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A Comparative Evaluation of Force Decay in Six Different Orthodontic Elastomeric Chains - An Invitro Study

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Abstract

Aims: Comparison of degradation of force of 6 commercially available orthodontic elastomeric chains (e-chains) for the period of 8 weeks. **Settings and Design:** In-vitro Study. **Method and Materials:** Elastomeric chains of 6 companies were stretched to a particular distance that is pre determined and comparison was made at two force magnitudes (200 gm and 350 gm) at different time points. Digital force gauge is used for measuring remaining force magnitudes at different time points. **Statistical Analysis used:** The comparison of difference in force decay between subgroups and effect of time on force decay was calculated using Analysis of Variance (ANOVA). Comparison of the mean force differences using paired t-test is performed from initial to final measurements. For comparison of difference of force decay of elastomeric chain products of same company, independent samples t-tests were used. **Results:** Maximum remained force (129.7 gm) was observed in American Orthodontics I (Ao I) subgroup followed by Ormco (Or) I (120.1 gm), Orthoorganizers (Oo) I (105.5 gm), 3m I (91.9 gm, G and H (Gh) I (80.4 gm) and Orthoclassic (Oc) I subgroup showed minimum remained force (74.9 gm) at end of 8 weeks in light force. Maximum remained force (209.0 gm) was observed in Ao II subgroup followed by Or II (191.3 gm), 3M II (188.8 gm), Oc II (129.9 gm), Oo II (121.5 gm) and Gh II subgroup showed minimum remained force (108.5 gm) at end of 8 weeks in heavy force. C**onclusions:** American Orthodontics showed minimum rate and Ortho Classic showed maximum rate of force decay over 8 weeks in both light force (200 gm) and heavy force (350 gm).

Keywords: ANOVA, Elastomeric Chains, Force Degradation

1. Introduction

"Elastomer" refers to a member of a class of polymeric materials with ability to regain shape after deformation. After vulcanization, introduced by Charles Goodyear in 1839, physical properties of rubbers were improved, that has enhanced in its use[1]. Elastomeric chain was introduced in orthodontics in the 1960's and used for general space closure and retraction[2,3]. Orthodontic elastomers are polyurethanes, thermosetting polymer products of a step-reaction polymerization process, possessing a -(NH)-(C=O)-O-unit. Permanent deformation mechanisms include molecular chain stretching, slippage between adjacent molecular chains, and molecular chain scission[4]. During orthodontic treatment major goal is that light continuous force should be applied to ensure maximum effective tooth movement with minimum root resorption and bone resorption[5]. Elastic chains are used in combination with fixed orthodontic appliances to close or to prevent opening of spaces. Advantages included ease of use, reduced potential for intraoral trauma, low price, and minimal need for patient compliance. Disadvantages can be seen in inconsistency of force levels over time, absorption of fluids leading to discoloration, and impairment of oral hygiene[6]. This study was conducted to compare force degradation of six different commercially available orthodontic elastomeric chains.

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2. Methodology

In this invitro study, elastomeric chains were stretched to predetermined distances and force decay is measured at different time. The factors studied were: **Chain type 6** (Plastic Chain; American Orthodontics, Power chain generation II Ormco, Dyna-Link; G & H Orthodontics, Elastic chain; Ortho Organizer, Alastik Chain; 3M Unitek and Elastomeric chain; Ortho Classic) and **force magnitudes** 2 levels (Light force - 200 grams and heavy force - 350 grams). A digital force gauge is used for measuring remaining force magnitudes at determined time points. In all brand groups clear and continuous type of chain was used. For each group thirty elastomeric chain specimens were used. Total number of chains used was 180. Six elastomeric chain groups were subdivided into two subgroups to test two force magnitudes, as follows:

Group I

a. Light force (200 gm),

b. Heavy force (350 gm),

There will be 15 specimens per subgroup.

A. Sample (Figure 1) – Elastomeric chain specimens were cut from spools using a ligature cutter immediately before testing.

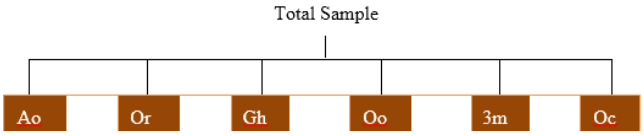


Figure 1. Total sample comprised of 6 chain groups.

B. Testing Apparatus includes

1. *Stretch jig (Figure 2)*

A customized stretch jig made of wood had two halves that were used joined by two jack screw including 15 pins on each half.

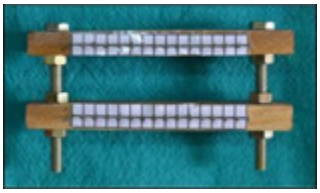


Figure 2. Stretch jig.

2. *Media/Medium*

A medium was made by using 0.09 % aqueous sodium chloride solution and dissolving reagent-grade granular sodium chloride in reverse osmosis (RO)-treated water having a resistance of 18 mΩ or greater which is considered as artificial saliva that can be maintained at a temperature of 37^{0}C throughout test period[7].

3. *Container (Figure 3)*

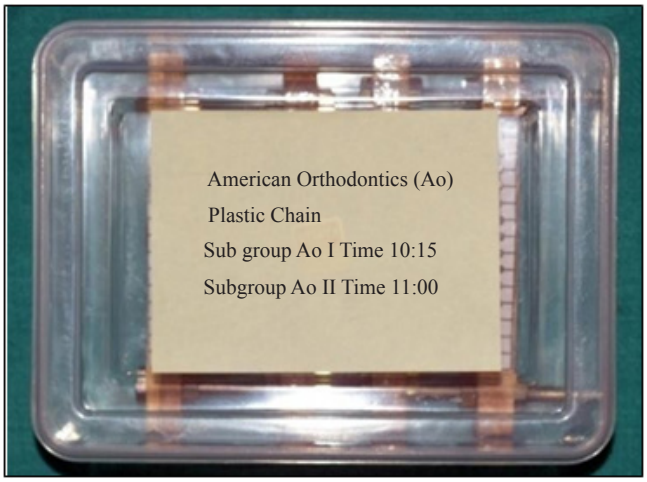


Figure 3. Closed container with label on lid.

4. *Digital force gauge (Figure 4)*

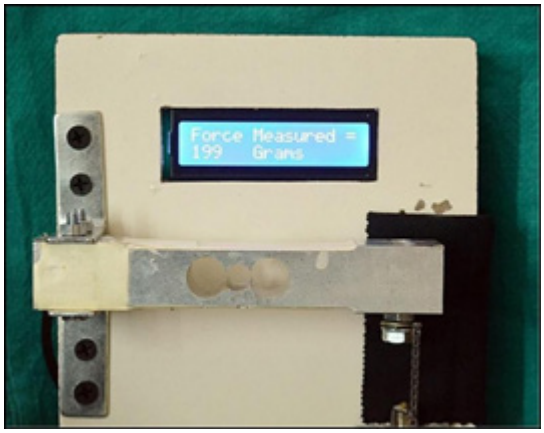


Figure 4. Digital force gauge

5. *Digital caliper (Figure 5)*

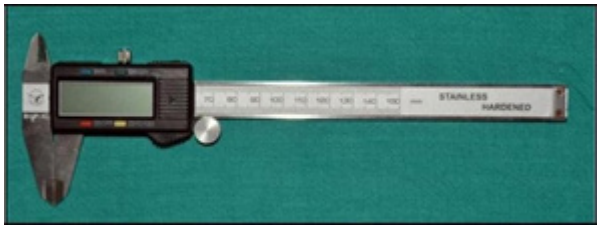


Figure 5. Digital Caliper.

6. Transfer jig (Figure 6)

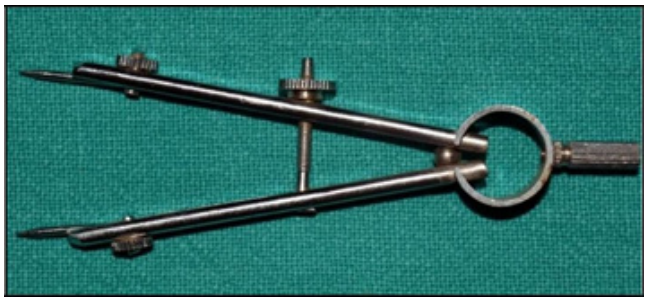


Figure 6. Transfer jig.

C. Experimental Measurement Procedure

1. The specimen of elastomeric chain from spools were cut using a ligature cutter and stretched over hooks of force gauge and were allowed to remain stretched for 15 seconds before force was recorded on an Excel spread sheet. Transfer jig was opened and tips were inserted in extra modules to transfer specimens from force gauge to designated stretch jig. 15 seconds relaxation period was taken because continuous force decay was at much slower rate after 15 seconds. Force magnitudes were measured at eleven different time points: zero hour, one hour, twenty four hours, one week, two weeks, three weeks, four weeks, five weeks, six weeks, seven weeks, and eight weeks.

D. Describing the amount of stretching needed for reaching different selected force magnitudes

To calculate how long each chain group needed to be stretched to reach the desired light and heavy forces measurements were obtained for analysis and estimation. Specimens from American Orthodontics (Ao) were cut from spool. For subgroup 1 (chains light force) these

Specimens were extended on hooks of force gauge and force magnitude recorded was 200 grams (after 15 seconds of being stretched). Average stretch distance between hooks from these specimens was used as distance between pins on stretch jig for American Orthodontics subgroup Ao I. These specimens were discarded and no specimens were reused. The same process was repeated by using new specimens for other one subgroup of American Orthodontics (Ao II) and entire process was again performed for other remaining chain groups (Ormco, G & H Orthodontics, Ortho Organizer, 3M Unitek and Ortho Classic). Following distances between the pins were selected for every chain group (table 1 and table 2).

Table 1. Required Stretching for Chains Light Force (200 gm)

Chain group	Initial length (mm)	After stretching (mm)	No of loops
Ao	16	31	6
Or	20	30	7
Gh	17.5	27.4	7
Oo	17.7	26	6
3m	12.8	26.6	5
Oc	18	25	8

Table 2. Required Stretching for Chains Heavy Force (350gm)

Chain group	Initial length (mm)	After stretching (mm)	No of loops
Ao	13	31	5
Or	12	30	4
Gh	14.5	28.5	6
Oo	13.9	28.7	5
3m	10	30	4
Oc	14	26.5	6

1. Grouping the Sample

A total of 12 stretch jigs were used in this experiment. Two stretch jigs were used per chain group, one for each of the two subgroups. Each stretch jig had 15 specimens (Figure 7)

E. Measurement Protocols

Two different protocols were established for measuring: initial measurements and one hour, one day and weekly measurements.

3. Baseline Measurements

At time point 0, hooks on gauge were adjusted to needed distance for subgroup 1 of one of chain groups. A jig was also opened so that distance between pins matched that distance. Specimens were cut and stretched over hooks of force gauge. Chains were allowed to remain stretched for 15 seconds before force magnitude was recorded on an Excel spread sheet. Transfer jig was used to transfer specimen from gauge to jig. Measurements were obtained for all hooks were adjusted. A jig was adjusted to same distance and force was recorded for 15 specimens in a similar manner for subgroup. Once this was done for the

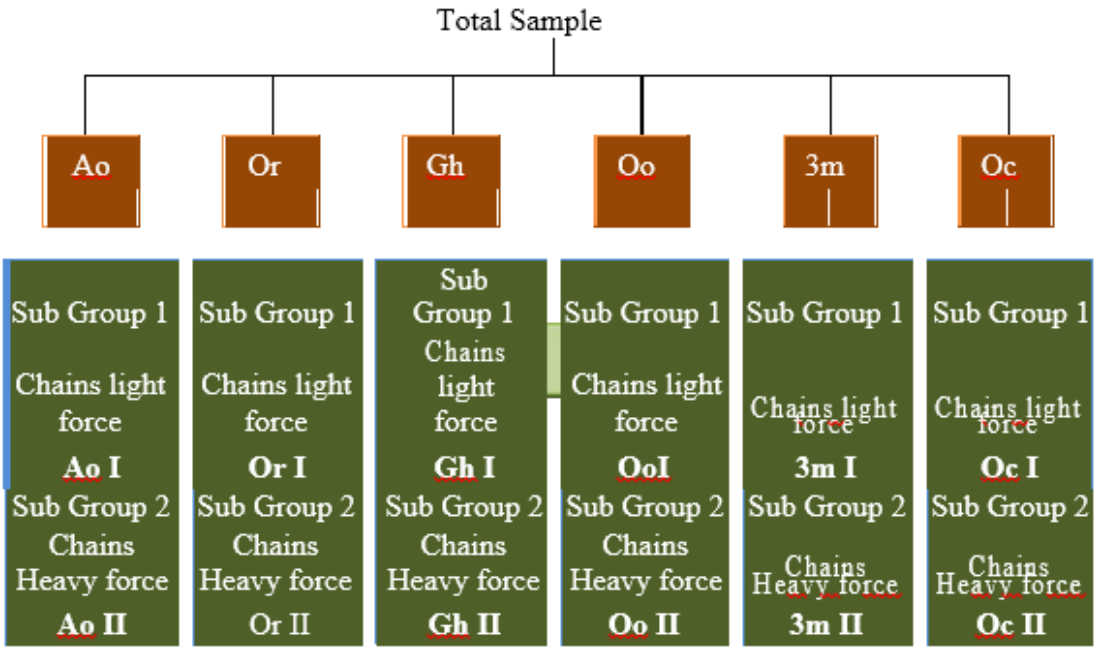


Figure 7. Grouping of Samples.

remaining other subgroup of that chain group, artificial saliva was added to a container, the 2 jigs were immersed in media, and container were sealed and inserted into incubator to maintain temperature at 37°C. Entire process was reperformed for the other 5 remaining elastomeric chain groups and 0 hour measurements were obtained.

2. *One Hour, One Day and Weekly Measurements*

After an hour had passed from time first jig was put in incubator it was taken out and 1 hour measurements were obtained for first jig. Divider was used to transfer first specimen from jig to hooks of gauge. Specimen was left stretched on the hooks for about fifteen seconds before recording force magnitude. The same is performed for remaining 14 specimens and time was noted. The same was done for second jig which was incubated for 1 hour. Same protocol followed for remaining time points.

A. Elongation percentages (Table 3)

To determine the elongation percentages, the first step was obtaining the elongation in millimeters. This was obtained by subtracting the unstretched lengths from the required stretch distances of each subgroup from Tables 1 and 2. The elongation in millimeters was then divided by the unstretched length of the specimens to determine the elongation percentage.

Table 3. Elongation Percentages of Chains

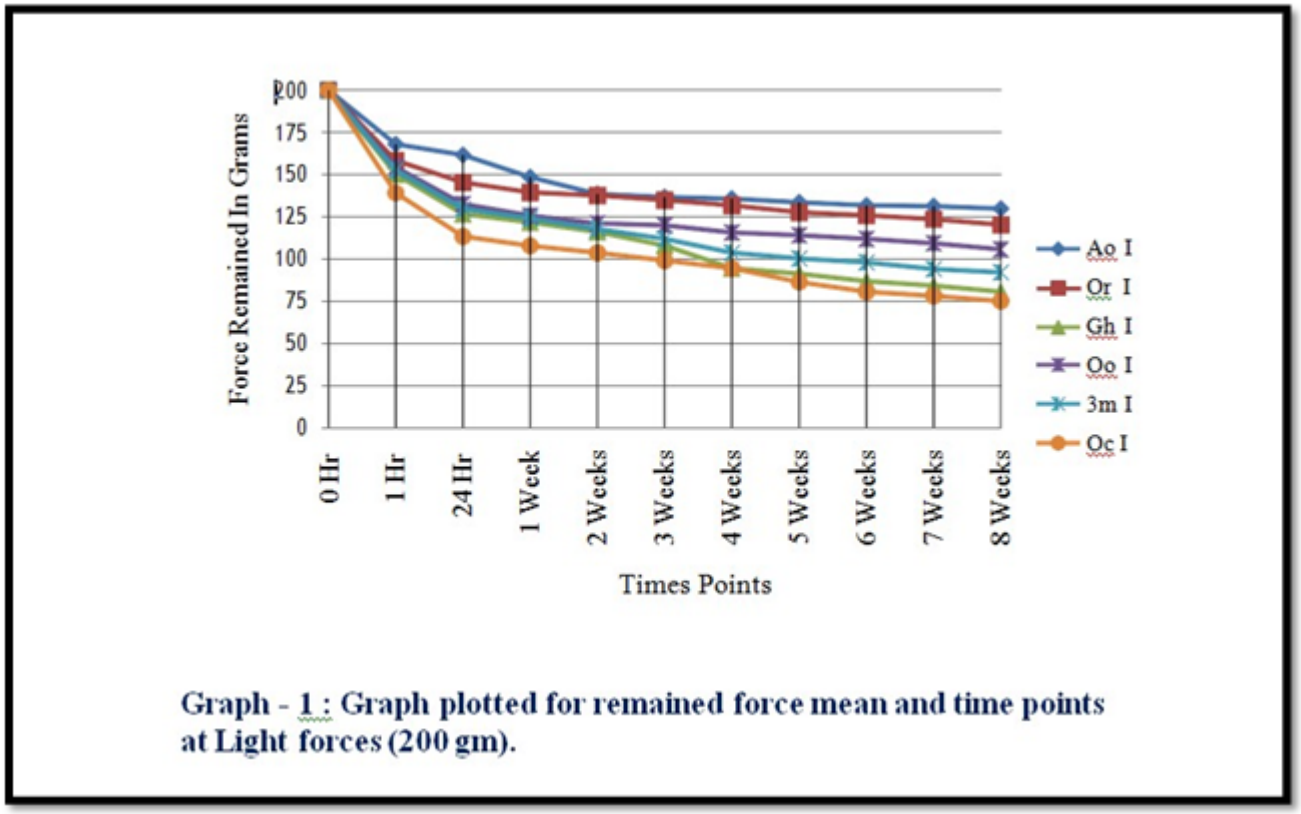
Chain group	Light force (200gm)	Heavy force (350gm)
Ao	93.75	138.46
Or	50	150
Gh	56.57	95.55
Oo	40.92	106.47
3m	107.81	200
Oc	38.88	89.28

B. Decay of force in six different elastomeric chains over time with light forces (200gm)

The results of one way ANOVA tests have to be statistically significant (Table 5) at various time intervals in light force. Maximum remained force (129.7 gm) was observed in Ao I subgroup followed by Or I (120.1 gm), Oo I (105.5 gm), 3m I (91.9 gm, Gh I (80.4 gm) and Oc I subgroup showed minimum remained force (74.9 gm) at the end of 8 weeks in light force (Table 4) (graph 1).

C. Decay of force in six different elastomeric chains over time with heavy forces (350gm)

Results of one way ANOVA has to be statistically significant (Table 7) at various time points in heavy force.



Graph - 1 : Graph plotted for remained force mean and time points at Light forces (200 gm).

Table 4. Force decay in overtime with light forces (200gms) determined by standard deviation and mean force in grams

SubGroup	Ao I		Or I		Gh I		Oo I		3MI		Oc I		'F ' Value
Time Points	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	
1H	167.9	5.2	158.3	5.9	150.0	8.9	154.3	11.0	152.3	5.5	139.0	5.0	25.8**
24H	161.5	5.1	145.3	8.6	126.5	4.2	132.5	7.4	129.7	5.5	113.2	8.4	91.4**
1W	148.4	6.2	139.3	7.1	121.6	7.0	125.5	4.5	123.9	6.1	107.7	5.0	82.7**
2W	138.3	8.2	137.5	5.7	1115.9	5.3	120.9	4.2	117.7	5.3	103.5	6.0	77.8**
3W	136.6	8.0	134.7	5.6	107.9	6.4	119.9	4.0	111.8	7.1	98.9	4.1	93.0**
4W	135.5	6.7	131.6	5.9	94.3	4.9	115.6	5.0	103.5	4.1	94.3	4.9	174.9**
5W	133.	5.7	127.5	4.2	91.1	4.4	113.9	5.1	100.2	6.2	86.2	4.7	217.6**
6W	131.7	6.3	125.7	3.4	86.6	4.5	111.7	5.0	97.9	5.3	80.4	4.5	270.5**
7W	131.7	5.5	123.5	4.8	84.0	5.6	109.2	5.3	93.9	6.1	77.9	3.0	261.2**
8W	129.7	5.5	120.1	4.1	80.4	4.5	105.5	6.6	91.9	5.5	74.9	4.2	271.0**

** Statistically Significant H=Hours, W=Weeks

Maximum remained force (209.0 gm) was observed in Ao II subgroup followed by Or II (191.3 gm), 3M II (188.8 gm), Oc II (129.9 gm), Oo II (121.5 gm) and Gh II subgroup showed minimum remained force (108.5 gm) at end of 8 weeks in heavy force (Table 6) (Graph 2).

D. Force remained (in %) in six different orthodontic elastomeric chains over time with light forces (200 gm)

Results of ANOVA tests showed has to be statistically significant (P<.001) at various time intervals in light force. Maximum remained force (64.8 %) was observed

Table 5. Sample 't' test for light force (200gm).

SubGroup	Ao I	Or I	Gh I	Oo I	3m I	Oc I
1 H AND 24 H	0.012*	0.000**	0.000**	0.000**	0.000**	0.000**
1 H AND 1 W	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
1 H AND 2 W	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
1 H AND 3 W	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
1 H AND 4 W	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
1 H AND 5 W	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
1 H AND 6 W	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
1 H AND 7 W	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
1 H AND 8 W	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**

**Statistically Significant H=Hours, W=Weeks.

Table 6. Force decay in overtime with heavy forces (350) gm determined by and standard deviation and the force mean in grams.

SubGroup	Ao II		Or II		Gh II		Oo II		3M II		Oc II		'F ' Value
Time Points	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	
1H	285.9	16.5	258.9	10.5	204.2	13.8	212.3	13.7	257.7	10.7	247.5	11.1	85.1**
24H	253.3	15.0	236.6	12.6	172.7	11.0	168.1	10.3	229.1	9.9	190.3	11.9	137.1**
1W	236.0	15.3	223.8	10.7	160.9	12.4	156.7	11.0	215.7	12.9	170.7	9.6	125.7**
2W	233.8	14.5	214.5	12.0	146.7	12.3	148.9	7.6	204.1	10.6	158.7	11.0	159.4**
3W	227.2	10.1	212.3	8.9	135.5	12.6	144.3	9.0	202.5	5.8	153.3	11.0	242.2**
4W	222.3	12.1	203.9	10.3	130.1	8.3	137.2	8.8	202.5	5.8	150.4	9.7	269.7**
5W	219.5	12.8	198.9	7.2	121.1	9.7	130.0	6.0	197.2	7.1	140.7	12.1	293.9**
6W	215.1	13.5	196.5	9.0	109.5	6.3	127.1	6.2	197.2	7.1	136.1	12.3	327.1**
7W	211.9	14.8	192.2	9.3	110.0	8.8	124.9	5.6	195.3	7.7	133.0	8.8	308.2**
8W	209.0	12.4	191.3	8.4	108.5	6.9	121.5	6.4	188.8	7.0	129.9	7.8	393.5**

** Statistically Significant H=Hours, W=Weeks

Table 7. Sample 't' test for Heavy force (350gm)

SubGroup	Ao II	Or II	Gh II	Oo II	3m II	Oc II
1 H AND 24 H	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
1 H AND 1 W	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
1 H AND 2 W	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
1 H AND 3 W	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
1 H AND 4 W	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
1 H AND 5 W	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
1 H AND 6 W	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
1 H AND 7 W	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
1 H AND 8 W	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**

** Statistically Significant H=Hours, W=Weeks

Table 8. Force remained in overtime with light forces (200gm) determined by the standard deviation and mean force in percentage

SubGroup	Ao I		Or I		Gh I		Oo I		3MI		Oc I		'F 'Value
Time Points	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	
1H	84.0	2.6	79.1	2.9	75.0	4.4	77.2	5.5	76.1	2.7	69.5	2.5	25.8**
24H	80.8	2.6	72.6	4.3	63.3	2.1	66.2	3.7	64.8	2.7	56.6	4.2	91.4**
1W	74.2	3.1	69.7	3.6	60.8	3.5	62.8	2.2	62.0	3.1	53.9	2.5	82.7**
2W	69.1	4.1	68.8	2.8	57.9	2.6	60.4	2.1	58.9	2.7	51.7	3.0	77.8**
3W	68.3	4.0	67.3	2.8	54.0	3.2	60.0	2.0	55.9	3.5	49.4	2.1	93.0**
4W	67.8	3.4	65.8	3.0	47.1	2.4	57.8	2.5	51.8	2.0	47.1	2.4	174.9**
5W	66.7	2.8	63.8	2.1	45.5	2.2	57.0	2.6	50.1	3.1	43.1	2.4	217.6**
6W	65.8	3.1	62.8	1.7	43.3	2.3	55.9	2.5	49.0	2.7	40.2	2.3	270.5**
7W	65.5	2.8	61.7	2.4	42.0	2.8	54.6	2.7	47.0	3.0	38.9	1.5	261.2**
8W	64.8	2.7	60.1	2.1	40.2	2.3	52.7	3.3	45.9	2.8	37.4	2.1	271.0**

** Statistically Significant H=Hours, W=Weeks

Table 9. Remaining force in overtime with heavy forces (350gm) determined by the standard deviation and mean force in percentage

SubGroup	Ao II		Or II		Gh II		Oo II		3MII		Oc II		'F 'Value
Time Points	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	
1H	81.7	4.8	74.0	3.0	58.3	3.9	60.6	3.9	73.6	3.1	70.7	3.2	85.1**
24H	72.4	4.3	67.6	3.6	49.4	3.1	48.0	3.0	65.5	2.8	54.4	3.4	137.1**
1W	67.4	4.4	63.9	3.1	46.0	3.5	44.8	3.1	61.6	3.7	48.8	2.7	125.7**
2W	66.8	4.2	61.3	3.4	41.9	3.5	42.5	2.2	58.3	3.0	45.4	3.1	159.4**
3W	64.9	2.9	60.6	2.5	38.7	3.6	41.2	2.6	57.8	1.6	43.8	3.1	242.2**
4W	63.5	3.5	58.3	2.9	37.2	2.4	39.2	2.5	57.8	1.6	43.0	2.8	269.7**
5W	62.7	3.6	56.8	2.1	34.6	2.8	37.1	1.7	56.3	2.0	40.2	3.5	293.9**
6W	61.4	3.9	56.1	2.6	31.3	1.8	36.3	1.8	56.3	2.0	38.9	3.5	327.1**
7W	60.6	4.2	54.9	2.7	31.4	2.5	35.7	1.6	55.8	2.2	38.0	2.5	308.2**
8W	59.7	3.5	54.7	2.4	31.0	2.0	34.7	1.8	53.9	2.0	37.1	2.2	393.5**

**statistically significant H=Hours, W=Weeks

in Ao I subgroup followed by Or I (60.1 %), Oo I (52.7 %), 3m (45.9 %), Gh I (40.2 %) and Oc I subgroup showed minimum remained force (37.4 %) at end of 8 weeks in light force (Table 8) (Graph 3).

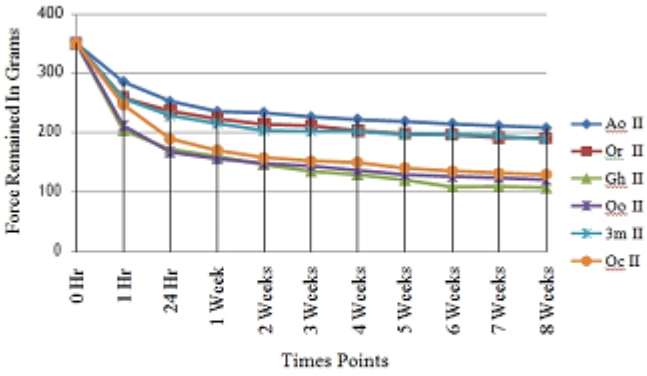
E. Force remained (in %) in six different orthodontic elastomeric chains over time with heavy forces (350gm)

Results of ANOVA tests was found statistically significant (P<.001) at various time intervals. Maximum remained force (59.7%) was observed in Ao II and Gh II showed minimum remained force (31 %) at end of 8 weeks in Heavy Force (Table 9) (graph 4).

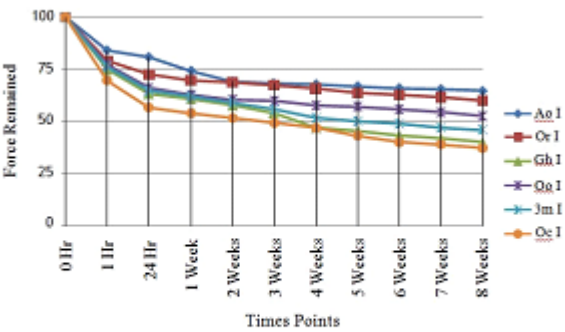
F. Comparison of force magnitude at various time intervals in light and heavy force

All group showed significant (Table 10) force decay at light (200 gm) and heavy force (350 gm) by two way ANOVA test at All time points (Table 10).

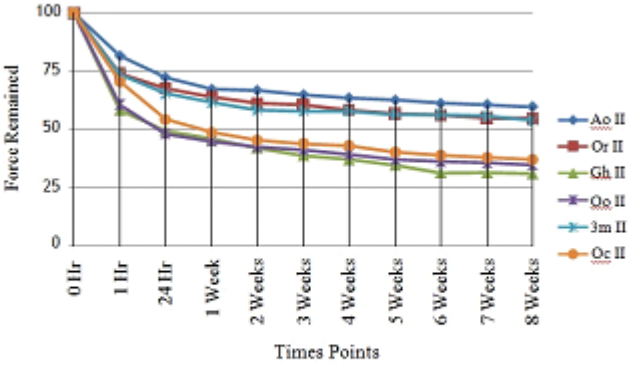
American Orthodontics (Ao) Group did not show any statistically significant difference in force degradation at 1 Hr. statistically significant difference was showed at twenty four hrs, one week, second weeks, third weeks, four week, five weeks, six weeks, seven weeks and eight weeks. Group Ormco (Or), G & H (Gh) and Ortho Organizer (Oo) showed statistically significant difference in force



Graph - 2 : Graph plotted for remained force mean with time points at Heavy forces (350 gm).



Graph - 3 : Graph plotted for remained force in % mean with time points at light force (200 gm).



Graph - 4 : Graph plotted for remained force in % mean with time points at Heavy forces (350 gm).

Table10. Force decay at light (200 gm) and heavy force (350 gm) by two way ANOVA test

FACTOR		" F VALUE"									
		1H	24H	1W	2W	3W	4W	5W	6W	7W	8W
Groups(A)	5	90.5**	195.6**	178.6**	211.6**	299.3**	378.4**	424.1**	484.9**	460.0**	571.1**
Force(B)	1	3357**	2602**	2146**	2070**	2516**	2976**	2707**	2633**	2552**	3096**
AB	5	51.4**	56.4**	55.7**	73.4**	102.8**	114.8**	129.8**	145.6**	135.4**	148.9**

** Statistically Significant H=Hours, W=Weeks

Table 11. Comparison of remained force magnitude (in gm) at various time intervals in light and heavy force by t – Test

Gp	1 H	24 H	1 W	2 W	3 W	4 W	5 W	6 W	7 W	8 W
Ao	0.114	0.000**	0.000**	0.132	0.013*	0.002**	0.002**	0.002**	0.000**	0.000**
Or	0.001**	0.002**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
Gh	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
Oo	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
3m	0.259	0.540	0.781	0.593	0.062	0.000**	0.000**	0.000**	0.000**	0.000**
Oc	0.250	0.120	0.000**	0.000**	0.000**	0.000**	0.001**	0.229	0.228	0.679

**Statistically significant. H=Hours, W=Weeks.

degradation at 1Hr, 24hrs, one week, two weeks, three weeks, four weeks, five weeks, six weeks, seven weeks and eight weeks at light force and heavy force respectively. In 3M Unitek (3m) group difference in force degradation at light force and heavy force was statistically not significant up to 3 weeks. However, statistically significant difference were found at four weeks, five weeks, six weeks, seven weeks and eighth weeks at light force and heavy force respectively. In Ortho Classic (Oc) group statistically significant difference were found up to five weeks at light and heavy force respectively. However the difference was statistically not significant at sixth weeks, seventh weeks and eighth weeks (Table 11).

3. Discussion

Different studies have been published and research is under process since 1970's on the decay of elastomers that have demonstrated ranges of force decay from 24% - 85% following twenty-eight days)[3,8,9,10]. So, this study was designed to compare force delivered by elastomeric chains.

A. Force magnitudes and percentage of stretching

Elastomeric chains needed to be stretched differently to reach 200 or 350 grams. The initial length of elastomeric chains is ranges from 12.8 to 20 mm, after stretching length is 25 to 31 mm in light forces (Table 1). The initial length of elastomeric chains is ranges from 10 to 14.5 mm, after stretching length is 26.6 to 31 mm in heavy forces (Table 2).

Brantley *et al.*[11] studied the effects on force decay of elastomeric chains by pre-stretching the elastomeric chains. They pre-stretched power chains 100% for 24 hours and 3 weeks. They showed 5% less force decay in pre-stretched groups and reported no meaningful difference (within 10 grams). More recently, Kim *et al.*[12] pre-stretched samples for one hour, twenty - four hours, two weeks, and four weeks. They concluded that pre-stretched modules had lower initial forces compared to the control group significantly. After four weeks also the similar remaining forces were found between prestretched and control groups.

In present study care was taken to maintain same level of initial forces in all elastomeric chain groups.

B. Comparison of elastomeric chains

Ortho Classic exhibited more force decay in all six elastomeric chain groups in light force and G & H in heavy force. This was evident in both heavy and light forces, in both 2 subgroups and in each points. 43-65 % in light force and 35 – 43 % in heavy force is the average mean difference in force decay between elastomeric chains.

C. Comparison of differences in force decay when using different force levels

American Orthodontics Group did not show any statistically significant difference in force degradation at 1Hr. statistically significant difference was found at 24hrs, first week, second weeks, third weeks, fourth weeks, fifth weeks, sixth weeks, seventh weeks and eighth weeks. Group Ormco, G & H and Ortho Organiser showed statistically significant difference in force degradation at 1Hr, 24hrs, first week, second weeks, third weeks, fourth weeks, fifth weeks, sixth weeks, seventh weeks and eighth weeks at light force and heavy force respectively. In 3M Unitek group difference in force degradation at light force and heavy force was statistically not significant up to 3 weeks. However, statistically significant difference were found at fourth weeks, fifth weeks, sixth weeks, seventh weeks and eighth weeks at light force and heavy force respectively. In Ortho Classic group statistically significant difference were found up to 5 weeks at light and heavy force respectively. However the difference was statistically not significant at sixth weeks, seventh weeks and eighth weeks.

D. Time effect on force decay

Repeated Measures ANOVA showed that all chain products had a fairly similar pattern of force decay. The maximum force decay occurred in the first hour and 24 hours. The result reveals at 24 hours there is a massive loss of initial exerted force and for all brands the loss of force ranged from 19.1-43.4% and 27.6-52% at light and heavy force respectively. At this specific time (24 hrs) the brand that retains maximum amount of initial force is American Orthodontics (Ao) at the level of 80.8% while maximum degradation of force was found in orthoclassic, which retained only 56.6% and maximum amount of initial force is American Orthodontics (Ao) at the level of 72.4% while maximum degradation of force was found in Ortho Organizer, which retained only 48% in light force and heavy force respectively. At 4 weeks maximum force retained by American Orthodontics (Ao) at 67.8% while maximum degradation was found in Ortho Classic (Oc) with only 47.1% and maximum force retained by American Orthodontics 63.5% while minimum was found in G & H (Gh) 37.2% in light force and heavy force respectively. At the end of 8 weeks the effective loss of initially expressed force appears different all the commercially available brands. However the study reveals the leading brand in maximum force retention was American orthodontics which retained 64.8% while Ortho Classic was found to have lost the maximum force and retained only 37.4% in light force and maximum force retention was American orthodontics which retained 59% while G&H was found to have lost the maximum force and retained only 31% in heavy force.

Clinicians who use self ligating brackets sometimes see patients at more than 6 week intervals. Results concluded that all six chain products had a significant level of decrease in force decay at 7th and 8th week. The percentages of force decay would be greater intraorally as the inter bracket distance decreases as the teeth moves closer[13,8,9,14]. In this experiment the distance between brackets was kept constant. Moreover, some researchers have concluded that the force decay is more in the elastomers that are tested in vivo[15].

E. Force magnitudes required for tooth movement

100-300 grams range of force are considered as optimal forces for canine retraction (Storey and Smith, Reitan, K, Boester and Johnston)[16–18]. In current study, all the groups have mean forces in the range of 94.3-135.5 grams remaining after 4 weeks in light force. In subgroups when the initial force was 350 grams, means of remaining forces after 4 weeks were between 130.1-222.3 grams. However, in G&H (Gh) I and Ortho Classic (Oc) I subgroups when initial force was 200 grams, the remaining forces mean after 4 week are below 100 grams. These means after 4 week ranged from 94.3 to 222.3 grams with highest value belonging to elastomeric chains from American Orthodontics (Ao) subgroup.

F. Clinical Significance

The findings showed that Plastic Chain; American Orthodontics (Ao) had maximum retained force at the end of study in both light and heavy force. For clinicians wanted to see patient at 6 or 8 week intervals, the subgroups from the American Orthodontics (Ao), Ormco (Or), Ortho Organiser (Oo) and 3M Unitek elastomeric chain light initial forces and all subgroup of elastomeric chains with heavy initial forces, had remaining forces within the suggested optimal forces to move teeth. Clinicians might also want to kn ow how much to stretch each elastomeric chain type. The present findings showed that for light forces 38.88-107.81% stretch was needed and 89.28-200% for heavy force level.

4. Conclusion

1. Within the limitations of the study it can be concluded that American Orthodontics showed minimum rate of force decay and Ortho Classic showed maximum rate of force decay over 8 weeks in both light force (200gms) and heavy force (350gms).

2. Result reveals at 24 hours there is a massive loss of initial exerted force and for all the brands the loss of force ranged from 19.1-43.4% and 27.6-52% at light force (200 gm) and heavy force (350 gm) respectively.

3. At the end of 4 weeks all elastomeric chains have showed optimal forces for canine retraction at heavy force (350 gm) and at light force (200 gm) except Dyna-Link; G & H and Elastomeric chain; Ortho Classic.

4. When compared between initial light (200 gm) and heavy force (350 gm) force in different elastomeric chain group with different time points some shows significant some shows not significant decay of force.

Further studies/research is needed to collaborate these clinical study findings.

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