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The Effect of Mouth Wash Containing Chlorhexidine on Force Degradation of Colored Elastomeric Chains

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Abstract: ***Background**: Colored elastomeric chains exhibit different performance of force degradation with time. The aims of the current study are estimation of the effect of chlorhexidine mouth wash on force degradation of colored elastomeric chains at different time intervals. **Materials and method**: A total of 240 elastomeric chain pieces (closed type) of three colors (transparent, pearl lilac, and crystal yellow) with an initial length 19mm and extend 29mm.These elastic chains divided into two groups one immersed in distilled water (control group) and the other cyclically immersed between distilled water and chlorhexidine mouth wash (test group), these elastic chains incubated in covered glass containers contain distilled water at 37C°for the entire testing period. Then the force measured by digital force gauge at different time intervalsT0, T1, T2, and T3. **Results**: Comparison of the effect of different immersion media on load value(gf) which showed highly significant difference (for transparent and crystal yellow separately at T1, T2, andT3, and for pearl lilac at T2 and T3) ,while it showed non-significant difference (for transparent and crystal yellow separately at T0 and for pearl lilac at T1),and showed significant difference (forpearl lilac at T0).As time progress the load value(gf)decreased which is obvious in repeated measure ANOVA test followed by Bonferroni test both showed highly significant difference. Comparison of the effect of different colors of elastomeric chain on the load value by repeated measure ANOVA test followed by Bonferroni test both showed statistically highly significant difference, except between crystal yellow and pearl lilac at T1 and T2 which showed non-significant difference. The mean of percentage of force decay increased with time. **Conclusion**: The use of chlorhexidine mouth wash will decrease the load value of the elastomeric chains used in this study, and transparent elastomeric chains deliver the highest initial force and have a lesser force decay than crystal yellow and pearl lilac elastomeric chains.*

Keywords: mouth wash, chlorhexidine, force degradation, colored elastomeric chains

1. Introduction

Elastomeric products are used as ligatures and chains in order to apply retraction forces to the teeth[1]. Elastomeric chains were introduced to the orthodontic profession in the 1960s, and are now an integral part of many practices [2]. Recently, a number of manufacturers have added colored elastomeric chains to their inventories, one of the major short coming of the elastomeric chains was their inability to maintain delivered force for a significant duration [3], therefore after placement the elastic chains were to be changed at 3-4 weeks intervals [4]. After that they become permanently elongated and discolored [5]. This was attributed to the stress relaxation behavior and un-esthetic appearance since they were susceptible to be stained from a variety of foods [6], which might render them to be unhygienic [7]. One of the most important reasons of plastic deformation and force decay of elastomeric modules is their sensitivity to the changes in intraoral environment that arise from a number of factors including different foods and beverages and other materials that enter the oral cavity[8,9]. Use of mouth rinses has been introduced as the effective way for reducing dental plaque accumulation and improving oral health during orthodontic treatment [10].Among frequently used antiseptic mouth washes, Chlorhexidine (CHX) is known as the most potent chemical .CHX has several side effects such as undesirable tooth discoloration, unpleasant taste and causing dryness and burning sensation in the mouth, leading to patient dissatisfaction [11,12]. It is possible that some recommendations of the orthodontists to their patients may be contributing to the force decay of our materials and subsequently will lead to a less efficient orthodontic treatment [13]. Recently, the use of herbal mouthwashes free of chlorhexidine is increasing. It has been shown that using herbal medicine or its extract would support periodontal health, and reduces the accumulation of microbial plaques with no side effects [14].

The aims of the current study are estimation of the effect of chlorhexidine mouth wash on force degradation of colored elastomeric chains at different time intervals.

2. Materials and Method

The sample

A total of 240 elastomeric chain pieces were cut (Morelli/Sorocaba-Brazil) of closed type of three colors (transparent, crystal yellow, and pearl lilac), 80 pieces for each color with initial length 19 mm of each piece which were checked by using digital vernier caliper, and extend to 29 mm, which is to be efficient in canine retraction[15].All the samples checked by magnifying lens(x10) to distinguish any manufacturer imperfections like sharp edges or cracks [1].

Eight acrylic blocks measured as 44x6x1 cm, were purposely constructed. Each board carried a circular cross section stainless steel pins 3mm in diameter arranged in two parallel rows. Each board include sixty pins with 30 elastic chain pieces, the distance between pins in the same raw is 1cm, and the distance between pins in opposite rows was 29 mm to be similar to the elastic chain stress and strain in the oral cavity (activation distance)[16], these pins are divided into 3 groups of 20 pins with 10 elastic chain pieces for each color (transparent, pearl lilac, and crystal yellow).

Procedure of Samples immersion

The samples were divided into two main groups according to the media the control group which immersed in distilled water, and the test group which immersed in distilled water and cyclically immersed inchlorhexidine mouth wash (Bio fresh mouth wash /UAE alcoholfree0.12%chlorhexidine content as active ingredient),each group composed of four acrylic boards with elastomeric chains in closed glass containers separately(with exception of both groups at T0).All the colored elastomeric chain specimens were carefully installed by artery forcepson the pins which fixed on the holding boards, The initial force was measured at T0, then the control group immersed in distilled water solution and the test group immersed in distilled water solution and immersed in chlorhexidine mouth washat one time for each time intervals 1day(T1), 7 days(T2), and 21 days (T3), and kept in the incubator at a constant temperature of 37 C˚ which was checked daily by a sensitive thermometer[17] for regulating the incubator temperature to avoid increased temperature of the testing media which cause further force degradation of the elastomeric chains[18]. The test group immersed in chlorhexidine 30 seconds twice daily each 12 hours for each time intervals using a digital clock, corresponding to the manufacturers guide lines. After immersion of the elastomeric chains in the mouth wash for 30 seconds then the elastic chain rinsed with intermediate separate baths of distilled water for 10 seconds to be similar to salivary cleaning of the mouth wash from the oral cavity, and the distilled water bath was changed after time of rinsing, and then immersed again into distilled water immersion media at 37C˚in incubator for the entire testing period. The same protocol was carried on the control group which only immersed again in distilled water [13].So all the samples of test group (except those tested for their initial force at T0) were cyclically immersed between distilled water and chlorhexidine mouth wash, from first day of experiment.

Method of force degradation measurement:

Force measurements were made by a digital force gauge which was reset to a zero reading before each measurement, and then measurements were taken by permitting one end of the elastomeric chain to be held on the pin and fitting the other end to the force gauge. Throughout force measurement, the acrylic boards were tightly attached to a workbench top using a vice lock clamp, in addition all the elastomeric chains held and gauged at the same horizontal and vertical distance on the acrylic board .The initial force (gf) was immediately measured at T0. Then force values (gf) were recorded at three time intervals T1, T2, and T3, and in each time interval new 10 elastic specimens were tested [19]. The load value was measured in gram force unit (gf). Force decay compared to the baseline and was calculated using the following equation:

% FD= 100 x [(IF-Ft)/IF]

FD=force decay IF=initial force Ft=force at specific time [13].

Statistical analysis

Data were collected and statistically analyzed by a software computer program SPSS(statistical package of social science) software version 21for windows XP .The following statistics were used:

a) Descriptive Statistics: mean, standard deviations, standard error for the mean of load value and percentage of force decay.
b) Inferential Statistics: including the following test:

1) Repeated measure ANOVA test: to test any statistically significant difference among different time intervals, different media, and different elastomeric chain colors separately for the mean of load value of elastomeric chain.
2) Bonferroni test: to compare the load value between each two time intervals and each two colors of elastomeric chain separately when repeated measure ANOVA test showed a statistically significant difference.

   In the statistical evaluation, the following levels of significance are used:

$P > 0.05$	NS	Non-significant
$0.05 \geq P > 0.01$	S	Significant
$P \leq 0.01$	HS	Highly significant

3. Results

The multivariate test of the main effect and interaction of time, elastomeric chain colors, and immersion media on the mean of the load value (Table 1) showed the effect of time on the mean of load values was highly significant, the interaction effect of time and elastomeric chain colors was highly significant, the interaction effect of time and immersion media was highly significant, and the interaction of time, elastomeric chain colors, and immersion media was highly significant.

The descriptive statistics (Table 2) for the mean of load value of each elastomeric chain color immersed in distilled water(control group) and chlorhexidine mouth wash(study group), and comparison of the effect of immersion media on load value using repeated measure ANOVA at different time intervals T0,T1,T2, and T3 which showed non-significant difference for transparent and crystal yellow elastomeric chain separately at T0 and the pearl lilacat T1, while for pearl lilac at T0 showed significant difference, and also showed highly significant difference at T1,T2 , and T3for transparent and crystal yellow elastomeric chain separately, and at T2 and T3 for pearl lilac.

The descriptive statistics and comparison of the load value of different elastomeric chains color (Table 3) immersed in distilled water and chlorhexidine mouth wash amongT0, T1, T2 and T3 using repeated measure ANOVA test which showed highly significant difference, followed by Bonferroni test which showed highly significant difference between each two time intervals (T0 and T1, T0 and T2, T0 and T3, T1 and T2, T1and T3, T2 and T3).

The descriptive statistics and comparison of the load value among different elastomeric chain colors(transparent, crystal yellow and pearl lilac) when immersed in distilled water and chlorhexidine mouth wash at different time intervals using repeated measure ANOVA test(Table 4) which showed highly significant difference, followed by Bonferroni test that showed highly significant difference between each two colors of elastomeric chains (transparent and crystal yellow, transparent and pearl lilac, crystal yellow and pearl lilac) in distilled water and chlorhexidine mouth wash atdifferent time intervals, except between crystal yellow and pearl lilac in distilled water at T1 and T2 which showed non-significant difference.

The descriptive statistics which show the change of percentage of force decay for all the elastomeric chain colors in different media within time (Table 5) illustrated that the mean of the force decay increased with time.

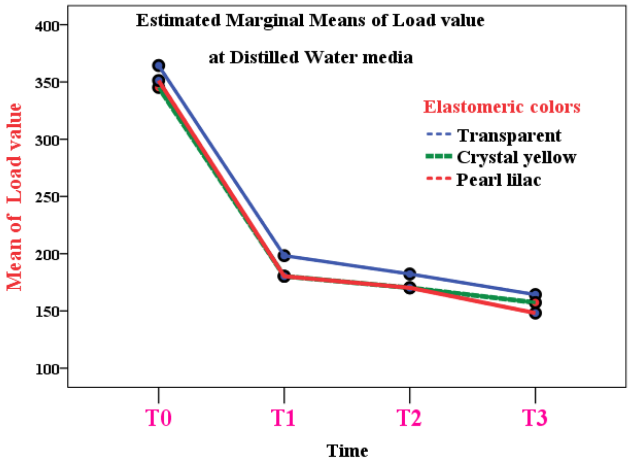

Figure 1: Estimated marginal means of load value (gf) of colored elastomeric chain within time in distilled water

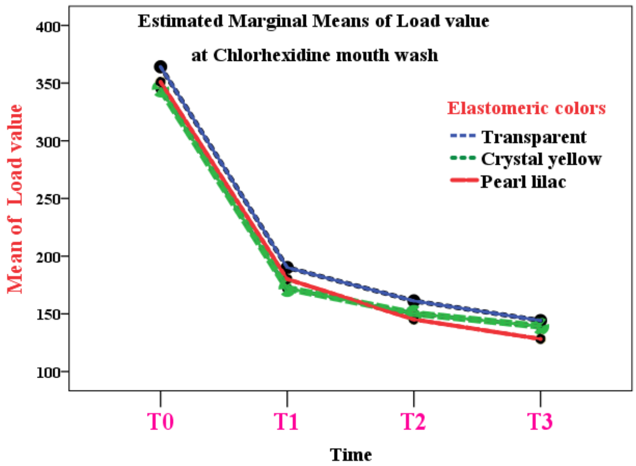

Figure 2: Estimated marginal means of load value (gf) of colored elastomeric chain within time in chlorhexidine mouth wash

Table 1: Multivariate test of the main effect and interaction of time, elastomeric colors and media on load value (gf)

Multivariate Tests				
Effect		*F-test*	*d.f.*	*Sig.*
Time	Wilks' Lambda	4582690.316	3	.000**
Time * elasticomeric colors	Wilks' Lambda	443.012	6	.000**
Time * Media	Wilks' Lambda	13720.044	3	.000**
Time * elasticomeric colors*Media	Wilks' Lambda	138.063	6	.000**

Table 2: Descriptive statistics and comparison of the effect of different immersion media on the load values (gf) of colored elastomeric chain at different time interval

Elastomeric colors	*Time*	*Media*				*Media difference*	
		Distilled water		*Chlorhexidine mouth wash*			
		Mean	*±SE*	*Mean*	*±SE*	*F-test*	*Sig.*
Transparent	T0	364.350	.109	364.130	.109	2.046	.158(NS)
	T1	198.290	.129	190.140	.129	1987.596	.000**
	T2	182.290	.095	161.230	.095	24589.604	.000**
	T3	164.310	.115	144.220	.115	15177.463	.000**
Crystal yellow	T0	345.200	.109	345.020	.109	1.370	.247(NS)
	T1	180.320	.129	172.090	.129	2026.807	.000**
	T2	170.250	.095	150.290	.095	22087.974	.000**
	T3	157.350	.115	139.240	.115	12333.213	.000**
Pearl lilac	T0	351.290	.109	350.980	.109	4.062	.049(S)
	T1	180.320	.129	180.110	.129	1.320	.256(NS)
	T2	170.250	.095	145.130	.095	34984.371	.000**
	T3	148.170	.115	128.250	.115	14921.689	.000**

Table 3: Descriptive statistics and comparison of the effect of different time interval on load value (gf) of different elastomeric chain colors treated with distilled water and chlorhexidine mouth wash

Elastomeric colors	*Media*	*Time*	*Mean*	*±SE*	*F-test*	*Sig.*	*Bonferroni test*	
Transparent	Distilled water	T0	364.350	.109	713237.343	.000**	T0 -T1	0.000**
		T1	198.290	.129			T0 -T2	0.000**
		T2	182.290	.095			T0 - T3	0.000**
		T3	164.310	.115			T1 - T2	0.000**
							T1 - T3	0.000**
							T2 - T3	0.000**
	Chlorhexidine mouth wash	T0	364.130	.109	857607.153	.000**	T0 -T1	0.000**
		T1	190.140	.129			T0 -T2	0.000**
		T2	161.230	.095			T0 - T3	0.000**
		T3	144.220	.115			T1 - T2	0.000**
							T1 -T3	0.000**
							T2 - T3	0.000**
Crystal Yellow	Distilled water	T0	345.200	.109	649596.230	.000**	T0 -T1	0.000**
		T1	180.320	.129			T0 -T2	0.000**
		T2	170.250	.095			T0 - T3	0.000**
		T3	157.350	.115			T1 - T2	0.000**
							T1 - T3	0.000**
							T2 - T3	0.000**
	Chlorhexidine mouth wash	T0	345.020	.109	776096.015	.000**	T0 -T1	0.000**
		T1	172.090	.129			T0 -T2	0.000**
		T2	150.290	.095			T0 - T3	0.000**
		T3	139.240	.115			T1 - T2	0.000**
							T1 - T3	0.000**
							T2 - T3	0.000**
Pearl Lilac	Distilled water	T0	351.290	.109	730827.558	.000**	T0 -T1	0.000**
		T1	180.320	.129			T0 -T2	0.000**
		T2	170.250	.095			T0 - T3	0.000**
		T3	148.170	.115			T1 - T2	0.000**
							T1 - T3	0.000**
							T2 - T3	0.000**
	Chlorhexidine mouth wash	T0	350.980	.109	874734.962	.000**	T0 -T1	0.000**
		T1	180.110	.129			T0 -T2	0.000**
		T2	145.130	.095			T0 - T3	0.000**
		T3	128.250	.115			T1 - T2	0.000**
							T1 - T3	0.000**
							T2 - T3	0.000**

Table 4: Descriptive statistics and comparison of the effect of different elastomeric chain colors immersed in distilled water and chlorhexidine mouth wash on load values (gf) of elastomeric chain at different time interval

Media	*Time*	*Elastomeric colors*						*Statistics*		*Bonferroni test Elastomeric colors difference*		
		Transparent		*Crystal yellow*		*Pearl lilac*						
		Mean	*±SE*	*Mean*	*±SE*	*Mean*	*±SE*	*F-test*	*Sig.*	*Transparent - Crystal yellow*	*Transparent - Pearl lilac*	*Crystal yellow – Pearl lilac*
Distilled water	T0	364.350	.109	345.20	.109	351.29	.109	8093.577	.000**	.000**	.000**	.000**
	T1	198.290	.129	180.32	.129	180.32	.129	6441.955	.000**	.000**	.000**	1.00(NS)
	T2	182.290	.095	170.25	.095	170.25	.095	5357.924	.000**	.000**	.000**	1.00(NS)
	T3	164.310	.115	157.35	.115	148.17	.115	4928.861	.000**	.000**	.000**	.000**
Chlorhexidine mouth wash	T0	364.130	.109	345.02	.109	350.98	.109	8083.178	.000**	.000**	.000**	.000**
	T1	190.140	.129	172.09	.129	180.11	.129	4894.729	.000**	.000**	.000**	.000**
	T2	161.230	.095	150.29	.095	145.13	.095	7494.195	.000**	.000**	.000**	.000**
	T3	144.220	.115	139.24	.115	128.25	.115	5021.717	.000**	.000**	.000**	.000**

Table 5: Descriptive statistics of percentage of force decay change for all the elastomeric chain colors and media within time

Time	*Elastomeric colors*	*Media*					
		Distilled water		*Chlorhexidine mouth wash*		*Total*	
		Mean	*±SD*	*Mean*	*±SD*	*Mean*	*±SD*
T0	Transparent	0	0	0	0	0	0
	Crystal yellow	0	0	0	0	0	0
	Pearl lilac	0	0	0	0	0	0
	Total	0	0	0	0	0	0

T1	Transparent	45.577	.106	47.782	.138	46.680	1.138
	Crystal yellow	47.764	.048	50.122	.197	48.943	1.218
	Pearl lilac	46.093	.120	48.684	.144	47.388	1.335
	Total	46.478	.954	48.863	.992	47.670	1.542
T2	Transparent	49.968	.094	55.722	.137	52.845	2.954
	Crystal yellow	50.681	.061	56.440	.067	53.560	2.955
	Pearl lilac	52.410	.090	58.650	.111	55.530	3.203
	Total	51.020	1.046	56.937	1.272	53.978	3.199
T3	Transparent	54.903	.113	60.393	.127	57.648	2.819
	Crystal yellow	54.418	.087	59.643	.078	57.030	2.682
	Pearl lilac	57.821	.096	63.459	.113	60.640	2.894
	Total	55.714	1.532	61.165	1.682	58.440	3.178

Note:T0= immediately, T1=1 day, T2=7 day, T3=21 day

4. Discussion

Elastomeric chains are force generating constituents used to deliver force to move the teeth in a predestined manner in orthodontic treatment. The various colors of elastomeric chains reveal various performances [20-22].

The multivariate test showed that the effect of time on the mean of load values was highly significant. The two way interaction effect of time and elastomeric chain colors was highly significant. The two way interaction effect of time and media was highly significant. The three way interaction of time, elastomeric chain colors, and media was highly significant as illustrated in table (1). The finding of the present study (Table 2) showed non-significant difference between the two immersion media for the mean of load values of the pearl lilacat T1,and transparent and crystal yellow elastomeric chain color separately at T0, due to that the initial force were instantly measured for the elastomeric chains at T0 (0 hour), while for pearl lilac at T0 showed significant difference , and also for transparent and crystal yellow showed highly significant difference at T1,T2 , and T3,in addition for pearl lilac at T2 and T3,these results were due to the fact that water sorption, the stretching influence, and leakage out of some ingredient from elastics after immersion in water because of its liability to hydrolysis[23],in addition water molecules may perform as plasticizers and negatively influence the intermolecular attraction forces of elastomeric chains [24] .The water sorption leads to swelling of the elastics because of filling up of the spaces in the rubber matrix by fluids lead to microstructure fissures with subsequent breakdown in the intermolecular bond result in loosing of force delivered[25,26]. The plasticizers influence, correspondingly with the existence of load effect result in slippage of the polymeric chains sticking each other [27].Huget et al [24], discovered polyurethanes are not inert materials and as an alternative may be exposed to water absorption and may plasticizes or triggers degradation of the elastomers with prolonged exposure to chemical substances with different PH level, water, heat, and moist.

In the present study, samples immersed in distilled water showed greater load values than those in chlorhexidine mouth wash due to the fact that these media include constituents which simplifies migration by infiltrating the polymer in comparison with the distilled water, and this was the similar to the findings of Gray et al. [28], Nattrass et al [29], Long [30], and Abdullah [31].

Concerning the effect of immersion time on the mean of the load value of elastomeric chain (Table3, figure1 and 2) the result of repeated measure ANOVA and Bonferroni test both showed highly significant difference for the mean of load value of elastomeric chain among the four time intervals, this result showed that, as time progress the load value decreased due to permanent deformation of elastomeric chains which resulted from the existence of humidity and stretching effect. The load value was decreased under the extended attachment with water. The stretching of elastomeric chain between two points leading to the polymer chain get uncoiled, straightened, extended, and later causing chain slippage, sliding of polymer molecules which stuck one another, breaking of primary bonds and development of permanent deformation[26], this result agreed with Abdullah [31].

Regarding the effect of colors of elastomeric chain on the mean of the load value of elastomeric chain(Table 4),the present study showed highly significant difference among different colors of elastomeric chains which is obvious in repeated measure ANOVA test that followed by Bonferroni test which showed highly significant difference between each two colors of elastomeric chains in distilled water and chlorhexidine mouth wash at different time intervals, except between crystal yellow and pearl lilac in distilled water at T1 and T2which showed non-significant difference. The result showed various colors of elastomeric chain exhibited various performances, so crystal yellow and pearl lilac elastomeric chains delivered lesser force than transparent elastomeric chains at all four time intervals, this is because of the adding of pigment changes the molecular structure causing steric interference revealing higher force loss[1]. The properties of the Force delivery of colored elastomeric chains were significantly influenced by the filler material employed in coloring the chains [32].pigmented elastomeric chains displayed higher force degradation at 24 hours and 21 day time interval in comparison with non-pigmented ones [33], and this is may be associated with the adding of pigment and the difference in the manufacturing method. The addition of Pigments to elastomeric chains is to give the material various colors appear to influence its mechanical properties [33].

The change of percentage of force decay for all the elastomeric chain colors in different media within time (Table 5) in which there is marked increase in the mean of the force decay with time, except at T0 the force decay was zero. Loosing of force during 21 days was pronounced, the majority of force loss took place after the first day with a range of force decay 46.68%-47.38%, then followed by gradual and steady loosing of force levels for the rest of the working periods, this result agreed with Mohammed [18], Abdullah [31], Balhoff et al[34], and Hemed [35].This could be attributed to load relaxation pattern ,which is correlated to the variances in the viscosity of the elastic material presenting various force /relaxation ratios by consumption of the chemical environment [31,34,35].

So it can be concluded that the use of chlorhexidine mouth wash will decrease the load value of the three colors of elastomeric chains used in this study, in addition to the obvious force decay occurred after the first day then followed by gradual loss in the remaining time,and transparent elastomeric chain deliver the highest initial force and have a lesser force decay than crystal yellow and pearl lilac elastomericchain. So the accurate selection of practical elastomeric chain for efficient tooth movement is recommended.

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