ISSN: ***1812–1217***

Evaluation and Comparison of The Effect of Artificial saliva and Mouthwash Solution on Force Degradation of Different Types of Orthodontic Traction Aids (Comparative in Vitro Study)

Khudair A Al-Jumaili
BDS, CES, DSc (Prof)

Abdulrahman I Ali
BDS, MSc (Asst Lec)

Dept of Pedod, Orthod and Prev Dentistry
College of Dentistry, University of Mosul

الخلاصة

أهداف الدراسة:تحديد مقدار اضمحلال القوة لثلاثة أنواع من وسائل السحب التقويمية حلقات البولي يورثران ، نابض حلقي مقفل من نوع نيكل تيتانيوم و نابض حلقي مقفل من نوع نحاس لايصدا. **المواد و طريقة العمل**: نماذج الاختبار مدت إلى مسافات محددة والتي كانت : 18 مليمتر في حالة حلقات البولي يورثران و 20 مليمتر في حالة نابض حلقي مقفل من نوع نيكل تيتانيوم و نابض حلقي مقفل من نوع نحاس لايصدا. وبعدها تحضن النماذج في ثلاثة أوساط (في حالة جافة ، في لعاب صناعي و في سائل غسول الفم) لفترة ثلاثة أسابيع. **النتائج** : أظهرت النتائج أن النماذج في الحالة الجافة لديها دائما اقل نسبة لاضمحلال القوة مقارنة بالنماذج في الحالات الرطبة. وأظهرت النتائج كذلك أن زيادة فترة الحضن تؤد إلى زيادة في نسبة اضمحلال القوة مع وجود النسبة العظمى في أول أربع وعشرين ساعة من بداية فترة ألحضن. **الاستنتاجات**: في الوسائط الجافة و الرطبة اظهر النابض الحلقي المقفل من نوع نيكل تيتانيوم اقل نسبة من اضمحلال القوة فيما أظهرت حلقات البولي يورثران أعلى نسبة من اضمحلال القوة فيما امتلك النابض الحلقي المقفل من نوع نحاس لايصدا قيمة وسطى من اضمحلال القوة بيت الأنواع السابقة.

ABSTRACT

Aims: To determine the amount of force degradation of three types of orthodontic traction aid polyurethane elastomeric chain (PEC), nickel titanium closed coil spring (NiTi CCS) and stainless steel closed coil spring (SS CCS). **Material and methods:** Samples were extended to a specific distance which was 18 mm in case of PEC and 20 mm in case of NiTi CCS and SS CCS. Each extended sample will then incubated in dry condition, artificial saliva, and mouthwash solution, for total incubation period of three weeks. **Results:** showed that samples in dry condition always showed minimum force degradation percent than in wet conditions. It also showed that the increase of incubation time leads to increase in force degradation percent with major degradation percent located within first twenty four hours. **Conclusions:** in dry and two wet conditions, NiTi CCS reflects the lowest percent of force degradation, PEC showed highest percent, while SS CCS showed intermediate one.
Keywords: Traction aids, Polyurethane elastomeric chain, Nickl titanium, Stainless steel, Closed coil spring, Mouthwash.

Al-Jumaili KA, Ali AI. Evaluation and Comparison of The Effect of Artificial saliva and Mouthwash Solution on Force Degradation of Different Types of Orthodontic Traction Aids (Comparative in Vitro Study). *Al–Rafidain Dent J*. 2011; 11(1):172-182.

Received: 16/10/2008 ***Sent to Referees***: 20/10/2008 ***Accepted for Publication:*** 26/10/2009

INTRODUCTION

Orthodontic traction aids are essential component of fixed orthodontic appliance, one of the major drawbacks of current traction aid types are their ability to lose traction force with time during action, a phenomenon called "force degradation".

Elastomeric chain are economical and easy to use though they absorb water and saliva, permanently stain and suffer of breakdown of internal bonds, that lead to permanent deformation. Also, elastomeric chain undergoes stress relaxation (degradation), which is a decrease in the magnitude of force transmitted while held at a fix strain. This relaxation is in part due to rearrangement within the polymer structure[1].

In addition to elastomeric chain, closed coil springs of various types nickel titanium, stainless steel, and cobalt chromium also show force loss after activation but in an amount lower than that shown by synthetic elastomeric chain[2,3].

In oral cavity, many factors can affect on force production and force degradation of traction aids, such as saliva, temperature fluctuation[4], pH variation[5], fluoride ions and rinses[1], oxygen content[6], free radicals[7], salivary enzymes and masticatory forces[8].

The aims of this study are 1. Detection and comparison the magnitude of force production and force degradation among three types of traction aids (polyurethane elastomeric chain, SS closed coil spring, and NiTi closed coil spring). 2. Determining and comparing the amount of force degradation for each type of incubated stretched traction aids at five intervals of whole incubation period (0 hour, 1 hour, 24 hours, 1 week, and at end of incubation at 3 weeks). 3. Comparison of the amount of force degradation among three incubation media for each type of traction aid.

MATERIALS AND METHODS

Samples

The total number of samples consisted of 90 pieces of traction aids (30 pieces of PEC, 30 pieces of NiT CCS and 30 pieces of SS CCS), that divided into:

A– Polyurethane Elastomeric Chain **(Continuous, Clear)**

Each piece of PC consisted of 6 loops. The total length of each piece was 17.0mm (Dentarum, Germany).

B – Nickel Titanium Closed Coil Spring

The total length of spring is 12.0mm. The spring has the following dimensions: an inner diameter of 0.030 inch and a wire size of 0.010 inch (Dentaurum, Germany).

C – Stainless Steel Closed Coil Spring

The total length of SS CCS was 17.5mm. The spring has the following dimensions: an inner diameter of 0.028 inch and a wire size of 0.009 inch (Orthomatrix, USA).

Preparation of Artificial Saliva Solution

The formula of preparation of artificial saliva solution was described by Barrett *et al*.,[9] which include: 0.4gm NaCl, 1.21gm KCl, 0.78gm NaH2PO4.H2O. 0.005gm Na2S.9H2O, 1gm urea [CO(NH2)2] and 1000ml distilled and deionized water.

The components of artificial saliva were measured and added to the (500)ml deionized water and 500ml distilled water. The pH was adjusted to 6.75 ± 0.15 with sodium hydroxide and/or with HCl.

Mouthwash Solution

Mouthwash solution of ZAK type which contains (Chlorhexidine Digluconate 0.12% and Sodium fluoride 0.05%) is ready made and commercially available, it present with a pH of 5.1.

Preparation of Acrylic Blocks

Acrylic blocks were prepared according to Ferriter *et al*., and Kim *et al*., [5,10]. The acrylic block was contains 10 stainless steel pins in above surface, 1cm apart from each other, each two blocks are joined together by two SS screws, so the space between pins (inter pins distance) can be adjusted for each type of sample. In case of PC, screws adjusted so the pins are separated for distance of 18mm, in case of NiTi CCS and SS CCS the pins were separated for a distance of 20mm.

Preparation Of Sample Attachments (Metallic Hooks)

Each attachment consisted of metallic ruler; the ruler was cut in L shape. A stainless steel hook was soldered to the middle of the L shaped ruler in a horizontal direction. This ruler was attached in a upper clamp in the universal tensile testing machine. A similar ruler was prepared in the same manner and attached in the lower clamp in the machine. The purpose of these hooks was for sample attachment in the testing machine.

Method of Samples Extension Lengths Determination

The lengths of extensions of traction aids samples are chosen so that each sample will produce a (200 ±5)gm force at that extension, this force used by study of Bousquet *et al*., [11], The method of determining the sample extension length in a relation to a specific force value produced by that extension, was used by Ferriter *et al*., and Angolkar *et al*., [5,2].

To determine samples extension lengths that produce 200±5gm; an experiment was conducted by taking a five pieces of each sample type, each piece of each sample type was attached to the universal testing machine and extended to a limit that produce 200gm force, and the length of the extended sample was measured to determine the extension that produce 200 ±5gm. After measurement, the results show the following: 1.The extensions of PC samples that produce 200 ± 5gm were 18 mm. 2. The extensions of SS CCS and NiTi CCS sample that produce 200 ± 5gm were 20 mm.

Incubation Methods

Ten pieces of each traction aids type used attached to three acrylic blocks; each block contains 10 samples of each material of either PC, NiTi CCS or SS CCS which extended to their specific extensions.

In case of dry condition, the three loaded blocks were stored in incubator at 37°C for the whole incubation period which was three weeks.

In case of artificial saliva, another three loaded blocks immersed inside artificial saliva solution and stored inside incubator at 37°C for whole incubation period which was three weeks.

While in case of mouthwash solution, another three loaded blocks were incubated initially inside artificial saliva solution at 37°C inside incubator, after that the three blocks removed from saliva solution and immersed inside mouthwash solution which present inside glass containers and stored inside the same incubator at 37°C. The immersion period inside mouthwash solution was for two minutes, twice daily for three weeks. After the end of two minutes immersion period; the loaded blocks were returned to artificial saliva container at 37°C until next mouth wash immersion period. The whole incubation period was three weeks.

Measurement Methods

Measurement of force generated by each of the samples was performed at five time periods, which were: 1. Initially(0 hour, just before incubation) the measurement at 0 h used to determine initial force (IF). 2. One hour period.

3. Twenty four hours period. 4. One week period (168 hours). 5. Three weeks (504 hours) period (end of incubation).

The term initial force was reserved for the force values recorded during the first stretch of the material when taken from the manufacturer's envelopes, i.e., the material was not manipulated before being stretched[12]. From the initial force (IF) value the percentage of force degradation (FD %) can be obtained according to the following equation [13]:

$$\% \ FD = 100 \times ((IF - Ft) / IF) \quad \ldots\ldots\ldots\ldots..(1)$$

Where: IF = initial force, Ft = force at specific period of time.

The extended sample was attached between the two ends of sample holder (which was an instrument used to carry sample without relaxation, and a similar instrument was used by Josell *et al*.,[14] and transferred to the machine without any relaxation in sample. In the machine, the sample was attached to pins between upper and lower fixtures attached to upper and lower clamps. After measurement, the sample reattached to two opposite pins in block, and stored in incubator. The next measurements performed in the same manner.

Therefore, in case of dry condition, the following testes were resulted in relation to material–time combinations, and their force degradation was measured, these tests were:

1.PCD0h, PCD1h, PCD24h, PCD1w, PCD3w.

2.NiTiD0h, NiTiD1h, NiTiD24h, NiTiD1w, NiTiD3w.

3.SSD0h, SSD1h, SSD24h, SSD1w, SSD3w.

Where, D= Dry, h = hour, W = Week.

While, in case of artificial saliva, the testes were:

1.PCN0h, PCN1h, PCN24h, PCN1w, PCN3w.

2.NiTiN0h, NiTiN1h, NiTiN24h, NiTiN1w, NiTiN3w.

3.SSN0h, SSN1h, SSN24h, SSN1w, SSN3w.

Where, N= Normal artificial saliva, h = hour, W = Week.

And, in case of mouthwash solution, the testes were:

1.PCZ0h, PCZ1h, PCZ24h, PCZ1w, PCZ3w.

2.NiTiZ0h, NiTiZ1h, NiTiZ24h, NiTiZ1w, NiTiZ3w.

3.SSZ0h, SSZ1h, SSZ24h, SSZ1w, SSZ3w. Where, Z= ZAK mouthwash, h = hour, W = Week.

After the force was measured for the three types of traction aids (after each time interval) under each incubation media; the statistical analyses were done and this includes: Descriptive Statistics, Which shows minimum and maximum values, mean, standard deviation and standard error, analyses of Variance (ANOVA) by using the one way ANOVA test, and the Duncan's multiple analysis range test: To locate the significant differences among the groups.

RESULTS

The descriptive statistics of the results of force production and percent of force degradation of PC samples in dry condition, artificial saliva and mouthwash solution are listed in Table (1). While, the descriptive statistics of the results of force production and force degradation of NiTi CCS samples in dry condition, artificial saliva and mouthwash solution are listed in Table (2).

Table (1): Descriptive statistics of FP and percent of FD of PC in all incubation media and at five immersion periods studied.

Media	Test	N	Mean FP**	% of FD	SD	Min.	Max.
Dry	**PCD0h***	10	201.70	0%	1.889	198	204
	PCD1h	10	174.20	13.63%	3.706	168	179
	PCD24h	10	149.20	26.02%	2.700	145	154
	PCD1w	10	126.80	37.13%	1.687	124	129
	PCD3w	10	117.30	41.84%	1.889	114	120
Arti. Saliva	**PCN0h***	10	200.70	0%	2.359	196	203
	PCN1h	10	147.90	26.3%	2.331	145	151
	PCN24h	10	111.50	44.44%	2.838	107	115
	PCN1w	10	76.10	62.08%	2.183	73	80
	PCN3w	10	63.80	68.21%	2.530	59	68
Mouth wash	**PCZ0h***	10	200.20	0%	1.814	197	203
	PCZ1h	10	147.00	26.57%	2.625	143	151
	PCZ24h	10	108.70	45.7%	2.163	105	113
	PCZ1w	10	70.90	64.58%	1.792	69	74
	PCZ3w	10	60.20	69.93%	1.874	57	63

*Tests used for initial force determination. ** mean measurement units in grams.

Table (2): Descriptive statistics of FP and percent of FD of NiTi CCS in all incubation media and at five immersion periods studied.

Media	Test	N	Mean FP**	% of FD	SD	Min.	Max.
Dry	**NiTiD0h***	10	200.80	0%	1.874	198	203
	NiTiD1h	10	195.60	2.6%	1.265	194	198
	NiTiD24h	10	189.00	5.87%	1.563	187	191
	NiTiD1w	10	184.00	8.36%	1.054	183	186
	NiTiD3w	10	180.10	10.3%	1.663	178	183
Arti. Saliva	**NiTiN0h***	10	200.90	0%	1.969	198	204
	NiTiN1h	10	191.50	4.67%	1.509	190	194
	NiTiN24h	10	184.20	8.31%	1.317	182	186
	NiTiN1w	10	179.70	10.55%	2.312	178	186
	NiTiN3w	10	173.10	13.83%	1.912	169	176
Mouth wash	**NiTiZ0h***	10	199.90	0%	1.853	196	202
	NiTiZ1h	10	191.00	4.45%	1.764	189	194
	NiTiZ24h	10	183.20	8.35%	1.874	180	187
	NiTiZ1w	10	176.40	11.75%	1.838	173	179
	NiTiZ3w	10	170.20	14.85%	2.150	166	173

*Tests used for initial force determination. ** mean measurement units in grams.

The descriptive statistics of the results of force production and force degradation of SS CCS samples incubated in air, artificial saliva and mouthwash solution are listed in Table (3). The analysis of variance (ANOVA) of the FP for PC, NiTi CCS and SS CCS in all five immersion periods in dry condition shows significance difference ($p < 0.001$) among them as in Table (4).

Table (3): Descriptive statistics of FP and percent of FD of SS CCS in all incubation media and at five immersion periods studied.

Media	Test	N	Mean FP**	% of FD	SD	Min.	Max.
Dry	**SSD0h***	10	200.60	0%	1.838	198	203
	SSD1h	10	190.70	4.93%	2.263	186	194
	SSD24h	10	178.80	10.86%	2.440	175	183
	SSD1w	10	168.40	16.05%	2.271	165	172
	SSD3w	10	159.10	20.68%	2.079	156	162
Arti. Saliva	**SSN0h***	10	200.70	0%	1.947	198	204
	SSN1h	10	186.40	7.12%	1.838	184	190
	SSN24h	10	167.50	16.54%	2.915	163	172
	SSN1w	10	151.70	24.41%	2.830	148	156
	SSN3w	10	143.70	28.40%	2.869	140	149
Mouth wash	**SSZ0h***	10	200.60	0%	1.713	198	203
	SSZ1h	10	187.30	6.63%	1.494	185	190
	SSZ24h	10	165.20	17.64%	2.098	162	168
	SSZ1w	10	150.80	24.82%	2.440	147	155
	SSZ3w	10	144.40	28.01%	2.119	141	148

*Tests used for initial force determination. ** mean measurement units in grams.

Table (4): One – way ANOVA analysis for FP of PC, NiTi CCS and SS CCS at five time intervals in dry condition.

	Sum of Squares	Degree of Freedom	Mean Square	F–test	Sig.
Between Groups	96323.240	14	6880.231	1555.050	<0.001
Within Groups	597.300	135	4.424		
Total	96920.540	149			

The results of Duncan multiple range test as illustrated in table (5) showed that test PCD3w had the lowest amount of FP in all periods in dry condition highest FD, with a significance difference ($p \leq 0.05$) from other tests. While NiTiD1h test show the highest amount of FP than other tests except initial force tests (SSD0h, NiTiD0h, and PCD0h), which had a higher FP than NiTiD1h. The remaining tests distributed on statistical levels of significance between the upper and lower level. The analysis of variance (ANOVA) of the FP of PC, NiTi CCS and SS CCS in five immersion periods in artificial saliva show significant difference ($p < 0.001$) among them as in Table (6).

Table (5): Duncan's test for the fifteen tests tested for amount of FP in dry condition.

Test	Mean* ± SE	Duncan's Groups**
PCD3w	117.3 ± 0.597	A
PCD1w	126.8 ± 0.533	B
PCD24h	149.2 ± 0.854	C
SSD3w	159.1 ± 0.657	D
SSD1w	168.4 ± 0.718	E
PCD1h	174.2 ± 1.172	F
SSD24h	178.8 ± 0.772	G
NiTiD3w	180.1 ± 0.526	G
NiTiD1w	184.0 ± 0.333	H
NiTiD24h	189.0 ± 0.494	I
SSD1h	190.7 ± 0.716	I
NiTiD1h	195.6 ± 0.400	J
SSD0h* **	200.6 ± 0.581	K
NiTiD0h* **	200.8 ± 0.593	K
PCD0h* **	201.7 ± 0.597	K

The mean in grams measurement.** Different letters mean significant different at $p \leq 0.05$.
*** Initial force tests.

Table (6): One – way ANOVA analysis for FP of PC, NiTi CCS and SS CCS at five immersion periods in artificial saliva.

	Sum of Squares	Degree of Freedom	Mean Square	F–test	Sig.
Between Groups	269751.893	14	19267.992	3657.451	<0.001
Within Groups	711.200	135	5.268		
Total	270463.093	149			

The results of Duncan multiple range test Table (7) showed that test PCN3w had the lowest amount of FP in all times in artificial saliva of normal pH (highest FD), with a significance difference ($p \leq 0.05$) from other tests.

While the tests of initial force (PCN0h, NiTiN0h and SSN0h) shows the highest amount of FP. The remaining tests distributed on statistical levels of significance between the upper and lower level.

The analysis of variance (ANOVA) of the FP for PC, NiTi CCS and SS CCS in five immersion periods in mouthwash solution shows significance difference ($p < 0.001$) among them as in Table (8).

Table (7): Duncan's test for the fifteen tests tested for amount of FP in artificial saliva.

Test	Mean* ± SE	Duncan's Groups**
PCN3w	63.8 ± 0.800	A
PCN1w	76.1 ± 0.690	B
PCN24h	111.5 ± 0.898	C
SSN3w	143.7 ± 0.907	D
PCN1h	147.9 ± 0.737	E
SSN1w	151.7 ± 0.895	F
SSN24h	167.5 ± 0.922	G
NiTiN3w	173.1 ± 0.605	H
NiTiN1w	179.7 ± 0.731	I
NiTiN24h	184.2 ± 0.416	J
SSN1h	186.4 ± 0.581	K
NiTiN1h	191.5 ± 0.477	M
PCN0h* **	200.7 ± 0.746	N
NiTiN0h* **	200.7 ± 0.623	N
SSN0h* **	200.9 ± 0.616	N

*The mean in grams measurement.** Different letters mean significant different at $p \leq 0.05$.*** Initial force tests.

Table (8): One – way ANOVA analysis for FP of PC , NiTi CCS and SS CCS at five immersion periods in mouthwash solution.

	Sum of Squares	Degree of Freedom	Mean Square	F–test	Sig.
Between Groups	283994.533	14	20285.324	5101.562	<0.001
Within Groups	536.800	135	3.976		
Total	284531.333	149			

The results of Duncan multiple range test Table (9) showed that test PCZ3w had the lowest amount of FP in all periods in mouthwash solution (highest FD), with a significance difference ($p \leq 0.05$) from other tests. While initial force tests NiTiZ0h, SSZ0h, and PCZ0h shows the highest amount of FP. The remaining tests distributed on statistical levels of significance between the upper and lower level.

Table (9): Duncan's test for the fifteen tests tested for amount of FP in mouthwash solution.

Test	Mean* ± SE	Duncan's Groups**
PCZ3w	60.2 ± 0.593	A
PCZ1w	70.9 ± 0.567	B
PCZ24h	108.7 ± 0.684	C
SSZ3w	144.4 ± 0.670	D
PCZ1h	147.0 ± 0.830	E
SSZ1w	150.8 ± 0.772	F
SSZ24h	165.2 ± 0.663	G
NiTiZ3w	170.2 ± 0.680	H
NiTiZ1w	176.4 ± 0.581	I
NiTiZ24h	183.2 ± 0.593	J
SSZ1h	187.3 ± 0.473	K
NiTiZ1h	191.0 ± 0.558	M
NiTiZ0h* **	199.9 ± 0.586	N
SSZ0h* **	200.2 ± 0.542	N
PCZ0h* **	200.6 ± 0.573	N

*The mean in grams measurement. ** Different letters mean significant different at $p \leq 0.05$.*** Initial force tests.

DISSCUSSION

As a general view, the NiTi CCS samples lose less force than SS CCS and PC samples, this finding agree with Angolkar *et al*.,[2] who found that NiTi CCS showed less FD than SS CCS and PC. In dry condition and at end of immersion period, NiTi CCS showed less FD percent than SS CCS which intern showed less FD percent than PC, as shown in Figure (1).The superelasticity, increased elastic limit and springback, lower load deflection rate, and less stiffness of NiTi CCS than SS CCS who show linear load deflection curve and no phase transition might be the cause for this difference in FD percent[15,2,16,17,18].

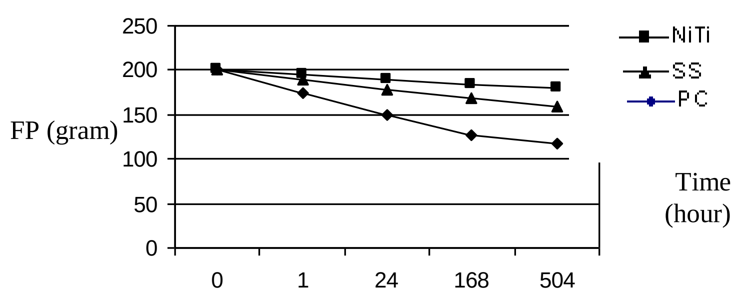

Figure (1): Force – time diagram of PC, NiTi CCS and SS CCS in dry condition.

The largest FD percent noticed in PC samples might be due to the mechanism of permanent deformation and rearrangement within the polymer structure[4,7,19,20]. The force loss in SS CCS samples in dry condition may be due to plastic deformation which takes place by slipping, twining (movement that divides the lattice into two symmetric parts) or a combination of the two[19].

In the remaining two wet media, all samples types showed more FD percent than in those percents in dry condition. In artificial saliva, NiTi CCS samples showed less FD percent than SS CCS which intern showed less FD percent than PC, as shown in Figure (2). This agrees with Han *et al*.,[21] who mentioned that NiTi springs are more resistance to degradation of mechanical properties in a simulated oral environments over SS springs and polyurethane elastics. Harris *et al*.,[22], Eliades *et al*.,[23], Eliades *et al*.,[20], Kaneko *et al*.,[24] and Kao *et al*.,[25] mentioned that nickel, chromium and iron are the most corrosive elements in artificial saliva and titanium was the most corrosion resistance element.

The titanium oxide layer formed on the NiTi wires is more stable than its chromium counterpart present in SS wires, particularly in environments containing chloride anion, lead to inferior corrosion resistance of SS relative to titanium alloys.

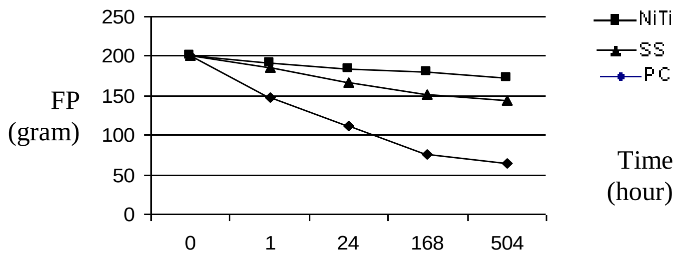

Figure (2): Force – time diagram of PC, NiTi CCS and SS CCS in artificial saliva of normal pH.

Stainless steel is not considered resistant to chloride ions at any temperature or concentration, chloride can penetrate and destroy the passivity that is responsible for corrosion resistance of SS, in addition to chlorides, other aggressive substance is the sulfurated compounds found in saliva[26,27,19]. The effect of water immersion on PC may take various forms: solubility with leaching out of constituents, swelling, and environmental stress cracking[28].

In mouthwash solution, all sample types showed increased in FD percent, where the least FD percent noticed in NiTi CCS, followed by SS CCS, and then PC, as shown in Figure (3).

Mouthwash solution contain fluoride ions that accelerate corrosion and hydrogen embrittlement in NiTi and SS CCS lead to more FD percent, and acidity of the mouthwash accelerate this processes. This agree with Reclaru *et al*.,[29], Watanabe *et al*., [30], Kaneko *et al*.,[24], Walker *et al*.,[31] and Walker *et al*., [32]. Polyurethane chain also affected by mouthwash solution lead to crease FD percent, this might be due to fect of fluoride ions and chlorhexidin that lead to more deteriorative effect [1,8].

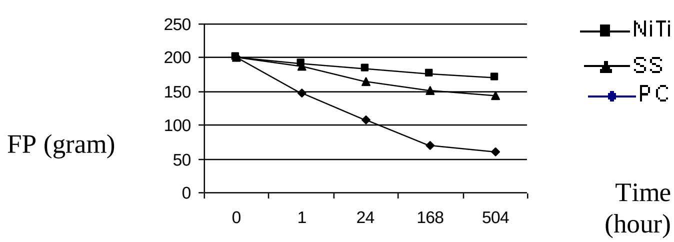

Figure (3): Force – time diagram of PC, NiTi CCS and SS CCS in mouthwash solution.

CONCLUSIONS

Nickel titanium CCS is more appreciate device for space closure than PC and SS CCS. If other factors had been constant, the FD percent of all samples in dry condition showed smaller value than those in wet conditions. If other factors had been constant, an increase of incubation time lead to increase in FD percent, with highest rate of degradation located within first twenty four hours. If other factor had been constant, NiTi CCS showed lowest FD percent than PC which intern showed highest FD percent, while SS CCS showed the intermediate one. In wet conditions and at the end of three weeks immersion period; PC and NiTi CCS samples incubated in mouthwash solution showed higher force degradation percent than samples incubated in artificial saliva, while SS CCS samples incubated in artificial saliva of normal pH and mouthwash solution showed non significant difference in force degradation percent at end of incubation period.

REFERENCES

1. Von Frounhofer JA, Coffelt MTP, Orbell GM. The effect of artificial saliva and topical fluoride treatments on the degradation of the elastic properties of orthodontic chains**.** *Angle Orthod.* 1992; 62(4): 265– 274.
2. Angolkar PV, Arnold JV, Nanda RS, Duncanson MG. Force degradation of closed coil springs: An in vitro evaluation. *Am J Orthod Dentofacial Orthop.* 1992; 102(2): 127–133.
3. Nattrass C, Ireland AJ, Sherriff M**.** The effect of environmental factors on elastomeric chain and nickel titanium coil springs. *Europ J Orthod.* 1998; 20: 169–176.
4. DeGenova DC, Ledoux PM, Weinberg R, Shaye R. Force degradation of orthodontic elastomeric chains–A product comparison study. *Am J Orthod Dentofacial Orthop.* 1985; 87(5): 377–384.
5. Ferriter JP, Meyers CE, Lorton L. The effect of hydrogen ion concentration on the force–degradation rate of orthodontic polyurethane chain elastics. *Am J Orthod Dentofacial Orthop.* 1990; 98(5): 404 – 410.
6. Stevenson JS, Kusy RP. Force application and decay characteristics of untreated and treated polyurethane elastomeric chains**.** *Angle Orthod.* 1994; 64(6): 455–467.
7. Baty DL, Storie DJ, Von Frounhofer JA. Synthetic elastomeric chains: A literature review. *Am J Orthod Dentofacial Orthop.* 1994A; 105(6): 536–542.
8. Evangelista MB, Berzins DW, Monaghan P. Effect of disinfecting solutions on the mechanical properties of orthodontic elastomeric ligatures**.** *Angle Orthod.* 2007; 77(4): 681–687.
9. Barret RD, Bishara SE, Quinn JK. Biodegradation of orthodontic appliances, part 1, Biodegradation of nickel and chromium vitro. *Am J Orthod Dentofacial Orthop.* 1993; 103(1): 8–14.
10. Kim KH, Chung CH, Choy K, Lee JS, Vanarsdall RL. Effect of prestretching on force degradation of synthetic elastomeric chain**.** *Am J Orthod Dentofacial. Orthop.* 2005; 128(4): 477– 482.
11. Bousquet JA, Tuesta O, Flores–Mir C. In vivo comparison of force decay between injection molded and die–cut stamped elastomers. *Am J Orthod Dentofacial. Orthop.* 2006; 129(3): 384–389.
12. Bishara SE, Andreasen GF**.** A comparison of time related forces between plastic alastiks and latex elastics. *Angle Orthod.* 1970 40(4): 319–328.
13. Gioka C, Zinelis S, Eliades T, Eliades G. Orthodontic latex elastic, A force relaxation study. *Angle Orthod.* 2006; 76(3): 475–479.
14. Josell SD, Leiss JB, Rekow ED. Force degradation in elastomeric chains. *Seminars Orthod.* 1997; 3(3): 189–197.
15. Miura F, Mogi M, Ohura Y, Karibe M. The super–elastic Japanese NiTi alloy wire for use in orthodontics. Part III . Studies on the Japanese NiTi alloy coil springs**.** *Am J Orthod Dentofacial Orthop.* 1988; 94(4): 89–96.
16. Barwart O. The effect of temperature change on the load value of Japanese NiTi coil springs in the superelastic range**.** *Am J Orthod Dentofacial Orthop.* 1996; 110(5): 553–558.
17. Manhartsberger C, Seidenbusch. Force delivery of Ni–Ti coil springs**.** *Am J Orthod*

Dentofacial Orthop. 1996; 109(1): 8–21**.**
18. Prymark O, Klocke A, Nieke BK, Epple M. Fatigue of orthodontic nickel–titanium wires in different fluids under constant mechanical stress. *Mat Sci Eng.* 2004: 110–114.
19. Graber T, Vannarsdall R. Orthodontic current principle and techniques. 3rd ed. C.V. Mosby Company. 2000; Pp: 305– 330,803.
20. Eliades T, Eliades G, Silikas N, Watts DC. Tensile properties of orthodontic elastomeric chains. *Europ J Orthod.* 2004; 26: 157–162.
21. Han S, Quick DC. Nickel–titanium spring properties in a simulated oral environment. *Angle Orthod.* 1993; 63(1): 67–71.
22. Harris EF, Newman SM, Nicholson JA**.** Nitinol arch wire in a simulated oral environment: Changes in mechanical properties. *Am J Orthod Dentofacial Orthop.* 1988; 93(6): 508–513.
23. Eliades T, Athanasiou AE. In vivo aging of orthodontic alloys: implications for corrosion potential, nickel release and biocompatibility. *Angle Orthod.* 2002; 72(3): 222–237.
24. Kaneko K, Yokoyama K, Moriyama K, Asaoka K, Sakai J. Degradation in performance of orthodontic wires caused by hydrogen absorption during short–term immersion in 2.0% acidulated phosphate fluoride solution**.** *Angle Orthod.* 2004; 74(4): 487–495**.**
25. Kao CT, Ding SJ, He H, Chou MY, Huang TH. Cytotoxicity of orthodontic wire corroded in fluoride solution in vitro. *Angle Orthod.* 2007; 77(2): 349–354.
26. Matasa CG. Attachment corrosion and its testing**.** *J Clin Orthod.* 1995; 29(1): 16–23.
27. Rondelli G, Vicentini B: Localized corrosion behavior in simulated human body fluids of commercial Ni–Ti orthodontic wires. *Biomater.* 1999; 20: 785–792.
28. Kanchana P, Godfrey K. Calibration of force extension and force degradation characteristics of orthodontic latex elastics. *Am. J. Ortho. Dentofac. Orthop.* 2000; 118(3): 280–287.
29. Reclaru L, Meyer M. Effect of fluorides on titanium and other dental alloys in dentistry. *Biomater*. 1998; 19: 85–92.
30. Watanabe I, Watanabe E. Surface changes induced by fluoride prophylactic agents on titanium based orthodontic wires. *Am J Orthod Dentofacial Orthop.* 2003; 123(6): 653– 656.
31. Walker MP**,** White RJ, Kula KS. Effect of fluoride prophylactic agents on the mechanical properties of nickel titanium based orthodontic wires. *Am J Orthod Dentofacial Orthop*. 2005; 127(6): 662–669.
32. Walker MP, Ries D, Kula K, Ellis M, Fricke B. Mechanical properties and surface characteristics of beta titanium and stainless steel orthodontic wire following topical fluoride treatment. *Angle Orthod.* 2007; 77(2): 342–348.