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Comparison of claimed and measured forces of inter-arch orthodontic elastics – an in vitro study

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Abstract

Introduction: Inter-arch elastics exert specific amount of force for the required tooth movement, therefore it is necessary for the orthodontist to be familiar with force extension characteristics of selected elastic band. Aim of this study was to compare claimed and actual force of four brands of inter-arch orthodontic elastics with respect to their initial force produced and force decay over a 24-hour period in dry and moist conditions.

Material and methods: Two hundred non-latex elastics of four brands (Dentaurum, Ortho care, Opal and Class one) and five sizes (1/8, 3/16, 1/4, 5/16 and 3/8 inch) with five elastics in each group were investigated in both dry and wet conditions statically. Force measurements were made by stretching elastics with orthodontic stress and tension gauge from to 10mm to 45mm. Samples were immersed in water for 24 hours, in starched state. Repeated Measures Analysis of Variance was used for comparisons among the groups. Dry and wet measurements were tested with paired sample T tests.

Results: Statistically no significant differences were found among the groups (P = 0.09). Class one elastics showed consistently higher values than the claimed values, conversely Dentaurum elastics showed consistently lower values. The pre and post immersion data comparison revealed significant differences at 15mm stretch (P =0.009).

Conclusions: Though statistically significant differences were found between claimed and actual force, but they seem to have no clinical impact. Force extension comparisons between dry and wet samples showed some degree of force degradation but the difference was not statistically significant.

Keywords: Force degradation; dry test; wet test; force extension

Introduction

Orthodontic elastics are commonly used in orthodontic treatment for settling of occlusion, overbite control and correction of molar relationship.[1-4] They are most commonly made of latex but can be made from synthetic polymers as well, as concerns about the latex allergy are on the rise.[5,6] Their availability in a variety of sizes and their low cost are key factors of the wide spread use in the orthodontic treatment.[2] The force and diameter characteristics are generally listed on the packets in which elastics are provided. By convention, the force resulting when an elastic is stretched to 3 times its diameter is considered as the standard force for a given elastic (force index).[7] Hence the force extension characteristics of elastics vary with the size and stretch of elastics.[1, 7-9] It is important for the orthodontist to be familiar with force extension characteristics of selected elastic band for the particular tooth movement.[2,4] The points of attachments of elastics vary in length and clinician may not be aware of the magnitude of the force of elastics in some situations. There is change in tooth location when force is applied mechanically on malaligned tooth.[10] Further force is transferred to periodontal ligament (PDL) through bone which results in orthodontic tooth movement and remodeling occurs in that area.[11] The force with sufficient magnitude and duration is applied to individual teeth or groups of teeth in clinical orthodontic therapy to ensure cellular

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response and remodeling of alveolar bone. Oral cavity is a dynamic environment and offers certain challenges to rubber elastics.[9,12-14] The imbibition of fluid causes loss of elastic force and it is generally recommended to change the elastics every 24 hours. It has been said that exposure of elastics to oral environment shows loss of initial force by 10 to 40%.[1,13] Liu et al[10] suggested that repeated stretching and relaxing of elastics during opening and closing of mouth in chewing and speech can also adversely affect the force characteristics of elastics.[10] In contrast, Bishara et al[15] found little difference in the force decay after initial force loss and proposed the use of elastic for longer than 24 hours.[15] Bales et al[16] found the actual values of the elastics force corresponding more closely with the 2x force index than 3x stretch. With such variance in the properties of elastics, it is imperative to be aware of the force extension characteristics of elastics used in orthodontic treatment. Hence the purpose of this study was to compare claimed and actual force of four brands of inter-arch non-latex orthodontic elastics with respect to their initial force produced and force decay over a 24-hour period in dry and moist condition.

Material and Methods

This study was carried out in the Department of Dental Materials, Sardar Begum Dental College, Peshawar from Sept 2013 to August 2014. Orthodontic non-latex elastics of four different brands (Dentaurum, Ortho care, Opal and Class One) and five sizes (1/8, 3/16, 1/4, 5/16 and 3/8 inch) with five elastics in each group were investigated in both dry and wet conditions statically. All samples were in sealed packets having recent manufacturing dates. A total of 195 elastics were used as 1/8 size from Ortho care was not available at the time of analysis. An Orthodontic Force measuring gauge (zinghua, China) with capability of measuring from 1-16 oz. (1-450g) was used for all the measurements (figure 1).

For dry test a testing apparatus was designed and fabricated. The apparatus consisted of wooden board having length measuring scale and hooks fixed. Force measurements were made by stretching elastics with orthodontic stress and tension gauge from 10mm to 45mm in 5mm increments over a wooden board against a single fixed hook. This test was performed under room temperature i.e. 25 ˚C. The data of 95 elastics for actual dry condition were recorded. Force degradation of other 95 elastics for wet test was evaluated in water maintained at 37 ˚C to imitate the oral environment. The elastics for wet test were mounted between hooks at the same fixed distances as in dry state. Then these elastics were immersed in a container full of water for a period of 24 hours. After that readings were obtained in the same manner as for dry condition. All samples were obtained within 5 weeks of the testing date and all testing was accomplished before the expiration dates on packets. Forty elastics were randomly selected after eight weeks for intra-examiner reliability testing. Elastics were stored according to manufacturer instructions.

All Statistical analyses were performed in SPSS version 16 (Chicago, III). Repeated Measures Analysis of Variance was used for comparisons among the groups. Dry and wet measurements were tested with paired sample T tests. Pearson's correlation coefficients were calculated for intra-examiner reliability of the data. P value of 0.05 or less was considered significant.

Figure 1: Orthodontic stress and tension gauge

Results

Table I and II represent the mean force levels at different stretch lengths of the elastics of all 4 companies tested in pre and post-immersion states. Maximum differences were observed for 45mm stretch; 2.72oz. for Ortho care,

1.3oz. for Class One and 1.0 oz. for Dentaurum elastics (Figure 2). Excellent intra-examiner reliability was observed for all the repeated measurements (r > 0.90).

Most of the claimed measurements were very close to the measurements observed in wet and dry states. A repeated measures ANOVA with a Greenhouse-Geisser correction showed no statistically significant differences among the groups (P = 0.09). Class One elastics

Table I: Pre immersion Descriptive Statistics

Pre-immersion		10mm	15mm	20mm	25mm	30mm	35mm	40mm	45mm
Class One	Mean	1.82	3.78	5.50	6.80	7.85	7.93	9.28	9.10
	Std. Deviation	1.93585	2.32773	2.23140	2.75000	3.16743	1.90757	2.53644	1.71339
	Maximum	5.50	8.50	10.50	13.00	16.00	11.00	14.00	13.00
	Minimum	0.00	1.00	2.50	3.50	5.00	6.00	6.50	7.00
Dentaurum	Mean	2.16	3.74	5.10	6.12	7.22	8.46	7.68	8.93
	Std. Dev.	2.25333	2.42865	2.49165	2.82577	3.28532	4.10772	2.97036	3.49915
	Maximum	7.00	8.50	9.50	11.00	13.50	16.00	11.00	12.00
	Minimum	0.00	0.50	1.00	1.50	2.00	2.50	2.50	
Opal	Mean	1.36	2.68	3.62	4.44	5.62	5.79	6.03	7.25
	Std. Dev.	1.36565	1.59243	1.72554	1.99228	2.88646	3.28851	2.67837	3.33354
	Maximum	4.00	7.00	8.00	9.00	11.00	13.00	15.50	16.00
	Minimum	0.00	1.00	2.00	3.00	4.00	5.00	6.00	6.00
Orthocare	Mean	1.45	3.45	5.03	6.30	7.38	8.65	9.90	9.97
	Std. Dev.	1.39454	2.22959	2.33100	2.42465	2.62014	3.04398	3.64403	4.17675
	Maximum	4.00	7.00	8.00	9.00	11.00	13.00	15.50	
	Minimum	0.00	1.00	2.00	3.00	4.00	5.00	6.00	
Total	Mean	1.71	3.41	4.78	5.87	6.96	7.71	8.19	8.69
	Std. Dev.	1.79624	2.18103	2.30254	2.65776	3.09949	3.40023	3.31984	3.41159
	Maximum	7.00	8.50	10.50	13.00	16.00	16.00	15.50	
	Minimum	0.00	0.50	1.00	1.50	2.00	2.00	2.50	

Table II: Post Immersion Descriptive Statistics

Post-immersion		10mm	15mm	20mm	25mm	30mm	35mm	40mm	45mm
Class One	Mean	2.00	3.98	5.44	6.94	7.61	7.75	8.88	10.40
	Std. Deviation	2.16025	2.46847	2.50965	3.00804	3.10043	2.08061	2.51770	3.46258
	Maximum	9.00	11.00	14.00	16.00	11.00	14.00	16.00	
	Minimum	1.00	2.00	3.50	4.50	5.00	6.00	6.50	
Dentaurum	Mean	2.04	3.60	4.86	5.90	6.74	8.04	7.43	7.93
	Std. Dev.	1.98914	2.08666	2.35637	2.70416	2.92660	3.63983	2.66199	3.26575
	Maximum	6.00	7.50	9.00	10.00	11.00	14.00	10.00	11.00
	Minimum	0.00	0.50	1.00	1.00	2.00	2.50	3.00	2.00
Opal	Mean	1.36	2.70	3.48	4.32	5.30	6.20	5.65	6.50
	Std. Dev.	1.16369	1.17260	1.34629	1.57268	2.39148	3.70338	2.07666	2.35081
	Maximum	4.00	7.00	8.50	10.00	11.50	13.50	16.00	15.00
	Minimum	1.50	2.00	2.50	3.00	0.00	4.00	4.50	4.50
Ortho care	Mean	1.60	3.85	5.30	6.50	7.53	8.65	10.10	7.25
	Std. Dev.	1.56104	2.21894	2.27342	2.40613	2.68757	3.09541	3.81341	5.25282
	Maximum	4.00	7.00	8.50	10.00	11.50	13.50	16.00	15.00
	Minimum	0.00	1.00	2.50	3.50	4.00	5.00	6.00	0.00
Total	Mean	1.83	3.65	4.91	6.07	6.97	7.85	8.33	8.36
	Std. Dev.	1.74241	2.01071	2.17576	2.53483	2.78911	3.21902	3.07923	3.86888
	Maximum	6.00	9.00	11.00	14.00	16.00	16.00	16.00	16.00
	Minimum	0.00	0.50	1.00	1.00	2.00	0.00	3.00	0.00

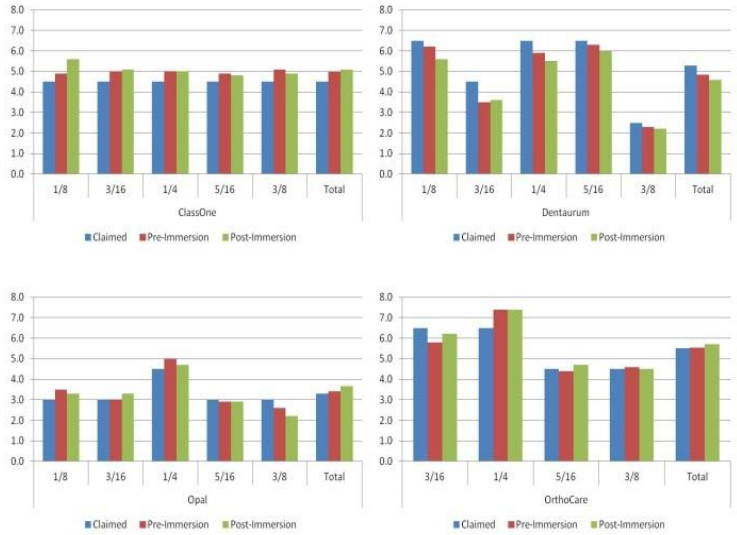

Figure 2: Mean force level comparisons at 3x lengths

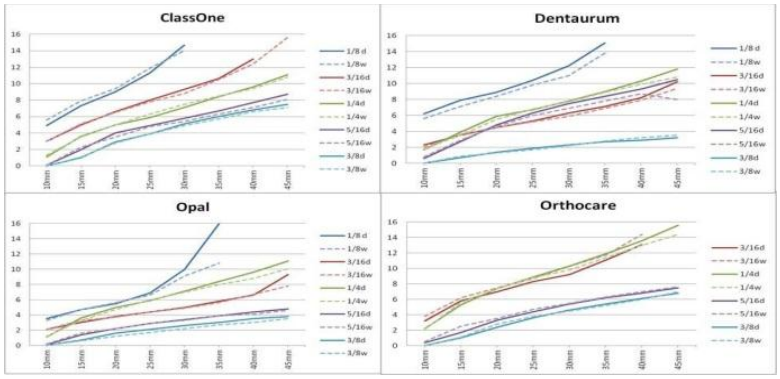

Figure 3: Load deflection curves

Table III: Paired comparisons of pre and post immersion stretching tests

	Paired Differences					Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		
				Lower	Upper	
10mm	-.11579	.60342	.06191	-.23871	.00713	.065
15mm	-.24737	.90175	.09252	-.43106	-.06367	.009
20mm	-.13158	.98448	.10101	-.33213	.06897	.196
25mm	-.20000	1.07039	.10982	-.41805	.01805	.072
30mm	-.03804	1.41272	.14729	-.33061	.25452	.797
35mm	-.01744	1.49006	.16068	-.33691	.30203	.914
40mm	-.13750	1.68195	.18805	-.51180	.23680	.467
45mm	.24286	2.15982	.25815	-.27213	.75785	.350

showed consistently higher values than the claimed values, although the magnitude was small (<1 oz.), Conversely Dentaurum elastics showed consistently lower values, but again the magnitude was less than 1 oz.

The pre and post immersion data comparison (Table III) revealed significant differences at 15mm stretch (p = 0.009). The maximum mean differences were 0.24±2 oz. at 45mm stretch and 0.24±0.9 oz. at 15mm. Standard deviations increased progressively with increased stretch.

The load-deflection curves comparisons, which essentially show the force degradation characteristics of dry and wet states of elastics are shown in Figure 3. Almost all elastics exhibited some degree of loss of force 24 hours after immersion.

Discussion

This study investigated the in-vitro behavior of orthodontic elastics in dry state and after immersion into water for 24 hours. The

results were expected to simulate the effects of oral environment on the elastics, which could help in the choice of elastic size, placement zone, stretch and duration of wear. Kanchana and Godfrey[7] cautioned that in-vitro elastic testing does not represent the clinical reality, however it can help in formulation of guidelines for elastics use.

We chose 5 elastics from each size and company for both dry and wet tests. Although more elastics samples per size have been used in some studies,[1,5] elastics are generally in concordance with other investigations.[5,7] Similarly the stretching distances from 10mm to 45mm were chosen at 5mm increments which would represent a variety of clinical situations.

For the measurement of forces, we used the orthodontic force measuring gauge which was sensitive up to 10th of an ounce (3gms). While many previous studies have utilized Universal testing machines which are much more sensitive,[4] we believe that from a clinical stand point use of a conventional force measuring gauge is perfectly acceptable.

Force extension comparisons between dry and wet samples showed some degree of force degradation but the difference was not statistically significant. We observed a maximum difference of 0.24 ± 2oz. (95% CI- 0.27 – 0.76 oz) for 15mm extension which was also statistically significant (p= 0.005). Given the number of sub group analysis, it seems likely that a random error may have resulted in this reading.

Several studies have demonstrated the loss of elastic force by varying percentages.[4,7] Our study found a maximum force loss of 8%. This is substantially less than the values reported in other investigations. Kanchana and Godfrey reported about 30% fall off after 24 hours.[7] However, they found that medium elastics (3 - 4.5oz) had less percentage of force loss than light (2oz.) elastics. This may well be the reason for less force loss of elastics in our study as most of elastics were medium. The same trend was noticed by Hixon et al[17] and our study corroborates their findings.

Another trend that we observed was the progressively more force decay with increased stretch. This was observed for almost all elastics tested. Yogosawa et al[18] found the similar trend in their study and a similar conclusion was made. This is also in agreement with Kanchana and Godfrey who reported maximum force degradations at maximum stretch.[7]

When the elastics were stretched to 3x size of the lumen diameter, Class One elastics showed consistently higher readings than claimed ones (max 1.1oz. higher for 1/8 size in wet sample and 0.6oz. for 3/8size in dry). The opposite trend was observed for the Dentaurum elastics (max 1.0 oz. less for 1/4 size in wet sample and 3/16 size in dry), while the remaining two categories demonstrated mixed patterns. This shows the variability of the responses to stretch and that claimed forces did not match the actual forces when extended to 3x diameter size. Kanchana and Godfrey in contrast only observed increased forces by 9-40% at 3x.[7] However the observed differences in our study hold little or no clinical impact for two reasons. First the force is generally applied to groups of teeth and 1oz. (28.5g) force difference in general would not compromise the desired movement of the teeth. Secondly, it is hard to predict the response of the elastics of different manufacturers and size categories.

Our findings of minimal force loss and differences at 3x lengths suggest that these elastics can be used for longer durations than just for 24 hours. Bishara et al[19] found that there is minimal loss of elastic forces from 24-72 hours and hence elastics can be used for longer than 24 hours, as long as elastics selected have 25-40% more force than desired, for compensation of initial force loss. Others however still recommend changing after 24 hours.[10, 16]

Our study had some limitations. Most of the elastics were medium so the results should be

cautiously applied to stronger or lighter elastics. Warm water at 37°C cannot simulate the oral fluid environment completely. Another important factor is the cyclic nature of stretching in oral environment which was not replicated in vitro.

Conclusions

- Class one elastics generated higher forces at an extension of 3 times the marketed internal diameter but the increase was not clinically significant.
- Dentaurum elastics generated less force at an extension of 3 times the marketed internal diameter but the difference was of no clinical consequence.
- Though statistically significant, differences were found between claimed and actual force but they have no clinical impact.
- Force extension comparisons between dry and wet samples showed some degree of force degradation but the difference was not statistically significant.

References

1. Fernandes DJ, Fernandes GM, Artese F, Elias CN, Mendes AM. Force extension relaxation of medium force orthodontic latex elastics. Angle Orthod 2011;81:812-9.
2. Polur I, Peck S. Orthodontic elastics: is some tightening needed? Angle Orthod 2010;80:988-9.
3. Tran AM, English JD, Paige SZ, Powers JM, Bussa HI, Lee RP. Force relaxation between latex and non-latex orthodontic elastics in simulated saliva solution. Tex Dent J 2009;126:981-5.
4. Wang T, Zhou G, Tan X, Dong Y. Evaluation of force degradation characteristics of orthodontic latex elastics in vitro and in vivo. Angle Orthod 2007;77:688-93.
5. Kamisetty SK, Nimagadda C, Begam MP, Nalamotu R, Srivastav T, Gs S. Elasticity in Elastics. An in-vitro study. J Int Oral Health 2014;6:96-105.
6. Dos Santos RL, Pithon MM, Da Silva Mendes G, Romanos MT, De Oliveira Ruellas AC. Cytotoxicity of intermaxillary orthodontic elastics of different colors: an in vitro study. J Appl Oral Sci 2009;17:326-9.
7. Kanchana P, Godfrey K. Calibration of force extension and force degradation characteristics of orthodontic latex elastics. Am J Orthod Dentofacial Orthop 2000;118:280-7.
8. Fernandes DJ, Abrahao GM, Elias CN, Mendes AM. Force relaxation characteristics of medium force orthodontic latex elastics: a pilot study. ISRN Dent 2011;53:60-89.
9. Lopez N, Vicente A, Bravo LA, Calvo JL, Canteras M. In vitro study of force decay of latex and non-latex orthodontic elastics. Eur J Orthod 2012;34:202-7.
10. Liu CC, Wataha JC, Craig RG. The effect of repeated stretching on the force decay and compliance of vulcanized cis-polyisoprene orthodontic elastics. Dent Mater 1993;9:37-40.
11. Lowney JJ, Norton LA, Shafer DM, Rossomando EF. Orthodontic forces increase tumor necrosis factor alpha in the human gingival sulcus. Am J Orthod Dentofacial Orthop 1995;108:519-24.
12. Jacobsen N, Hensten-Pettersen A. Changes in occupational health problems and adverse patient reactions in orthodontics from 1987 to 2000. Eur J Orthod 2003;25:591-8.
13. Sauget PS, Stewart KT, Katona TR. The effect of pH levels on nonlatex vs latex interarch elastics. Angle Orthod 2011;81:1070-4.
14. Teixeira L, Pereira Bdo R, Bortoly TG, Brancher JA, Tanaka OM, Guariza-Filho O. The environmental influence of Light Coke, phosphoric acid and citric acid on elastomeric chains. J Contemp Dent Pract 2008;9:17-24.
15. Bishara SE, Andreasen GF. A comparison of time related forces between plastic alastiks and latex elastics. Angle Orthod 1970;40:319-28.
16. Bales TR, Chaconas SJ, Caputo AA. Force-extension characteristics of orthodontic elastics. Am J Orthod 1977;72:296-302.
17. Hixon EH, Aasen TO, Clark RA, Klosterman R, Miller SS, Odom WM. On force and tooth movement. Am J Orthod 1970;57:476-8.
18. Yogosawa F, Nishimaki H, Ono E. Degradation of orthodontic elastics. Nihon Kyosei Shika Gakkai Zasshi 1967;26:49-55.
19. Andreasen GF, Bishara S. Comparison of alastik chains with elastics involved with intra-arch molar to molar forces. Angle Orthod 1970;40:151 -8.