ethanol and proved that chlorhexidine and Persica had a significant effect on the force degradation over time with the highest percentage of force loss with chlorhexidine.

Rafeeq, et al. [21] found that the force decay of coloured chains was higher than clear one immersed in chlorhexidine mouthwash (0.12%).

The aim of this study was to determine and compare the force degradation of two types of short clear elastomeric chains at different time intervals of immersion in various herbal mouthwashes.

MATERIALS AND METHODS

Sample

Elastomeric chain

Two types of clear short elastomeric chains namely; Regular (Lot. 311458) and Extreme™ (Lot. 00025194) from Orthotechnology®, USA were used in this study.

Herbal mouthwashes

Four types of herbal mouth washes were used to test their effect on the force degradation of the elastics in addition to the control medium (distilled water). Full details about the mouthwashes are presented in Table 1.

Table 1 Information about the mouthwashes used in this study

Mouthwash	Main components	Company	pH	Country	Method of use
Distilled water	De-ionized water	Poisoning center	7	Iraq	Direct
Listerine green tea	*Camellia Sinensis* (Green tea), sodium fluoride	IDS manufacturing Ltd.	6	Thailand	Direct
Tebodont	*Melaleuca Alternifolia* (Tea tree oil)	Dr. Wild & Co AG	6.5	Switzerland	Direct
Aloe-dent	Aloe Vera, Peppermint oil, Menthol, Melaleuca Alternifolia	Optima Health and Nutrition	6	Italy	Direct
Silca herb	Yarrow, Camomile, Marigold, Sage	Dental- Kosmetik GmbH & Co. KG	7.4	Germany	10 drops in 125 ml of water

Methods

The pH of each mouthwash and the distilled water was measured using digital pH meter. Rectangular self-cure acrylic plates were constructed to be the frameworks on which ten pairs of stainless steel pins arranged in parallel manner with 1 cm apart. The space between each parallel pair was 29 mm.

All the tested samples of elastomeric chains were examined under magnifying lens (10x) to perceive any manufacturer defects such as sharp edges or cracks [22].

Using the vernier caliper, the length of the elastic module was measured by insertion the narrow two ends of the vernier at holes of the two outer apertures.

All the specimens were cut using sharp ligature cutter. Attention was paid to circumvent extended handling during cutting as this incorporated stress into the material prior to testing [23]. The initial length of each elastic was 19 mm extension them 10 mm to be 29 mm to simulate the cases of en masse retraction.

To measure the initial force, the acrylic plates were firmly tied to a bench top using a subordinate clamp. Ten pieces of each type of chains were attached to one side of the pins (without pre-stretching) and the other side to the clamp of the digital force gauge (Portable electronic scale, China with 0-10 kg. range of weight) [15], the scale was calibrated with known weight before measurements. All chains were handled and extended to the level of the other pin in similar way at the same vertical and horizontal distances on the acrylic plate to ensure trustworthy measurements.

Every two acrylic plates containing the two types of elastomeric chains were stored in glass container containing distilled water at 37°C for one day then the force was measured. After that, these plates were immersed in the specific mouthwash for one minute every twelve hours, washed with distilled water and stored in glass container containing distilled water at 37°C for the rest of day. These containers were capped to prevent any contamination and evaporation. After 1, 2, 3 and 4 weeks, the force was measured by the same gauge in the same manner. The percentage of force decay at each time was calculated as: Percentage of force decay = (Initial force – Force after specific time)/Initial force × 100 [24].

Statistical analysis

The collected data were analyzed using SPSS program version 21. The descriptive statistics included the means and standard deviations of the force and percentages of force decay for each type of elastic chains. Inferential statistics included one-way ANOVA test to investigate the effect of mouthwashes and time intervals on the elastic chains force decay. Tukey's HSD test was used if ANOVA test indicated significant difference. Independent t-test was used to compare the force decay between the two types of elastics in different mouthwashes.

The levels of significance were set as follows:

Non-significant: $P>0.05$; Significant: $0.05 \geq P > 0.01$; Highly significant: $P \leq 0.01$.

RESULTS

Table 2 showed the descriptive statistics of the load values of the two types of clear short elastomeric chains in different mouthwashes at various intervals. Generally, the load decreased over time in all mouthwashes for both types of elastics.

Table 2 Descriptive statistics of load values (gm) of different elastomeric chain types immersed in various mouthwashes

Duration	Elastic Types	D.W.		Listerine green tea		Tebodont		Aloe-dent		Silica herb	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
0 day (N=10)	Regular	343.943	3.139	343.943	3.139	343.943	3.139	343.943	3.139	343.943	3.139
	Extreme	412.847	3.076	412.847	3.076	412.847	3.076	412.847	3.076	412.847	3.076
1 day (N=10)	Regular	165.391	0.545	165.391	0.545	165.391	0.545	165.391	0.545	165.391	0.545
	Extreme	260.391	0.732	260.391	0.732	260.391	0.732	260.391	0.732	260.391	0.732

1 week (N=50)	Regular	157.75	0.463	156.3	0.579	156.38	0.426	156.539	0.472	156.304	0.931
	Extreme	206.632	0.517	205.518	0.604	205.969	0.103	205.616	0.552	205.042	0.253
2 weeks (N=50)	Regular	145.398	1.064	144.352	0.656	144.205	0.324	143.645	0.45	144.393	0.689
	Extreme	198.864	0.989	198.209	0.554	198.31	0.346	197.813	0.519	197.201	0.742
3 weeks (N=50)	Regular	141.06	0.376	134.689	0.488	134.291	0.265	133.41	0.979	134.129	0.548
	Extreme	191.377	0.842	185.66	0.607	186.516	0.614	184.142	0.517	184.37	0.585
4 weeks (N=50)	Regular	136.664	0.539	132.497	0.418	132.635	0.616	130.186	0.799	130.667	0.458
	Extreme	182.077	0.626	180.695	0.409	181.519	0.62	181.096	0.497	178.513	0.586

Table 3 demonstrated the force degradation of the elastic chains in different mouthwashes and it is obvious that the force degradation increases with time and appears more in regular type.

Table 3 Descriptive statistics of the percentage of force decay of various elastomeric chain types immersed in different mouthwashes

Durations	Elastic Types	D.W.		Listerine green tea		Tebodont		Aloe-dent		Silca herb	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Day 0	Regular	0	-	0	-	0	-	0	-	0	-
	Extreme	0	-	0	-	0	-	0	-	0	-
Day 1	Regular	51.909	0.553	51.909	0.553	51.909	0.553	51.909	0.553	51.909	0.553
	Extreme	36.925	0.506	36.925	0.506	36.925	0.506	36.925	0.506	36.925	0.506
Week 1	Regular	54.131	0.456	54.553	0.426	54.53	0.343	54.484	0.398	54.551	0.541
	Extreme	39.918	0.554	40.242	0.571	40.111	0.553	40.214	0.509	40.38	0.531
Week 2	Regular	57.722	0.603	58.027	0.465	58.07	0.398	58.233	0.344	58.015	0.499
	Extreme	42.177	0.554	42.367	0.521	42.338	0.518	42.482	0.547	42.659	0.69
Week 3	Regular	58.984	0.398	60.837	0.403	60.952	0.391	61.208	0.477	60.999	0.436
	Extreme	44.353	0.615	46.016	0.513	45.767	0.575	46.457	0.529	46.391	0.549
Week 4	Regular	60.262	0.437	61.474	0.415	61.434	0.364	62.146	0.434	62.006	0.4
	Extreme	47.058	0.534	47.46	0.499	47.22	0.511	47.344	0.409	48.095	0.439

Table 4 Descriptive statistics and comparison of the percentage of the force decay between the two types of elastomeric chains

Mouth washes	Duration	Regular		Extreme		Comparison		
		Mean	S.D.	Mean	S.D.	Mean difference	t-test	p-value
D.W.	Day 1	51.909	0.553	36.925	0.506	14.984	63.241	0.00
	Week 1	54.131	0.456	39.918	0.554	14.213	62.657	0.00
	Week 2	57.722	0.603	42.177	0.554	15.544	60.021	0.00
	Week 3	58.984	0.398	44.353	0.615	14.631	63.154	0.00
	Week 4	60.262	0.437	47.058	0.534	13.204	60.457	0.00
Listerine green tea	Day 1	51.909	0.553	36.925	0.506	14.984	63.241	0.00
	Week 1	54.553	0.426	40.242	0.571	14.311	63.545	0.00
	Week 2	58.027	0.465	42.367	0.521	15.659	70.878	0.00
	Week 3	60.837	0.403	46.016	0.513	14.82	71.836	0.00
	Week 4	61.474	0.415	47.46	0.499	14.014	68.241	0.00

Tebodont	Day 1	51.909	0.553	36.925	0.506	14.984	63.241	0.00
	Week 1	54.53	0.343	40.111	0.553	14.42	70.098	0.00
	Week 2	58.07	0.398	42.338	0.518	15.732	76.145	0.00
	Week 3	60.952	0.391	45.767	0.575	15.186	69.118	0.00
	Week 4	61.434	0.364	47.22	0.511	14.214	71.599	0.00
Aloe-dent	Day 1	51.909	0.553	36.925	0.506	14.984	63.241	0.00
	Week 1	54.484	0.398	40.214	0.509	14.27	69.889	0.00
	Week 2	58.233	0.344	42.482	0.547	15.751	77.024	0.00
	Week 3	61.208	0.477	46.457	0.529	14.751	65.508	0.00
	Week 4	62.146	0.434	47.344	0.409	14.802	78.471	0.00
Silca herb	Day 1	51.909	0.553	36.925	0.506	14.984	63.241	0.00
	Week 1	54.551	0.541	40.38	0.531	14.171	59.075	0.00
	Week 2	58.015	0.499	42.659	0.69	15.356	57.016	0.00
	Week 3	60.999	0.436	46.391	0.549	14.608	65.882	0.00
	Week 4	62.006	0.4	48.095	0.439	13.911	74.093	0.00

Table 5 Effect of time of immersion on the force decay of different elastomeric chains

Mouth washes	**Elastic types**	**ANOVA test**	
		F-test	**p-value**
D.W.	Regular	493.431	0.00
	Extreme	949.729	0.00
Listerine green tea	Regular	807.112	0.00
	Extreme	669.888	0.00
Tebodont	Regular	976.888	0.00
	Extreme	613.443	0.00
Aloe-dent	Regular	954.716	0.00
	Extreme	745.582	0.00
Silca herb	Regular	759.62	0.00
	Extreme	673.317	0.00

Table 6 Tukey's HSD after ANOVA test for comparison between each two intervals

Duration		**Tukey's HSD test**									
		D.W.		**Listerine green tea**		**Tebodont**		**Aloe-dent**		**Silca herb**	
		Regular	**Extreme**	**Regular**	**Extreme**	**Regular**	**Extreme**	**Regular**	**Extreme**	**Regular**	**Extreme**
Day 1	Week 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Week 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Week 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Week 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Week 1	Week 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Week 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Week 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Week 2	Week 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Week 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Week 4	Week 4	0.00	0.00	0.025	0.00	0.09	0.00	0.00	0.002	0.00	0.00

A comparison between both types of elastic chains was presented in Table 4. Generally, there was high significant difference between them in all mouthwashes and time intervals being higher in regular type.

Tables 5 and 6 showed the effect of time intervals of immersion in the mouthwashes, ANOVA and Tukeys' tests revealed statistically high significant difference among different intervals and between each two intervals respectively except between the 3rd and 4th weeks for regular type immersed in Tebodont mouthwash.

Table 7 presented the effect of mouthwashes on the force degradation. Generally, there was non-significant difference among these agents in 1st and 2nd weeks while high significant difference in the 3rd and 4th weeks. For the 3rd week, the difference was between the herbal mouthwashes with distilled water, while in the 4th week, the third was high significant difference between each types of mouthwashes for regular type and between some of them in the extreme one (Table 8).

Table 7 Effect of mouthwashes on the force decay of different elastomeric chains

Duration	Elastic Types	ANOVA test	
		F-test	p-value
Week 1	Regular	1.697	0.167
	Extreme	0.999	0.418
Week 2	Regular	1.546	0.205
	Extreme	0.987	0.424
Week 3	Regular	46.585	0.00
	Extreme	23.52	0.00
Week 4	Regular	32.627	0.00
	Extreme	6.834	0.00

Table 8 Tukey's HSD after ANOVA test for comparison between each two mouthwashes

Mouthwashes		3 weeks		4 weeks	
		Regular	Extreme	Regular	Extreme
D.W.	Listerine green tea	0.00	0.00	0.00	0.349
	Tebodont	0.00	0.00	0.00	0.942
	Aloe-dent	0.00	0.00	0.00	0.674
	Silca herb	0.00	0.00	0.00	0.00
Listerine green tea	Tebodont	0.972	0.853	0.999	0.799
	Aloe-dent	0.298	0.403	0.006	0.983
	Silca herb	0.91	0.566	0.044	0.038
Tebodont	Aloe-dent	0.658	0.059	0.003	0.978
	Silca herb	0.999	0.108	0.026	0.002
Aloe-dent	Silca herb	0.801	0.999	0.94	0.009

DISCUSSION

Elastomeric chains got wide popularity in daily orthodontic practice because they are economic, relatively hygienic, required less chair time [7] and some types contain fluoride that reduced enamel decalcification [25]. On the other hand, they were made of industrial polyurethanes which were not inert materials so with long-drawn-out contact with enzyme, water or heat they will decompose [25].

The clear type was undergoing discoloration by foods and drinks causing aesthetic problems. Moreover, these elastics exhibited load relaxation when stretched beyond their elastic limit and this force loss made it intricate for practitioners to determine the actual force applied to dentition [2].

In this study, four types of herbal mouthwashes with different active ingredients were used for the first time to determine their effect on the force degradation of two types of clear short elastic chains. Currently, many types of mouthwashes prepared from herbs because of their soothing effect and anti-microbial effects against many microorganisms with fewer side effects unlike chemical mouthwashes especially teeth discoloration. All of these mouthwashes are alcohol-free. The active ingredients of each mouthwash were presented in Table 1.

The specimens were kept in distilled water at 37°C during the study except the time of immersion in mouthwashes in

order to be near to the mouth environment. Artificial saliva was not used as a storage media to exclude its effect on the force degradation.

Balhoff, et al. [26] determined 25 mm horizontal distances between the two parallel pins. This distance represented approximately the actual distance between the midpoint of the first molar and midpoint of the canine in a normal dentition preceding to space consolidation. In this study, 29 mm horizontal distances were used to simulate the cases of en masse retraction as this type of retraction is preferred over two steps retraction [2]. This distance represented approximately the distance between the midpoint of the first molar and a hook distal to the lateral incisor.

In this study, multiple specimens were used i.e. new elastic modules for each period to avoid the stress that aroused from arduous handling of the chains. In case of using one sample over four weeks, the elastic module must be relieved from the pin, re-stretched by the force measuring gauge to measure the force and then stretched between the two parallel pins for re-attachment. This will incorporate a stress on the modules that may affect the force decay [27].

Discussion of the results will be under three headings: effect of elastic type, effect of time and effect of mouthwashes on the force degradation.

Effect of the type of elastomeric chains

Two types of elastomeric chains were used; regular and extreme. The amount of force delivered by the extreme type was higher than regular one Table 2. This related to the material of the extreme type that's thinner and 25% stiffer than the regular chain [28].

The findings of Table 4 indicated that regular type showed significantly higher force decay than extreme type in a percent reached up to 15% in all periods and mouthwashes, this can be explained by its higher tensile strength with less deformation over extended periods of time [28].

Effect of time intervals

The time of this study extended to four weeks which is the ideal interval between the orthodontic appointments to change the elastic chains [2].

Table 2 revealed a decrease in the force level over time. The force decay after the first day of immersion in distilled water was about 52% for the regular type and 37% for extreme followed by steady increase till the fourth week; this comes in agreement with the findings of many studies [10-21]. This could be explained from many aspects:

1) The effect of stretching of elastic chains which is directly proportional with the force decay and inversely with the force [29].
2) Leaching out of several elements from the elastomeric chain caused by water sorption [30].
3) The molecules of the water acted as plasticizer and unconstructively affect the intermolecular attraction forces of the chains of elastomers [31].
4) Microstructure cracks and subsequent breakdown in the intermolecular bond caused by elastic swelling that fill the voids in the rubber matrix [32].

One-way ANOVA and Tukey's HSD tests revealed statistically high significant increased force decay of both types of elastics in all mouthwashes. The extreme type showed less force decay because of their properties mentioned above.

Effect of mouthwashes

Four herbal mouthwashes with different components were compared with the distilled water. Statistically, non-significant difference was found in the first and second weeks and just opposite for the third and fourth weeks (Table 7).

Reviewing Table 8, in the third week, there was statistically high significant difference in both types of elastics between the control group and tested mouthwashes owing slightly higher force decay than the distilled water. This difference is clinically negligible.

It had been found that the water and chemicals in the disinfectants acted as potent plasticizers that cause disruption of the intermolecular bonds and degradation of the elastomers and slipping the polymeric chains past each other especially under load [33].

The pH of the tested mouthwashes was measured and seem to be near to that of distilled water (Table 1), so no obvious clinical effect of pH on the force decay although statistically there was significant difference with the distilled water especially in the third week.

Listerine green tea contains sodium fluoride that is not found in the other mouthwashes. Its presence did not affect the force decay in accordance with the findings of Ramazanzadeh, et al. [12], Abdullah [15] and Mirhashemi, et al. [19] and contrary to that of Al-Kassar [11].

This is the first study that investigated these herbal mouthwashes, so no study to be compared with. Just two studies [18,19] determined that Percica had no effect on the force degradation in accordance with the present findings.

Further studies are needed to determine the effect of other types of herbal mouthwashes containing Cinnamon, Neem, Myrrh, *Punica granatum*, etc. on the force decay of different colours and configurations of elastomeric chains.

CONCLUSION

The extreme type is favoured more than the regular because of its low force degradation. With time, the force decay of the elastic chains increased significantly in all types of mouthwashes. Reviewing the mean values of the force decay, the tested mouthwashes had no clinical significant effect although statistically there were significant differences among some of them and with the control group in the third and fourth weeks.

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