Force Decay Characteristics of Niti Closed Coil Spring at Different Time Intervals

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dx.doi.org/10.13005/bbra/1258

(Received: 25 December 2013; accepted: 01 February 2014)

This study compared commercially available NiTi closed spring of three different companies for their force decay over a period of four weeks and the amount of extension that is needed for a spring to deliver an optimum sustained orthodontic force.

Key words: NiTi Springs, Force Degradation, Martensitic plateau, Modulus of Elasticity, Spring Back.

Efficient biological tooth movement using optimal force is the prime requisite by all orthodontic force systems[1]. NiTi springs, because of its super elastic property exert optimum sustained force over a large range of deflection[3]. NiTi springs differ from arch wires because of additional manufacturing procedures such as winding. NiTi springs are popular because of their superior properties such as low modulus of elasticity,high spring back and wide force delivery range[3]There is no clear indication as to how much extension is necessary to provide sustained optimum force.

MATERIALS AND METHODS

30 samples of closed coil springs of 9mm length of three different companies (Lancer orthodontics, Ortho technology, GAC international, 10 samples/ company) were selected for the test to evaluate the degree of stretch required to deliver the optimum orthodontic force and later force decay in 4 weeks.

An extension test was done with the help of Llyods universal testing machine. Two jigs were used to facilitate the extension test. They consist of an acrylic block to which a SS hook was attached. One of the jig is attached to the upper and the other jig to the lower jaw of universal testing machine. The eyelets of the springs were attached to the hooks on the jigs. Then the upper jaw was moved upward at the rate of 2mm/min .The extension required for each sample for each company to deliver an optimal force (150gms) was noted and then the mean value for each company was calculated.

The springs were extended to the mean value previously obtained and maintained with the help of a specially designed jig in an artificial salivary medium[1] to calculate the force degradation .Thereafter the springs were returned to the testing machine and extended to original extension at intervals of 24 hours, 1 week, 3 weeks, and 4 weeks and the force levels are recorded.

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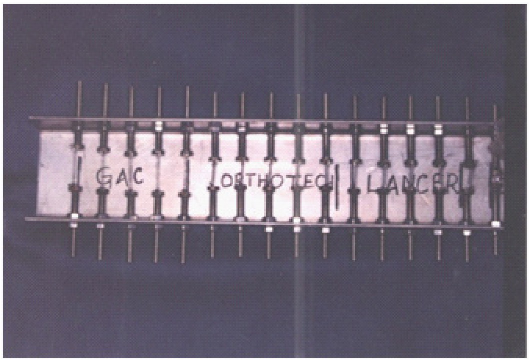
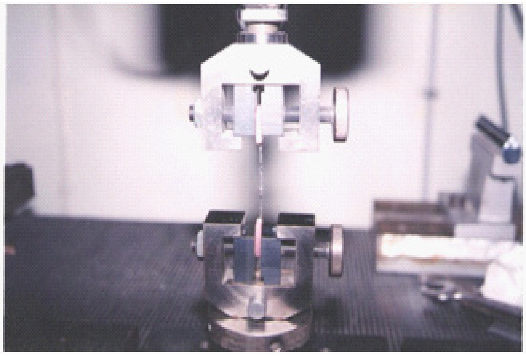
RESULTS

The statistical software SPSSPC+ (Statistical package for social science personal computer +) was used for statistical analysis. One way ANOVA, multiple range test by Duncan procedure and student paired t – test were employed to find statistical difference between groups. The results are as follows:

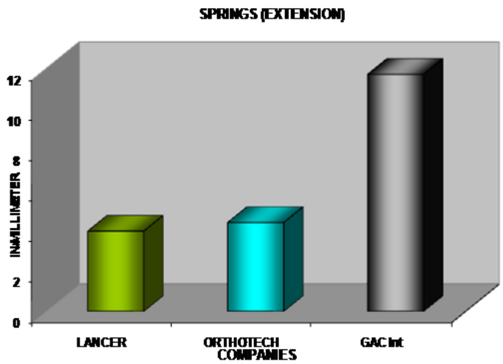
A Lloyds Universal Testing Machine (United Kingdom) model no. LR 100 K, equipped ith a 10 kg tensile load cell



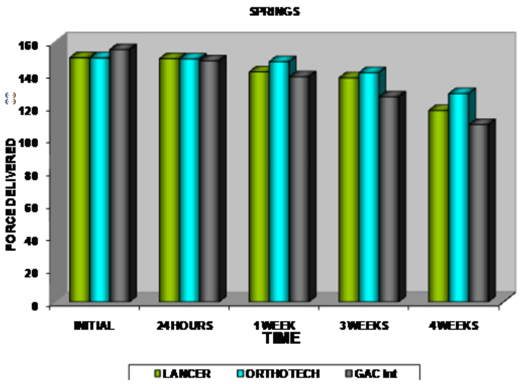
The springs were maintained in a specially designed apparatus



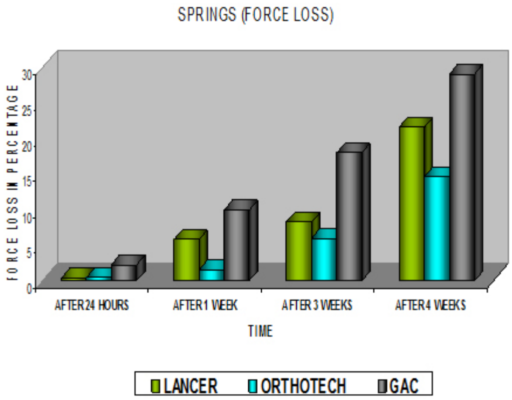
Upper jaw of the testing machine was moved upward at a rate of 2 mm/min



Graph 1.



Graph 2.



Graph 3.

Table 1. The mean and standard deviations of force along with mean extension and percent force loss of all springs at various time intervals are given below

Time	N	Ortho tech (S_1)				Lancer (S_2)				GAC Int. (S_3)			
		Force (±) SD	Extension in mm	Percent loss from	Percent consecutive intervals	Force (±) SD	Extension in mm	Percent loss from	Percent consecutive intervals	Force (±) SD	Extension in mm	Percent loss from	Percent consecutive intervals
Initial	10	150.154± 1.1507	4.402	-	-	150.32± 1.4077	3.973	-	-	155.27± 8.228	11.74	-	-
24 Hours	10	149.52± 0.907	4.402	0.42%	0.42%	149.74± 1.0039	3.973	0.38%	0.38%	148.37± 7.058	11.74	2.21%	2.21%
1st Week	10	147.84± 1.354	4.402	1.534%	1.117%	141.6± 3.4689	3.973	5.81%	5.44%	138.56± 5.603	11.74	9.95%	7.91%
3rd Week	10	141.13± 4.882	4.402	6%	4.55%	137.86± 2.5349	3.973	8.28%	2.62%	126.2± 3.76	11.74	17.99%	8.92%
4th Week	10	128.2± 2.343	4.402	14.621%	9.162%	117.8± 2.6	3.973	21.61%	14.52%	109.12± 3.846	11.74	29.03%	13.53%

The graph – 1 and table -1 shows the mean extension values of various *springs:* Orthotech (4.402m), Lancer (3.973mm) and GAC Int. (11.74mm) such that a force delivery of 150gms was obtained.

Table-1 and graph-2 shows the force delivered by the springs at various intervals of time.

Table-1 and Graph-3 shows the force loss by the springs of different companies. At the end of 4 weeks GAC showed maximum force loss of 29.03%, followed by Lancer 21.61% and Orthoteck 14.621%. In the first 24 hours Orthotech and GAC had significant degradation, whereas Lancer showed no significant degradation.

Between the intervals of 24hours to 1 week, 1st and 3rd week, 3rd and 4th week , all springs individually showed significant force degradation.

DISCUSSION

In the beginning the spring was extended to deliver a force of 150gms.At the end of 4 weeks the force loss for GAC spring (29.03%), is greater than Lancer spring (21.61%) and Orthotech (14.621%) spring. GAC showed significant force degradation during most intervals as in accordance with the study of Angolkar[13] on Japanese NiTi alloys. GAC spring although exhibited the Martensitic plateau, did not achieve the target force in the activation range given by the manufacturer (1 to 12mm) and in accordance with the work of Manhartsberger et al[14,15] Lancer spring showed no significant force loss during first 24 hours. Orthotech springs showed lesser force degradation throughout the test period as in accordance with Sangkyu Han and Quick[16, 17].

From this study it was noted that Lancer and Orthotech springs needed to be extended 3.973mm, 4.402mm and 11.74mm which is approximately 1/3rd length except GAC int. spring and in accordance with various authors recommendation of ½ to $^1/_3$ of its original length by Webb et al[18] and Miura[3].

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