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Original Research

Elasticity in Elastics-An in-vitro study

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Abstract:

Background: Orthodontic tooth movement results from application of forces to teeth. Elastics in orthodontics have been used both intra-orally and extra- orally to a great effect. Their use, combined with good patient co-operation provides the clinician with the ability to correct both anteroposterior and vertical discrepancies. Force decay over a period of time is a major problem in the clinical usage of latex elastics and synthetic elastomers. This loss of force makes it difficult for the clinician to determine the actual force transmitted to the dentition. It's the intent of the clinician to maintain optimal force values over desired period of time. The majority of the orthodontic elastics on the market are latex elastics. Since the early 1990s, synthetic products have been offered in the market for latex-sensitive patients and are sold as nonlatex elastics. There is limited information on the risk that latex elastics may pose to patients. Some have estimated that 0.12–6% of the general population and 6.2% of dental professionals have hypersensitivity to latex protein. There are some reported cases of adverse reactions to latex in the orthodontic population but these are very limited to date. Although the risk is not yet clear, it would still be inadvisable to prescribe latex elastics to a patient with a known latex allergy. To compare the in-vitro performance of latex and non latex elastics.

Materials & Methods: Samples of 0.25 inch, latex and non latex elastics (light, medium, heavy elastics) were obtained from three manufacturers (Forestadent, GAC, Glenroe) and a sample size of ten elastics per group was tested. The properties tested included cross sectional area, internal diameter, initial force generated by the elastics, breaking force and the force relaxation for the different types of elastics. Force relaxation testing involved stretching the elastics to three times marketed internal diameter (19.05 mm) and measuring force level at intervals over a period of 48 hours. The data were analyzed with student independent – t test, analysis of variance and the Tukey – HSD test at $p < 0.05$ level of significance.

Results: Non latex elastics had greater cross sectional area than latex elastics in all types of elastics. Forestadent heavy elastics had grater cross sectional area than GAC and Glenroe. There was no statistically significant difference in the internal diameter in between all type of elastics. Forestadent non latex elastics had greater breaking force compared to GAC and Glenroe elastics. Forces generated by the elastics decreased over 48 hours to an average load approximating 65-75% of the manufacturer's values. Force degradation was greater in non latex elastics compared to latex elastics.

Conclusion: The results of the study demonstrated that the clinical choice of elastics should be based on the patient's medical history and the specific mechanical properties of the type of elastic.

Key Words: Artificial saliva, elasticity, force degradation, force relaxation, latex elastics, non latex elastic

Introduction

"Force is the medicine in Orthodontics" - Sheldon Friel. Orthodontic tooth movement results from application of forces to teeth. Materials used to move teeth include arch wire loops, coil springs, elastics and synthetic elastomers, etc. Rubber and its derivatives and synthetic elastomers of polyurethane nature have been a reliable method of delivering forces in fixed appliances. Elastomer is a general term, which encompasses materials that after substantial deformation rapidly return to their original dimensions.

Natural rubber is an elastomer, but not all elastomers can be called rubber. The word rubber synergises with natural or tree rubber which is a hydrocarbon polymer of isoprene units.[1] The synthetic rubbers which have been developed posses different chemical structures but resemble tree rubber in many physical properties. Synthetic rubber polymers used for Orthodontic purpose is usually polyurethane rubber. They can be synthesized by extending polyester or a polyether glycol or polyhydrocarbon diol with a diisocyante. Depending upon the end use a variety of means of processing and synthesizing may be employed.[2] Increased incidence of latex allergic reactions was the reason for the increase in the use of non latex products within the orthodontic specialty. Hence, the assessment of the material properties of non latex elastics becomes increasingly important clinically.

Force decay over a period of time is a major problem in the clinical usage of latex elastics and synthetic elastomers.

Figure 1: Forestadent intra oral elastics.

Figure 2: Glenroe intra oral elastics.

This loss of force makes it difficult for the clinician to determine the actual force transmitted to the dentition. It is the intent of the clinician to maintain optimal force values over desired period of time. Hence knowledge of force decay of elastics and synthetic elastomers will help to determine their clinical usage.

The purpose of this study was to compare invitro performance of latex and non-latex elastics and to measure the internal diameter, cross sectional area, initial forces generated, force relaxation of elastics held at constant extension for 48 hours and the breaking force for the different types of elastics.

Materials and Methods

Samples of latex and non-latex, non-colored Orthodontic elastics were obtained from three manufacturers - Forestadent (Pforzheim, Germany), Glenroe (Bradenton, Florida) and GAC International (Islandia, NY). (Figure1-3). The elastics were reported to be of 0.25-inch internal diameter (ID) and of light, medium and heavy forces. The samples obtained were well within shelf life. They were refrigerated in plastic covers provided by the manufacturers and kept away from sunlight to prevent any

Figure 3: GAC intra oral elastics.

deterioration. All testing was conducted on 10 samples of each elastic type, thus there were 180 elastics tested for each specific mechanical test. All elastics were tested as intact loops.

Methodology

The internal diameter and cross sectional area of each elastic was measured with the use of a Mitutoyo thickness gauge (Model 7309, Mitutoyo, Aurora, III) (Figure 4). Measurements were made at four locations on 10 elastics. The mean cross-sectional area and internal diameter were calculated and used to assess the uniformity of the elastic's morphology. The following formula was used to calculate the cross sectional area.

$$\text{Cross sectional area} = \text{width} \times \text{thickness}$$

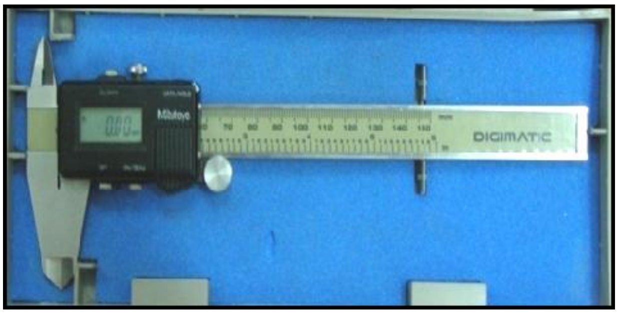

Figure 4: Mitutoyo Digital Vernier caliper.

Breaking force test was performed with a Universal Testing Machine. Two stainless steel pins of 1mm were mounted on two self cure acrylic blocks of dimension 35 × 9 × 9 mm, which were fixed on the upper and lower jaws of the testing machine. The elastics were engaged on the hooks and extended at a crosshead speed of 1 mm/min until failure, at which time the peak failure force and extension were recorded. The forces generated at the extension of twice and thrice the internal diameter of the elastics was also recorded in order to compare initial force values at this stretched distance.

The 48 hours load relaxation mechanical testing was conducted with a Universal Testing Machine. For load relaxation mechanical testing the elastics were mounted between two stainless steel pins of 1mm on acrylic board. The pins were set apart at a fixed distance of 19.05 mm, so as to stretch the elastics to three times the marketed internal diameter. The acrylic board was stored in artificial saliva and the temperature of the artificial saliva was regulated at 37°C using a submersible water heater and thermostat to simulate the oral environment.

The ingredients of the artificial saliva were as follows: 1.3 g/l potassium chloride, 0.1 g/l sodium chloride, 0.05 g/l magnesium chloride, 0.1 g/l calcium chloride, 2.5×10^{-5} g/l sodium fluoride, 0.035 g/l potassium dihydrogen phosphate and 0.162 g/l zinc sulphate. The pH value was 7.0.[2] Forces generated by the elastics were recorded immediately after they were placed in the apparatus at 1, 6, 12, 24, 48 hours. (Figure 5A, 5B, 5C) with a pair of

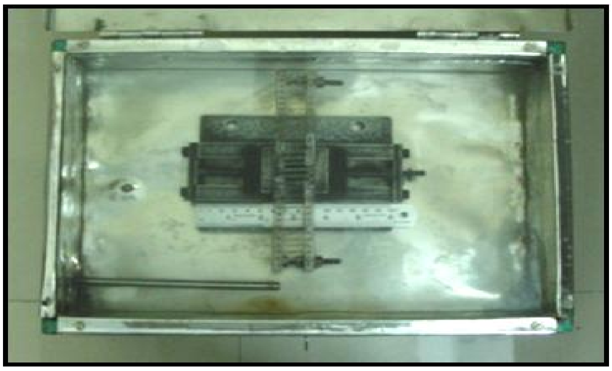

Figure 5A: Custom-made apparatus for 48-hour load relaxation tests- superior view.

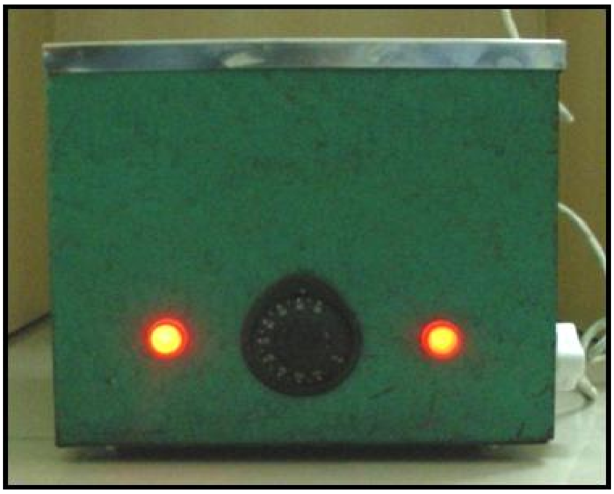

Figure 5B: Custom-made apparatus for 48-hour load relaxation tests- lateral view.

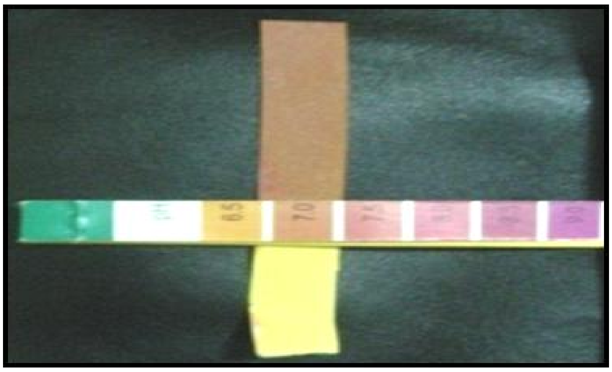

Figure 5C: Ph 7 for the artificial saliva.

tweezers, each elastic was transferred to the Instron universal testing machine from the acrylic measuring board at specific time interval as mentioned above.The resultant force at different immersion times were recorded in the personal computer.

From each specimen, the percentage of force relaxation (%R) was obtained as follows

$$\%R = 100 \times Fo - Ft$$

Where Fo: Initial force

Ft: Force at that particular time 1, 6, 12, 24, 48 hrs).

Percentage of load remaining (%LR) was obtained as follows

$$\% LR = 100 - \%R$$

Where %R: Percentage of force relaxation (1, 6, 12, 24, 48 hrs).

Statistical Methods

The cross sectional area, internal diameter, breaking force and load relaxation data were analyzed. Mean and standard deviation was calculated to determine the statistical significance of the differences in between different types of elastics. Mean and SD of the force values generated at 2 and 3 times extensions were calculated and descriptively compared with the manufacturers specified force values. Comparison was made between latex and non latex elastics with student t-test. Comparison was also made between light, medium, heavy elastics and between manufacturers with ANOVA and Tukey- HSD for multiple comparisons. All the statistical analyses were conducted with the package SPSS/pc+. (statistical package for social science, version 11.0 and systat 8.0).

Results

Table 1: Variability in elastic cross sectional areas between latex and non latex of 3 manufacturers.

ELASTIC TYPE		LIGHT				MEDIUM				HEAVY			
		Mean	S.D	Mean diff	Sig	Mean	S.D	Mean diff	Sig	Mean	S.D	Mean diff	Sig
FORESTADENT	Latex	0.703	0.031	-0.32	0.000	1.07	0.02	-0.085	0.000	1.62	0.03	-0.08	0.000
	Non latex	1.02	0.06			1.16	0.02			1.7	0.02		
GAC	Latex	0.62	0.02	-0.015	0.15	0.81	0.03	-0.17	0.000	1.18	0.03	-0.089	0.000
	Non latex	0.63	0.021			0.98	0.1			1.27	0.04		
GLENROE	Latex	0.95	0.012	-0.128	0.005	1.15	0.02	-0.045	0.002	1.2	0.03	-0.06	0.000

$P<0.01$ = significant

Table shows that the cross sectional area of non-latex elastics (light, medium, heavy) were significantly greater than latex elastics in all three manufacturers, except in GAC light elastics where there was no statistical difference ($p>0.05$) between latex and non latex elastics. Student independent t test was used to find the significance between the two (latex, non latex) groups.

Table 2: Comparison of breaking force between latex and non latex elastics.

ELASTIC TYPE		LIGHT				MEDIUM				HEAVY			
		Mean	S.D	Mean diff	Sig	Mean	S.D	Mean diff	Sig	Mean	S.D	Mean diff	Sig
FORESTADENT	Latex	1822	42.61	-89.8	0.000	2391	126.4	-193	0.000	3663	79.59	-215.2	0.000
	Non latex	1911	46.3			2584	56.29			3878	60.43		
GAC	Latex	1163	43.08	-68.6	0.000	2357	38.05	-1.9	0.917	3424	65.52	-86.1	0.003
	Non latex	1232	30.97			2359	42.21			3510	41.87		
GLENROE	Latex	1414	36.08	-210.4	0.000	1861	47.45	-42.6	0.053	2220	61.55	-264.5	0.000
	Non latex	1624	56.26			1904	44.64			2485	61.69		

$P<0.05$ = significant

Table shows that there were no statistically significant difference in breaking force in between latex and non latex GAC and Glenroe medium elastics. In the rest of the groups, non latex elastics had significantly greater breaking force than latex elastics. Student independent t- test was used to find significance.

The results showed that non latex elastics had greater cross sectional area compared to latex elastics except in GAC light elastics where there was no significant difference. The heavy elastics had larger cross sectional area than the medium elastics and the medium elastics had larger cross sectional area than the light elastics. Between manufacturers, Forestadent heavy elastics had greater cross sectional area compared to GAC and Glenroe but in light and medium elastics, Glenroe had greater cross sectional area compared to Forestadent and GAC There was no statistical significant difference in the internal diameter between the various types of elastics (Table 1)The results of breaking force comparison showed that non latex elastics had greater breaking force than latex elastics of all

Table 3: Load relaxation comparison between different elastics.

ELASTIC TYPE		LOAD AT 1 HOUR		LOAD AT 6 HOUR		LOAD AT 12 HOUR		LOAD AT 24 HOUR		LOAD AT 48 HOUR	
		Mean diff	sig.	Mean diff	sig.	Mean diff	sig.	Mean diff	sig.	Mean diff.	sig.
FORESTADENT LATEX	LIGHT vs MEDIUM	-37.74	0.000	-37.13	0.000	-36.78	0.000	-34.54	0.000	-31.46	0.000
	LIGHT vs HEAVY	-108.36	0.000	-103.1	0.000	-96.15	0.000	-90.06	0.000	-86.47	0.000
	LIGHT vs MEDIUM	-70.61	0.000	-65.16	0.000	-59.37	0.000	-55.51	0.000	-55.01	0.000
FORESTADENT NON LATEX	LIGHT vs MEDIUM	-33.21	0.000	-33.18	0.000	-32.56	0.000	-31.43	0.000	-30.11	0.000
	LIGHT vs HEAVY	-126.95	0.000	- 119.29	0.000	-117.28	0.000	-113.96	0.000	-107	0.000
	LIGHT vs MEDIUM	-93.74	0.000	-86.11	0.000	-84.72	0.000	-82.52	0.000	-76.88	0.000
GAC LATEX	LIGHT vs MEDIUM	-20.56	0.000	-17.55	0.000	-17.22	0.000	-14.65	0.000	-14.51	0.000
	LIGHT vs HEAVY	-50.96	0.000	-46.94	0.000	-44.18	0.000	-39.97	0.000	-40.06	0.000
	LIGHT vs MEDIUM	-30.4	0.000	-29.38	0.000	-26.16	0.000	-25.31	0.000	-25.55	0.000
GAC NON LATEX	LIGHT vs MEDIUM	-23.11	0.000	-21.17	0.000	-19.18	0.000	-17.79	0.000	-18.91	0.000
	LIGHT vs HEAVY	-58.81	0.000	-54.04	0.000	-50.35	0.000	-48.36	0.000	-46.78	0.000
	LIGHT vs MEDIUM	-35.7	0.000	-32.86	0.000	-31.17	0.000	-30.56	0.000	-27.87	0.000
GLENROE LATEX	LIGHT vs MEDIUM	-28.4	0.000	-27.51	0.000	-26.58	0.000	-24.73	0.000	-23.98	0.000
	LIGHT vs HEAVY	-46.96	0.000	-43.48	0.000	-41.35	0.000	-40.39	0.000	-37.48	0.000
	LIGHT vs MEDIUM	-18.56	0.000	-15.97	0.000	-14.77	0.000	-15.66	0.000	-13.5	0.000
GLENROE NON LATEX	LIGHT vs MEDIUM	-20.21	0.000	-21.9	0.000	-21.05	0.000	-18.79	0.000	-18.21	0.000
	LIGHT vs HEAVY	-54.77	0.000	-51.85	0.000	-48.18	0.000	-45.24	0.000	-42.39	0.000
	LIGHT vs MEDIUM	-34.55	0.000	-29.95	0.000	-27.12	0.000	-26.44	0.000	-24.18	0.000

$P<0.05$ = significant
Table shows that Heavy elastics had greater force loss compared to both Medium and Light elastics and Medium elastics had greater force loss than light elastics. Tukey-HSD test was done to find significance.

types from all manufacturers except GAC and Glenroe medium elastics where there was no statistically significant difference in breaking force between latex and non latex elastics. Heavy elastics had greater breaking force than medium and medium showed greater breaking force than light for all types of elastics. Between manufacturers it can be related as Forestadent had greater breaking force than GAC and GAC had greater breaking force than Glenroe. (Table 2).

When force degradation was compared Forestadent (light, medium and heavy), GAC (heavy), and Glenroe (heavy) non-latex elastics lost more force than latex elastics. There

Table 4: Load relaxation comparison between manufacturers.

ELASTIC TYPE		LOAD AT 1 HOUR		LOAD AT 6 HOUR		LOAD AT 12 HOUR		LOAD AT 24 HOUR		LOAD AT 48 HOUR	
		Mean diff	sig.	Mean diff	sig.	Mean diff	sig.	Mean diff	sig.	Mean diff.	sig.
LATEX LIGHT	Forestadent vs Glenroe	6.62	0.000	5.97	0.000	5.77	0.000	5.04	0.000	5.78	0.000
	Forestadent vs GAC	8.99	0.000	7.01	0.000	6.87	0.000	5.6	0.000	7.21	0.000
	Glenroe vs GAC	2.36	0.003	1.03	0.284	1.1	0.341	0.55	0.595	1.42	0.031
LATEX MEDIUM	Forestadent vs Glenroe	15.97	0.000	15.6	0.000	15.97	0.000	14.85	0.000	13.26	0.000
	Forestadent vs GAC	26.17	0.000	26.6	0.000	26.43	0.000	25.49	0.000	24.16	0.000
	Glenroe vs GAC	10.2	0.000	10.99	0.000	10.46	0.000	10.63	0.000	10.9	0.000
LATEX HEAVY	Forestadent vs Glenroe	68.02	0.000	65.61	0.000	60.56	0.000	54.7	0.000	54.77	0.000
	Forestadent vs GAC	66.38	0.000	63.18	0.000	58.83	0.000	55.69	0.000	53.62	0.000
	Glenroe vs GAC	-1.64	0.185	-2.43	0.003	-1.73	0.131	0.986	0.431	-1.15	0.139
NON LATEX LIGHT	Forestadent vs Glenroe	11.78	0.000	12.02	0.000	10.56	0.000	9.7	0.000	10.43	0.000
	Forestadent vs GAC	16.18	0.000	15.03	0.000	13.63	0.000	12.95	0.000	13.02	0.000
	Glenroe vs GAC	4.4	0.000	3	0.002	3.07	0.000	3.25	0.000	2.59	0.000
NON LATEX MEDIUM	Forestadent vs Glenroe	24.78	0.000	23.32	0.000	22.07	0.000	22.34	0.000	22.32	0.000
	Forestadent vs GAC	26.27	0.000	27.06	0.000	27	0.000	26.59	0.000	24.22	0.000
	Glenroe vs GAC	1.49	0.140	3.73	0.000	4.93	0.000	4.25	0.000	1.89	0.014
NON LATEX HEAVY	Forestadent vs Glenroe	83.96	0.000	79.47	0.000	79.66	0.000	78.42	0.000	75.03	0.000
	Forestadent vs GAC	84.32	0.000	80.27	0.000	80.56	0.000	78.55	0.000	73.23	0.000
	Glenroe vs GAC	0.355	0.921	0.8	0.742	0.89	0.405	0.128	0.985	-1.79	0.042

P<0.05 = significant

Table shows that force degradation is less in Forestadent when compared to Glenroe and GAC. When compared between Glenroe and GAC, force degradation is less in Glenroe except in latex heavy elastics where GAC had less force degradation than Glenroe. Tukey-HSD test was used to find the significance level.

was no statistically significant difference in force degradation between latex and non latex elastics in GAC light (at 1,6,12, and 48 hours) GAC medium (at 12 and 24 hrs) and Glenroe light elastics (at 6, 24, and 48 hours). At 24hrs GAC light latex elastics showed more force degradation than non-latex elastics. At 1 hour, 6 hrs and 48hrs the GAC medium non latex elastics showed more force degradation than latex elastics. At 1hour and 12 hrs the Glenroe light non latex elastics showed more force degradation than latex elastics Glenroe medium latex elastics showed more force degradation than medium non latex elastics. The results showed that the force degradation for all manufacturers latex and non-latex heavy elastics showed maximum force degradation than medium and medium showed more force degradation than light in 1, 6, 12, 24 & 48 hours. Between manufacturers it can be related as Forestadent had lesser force degradation than Glenroe and Glenroe had lesser force degradation than GAC. (Table 3, 4)

Percentage of load remaining was significantly greater in latex elastics than non-latex elastics. When compared between light, medium and heavy elastics the percentage of load remaining was significantly greater in light elastics. When compared between manufacturers the percentage of load remaining was significantly greater in Forestadent than Glenroe and GAC. Force degradation within the first hour was in the range of 14% - 21%. At 48 hrs around 26% - 35% of the force was lost. When stretched to 2 times the internal diameter the elastics generated forces lower than or equal to the manufacturers specified values, where as when the elastics stretched to 3 times the internal diameter, the forces generated were larger than or equal to the manufacturers specified values. (Table 5)

Discussion

Australian standards for latex orthodontic elastic bands which state that the breaking strength of the elastics must be greater than 150 Kpa and the extensions at which failures occur must be at least 750% of the resting ID. Thus

Table 5: Comparison of mean experimental loads with 3 I.D load values.

ELASTIC TYPE	% LOAD AT 1 HR	% LOAD AT 6 HRS	% LOAD AT 12 HRS	% LOAD AT 24 HRS	% LOAD AT 48 HRS
Forestadent Latex Light	86	81	78	75	74
Forestadent Latex Medium	84	80	78	74	71
Forestadent Latex Heavy	82	77	73	69	67
Forestadent Non Latex Light	84	79	75	71	70
Forestadent Non Latex Medium	82	78	75	72	70
Forestadent Non Latex Heavy	80	75	73	70	67
GAC Latex Light	85	81	78	76	73
GAC Latex Medium	82	76	74	70	68
GAC Latex Heavy	79	75	71	68	66
GAC Non Latex Light	83	78	75	72	70
GAC Non Latex Medium	82	76	72	69	68
GAC Non Latex Heavy	79	74	70	67	65
Glenroe Latex Light	84	79	76	74	72
Glenroe Latex Medium	83	79	76	73	71
Glenroe Latex Heavy	80	75	72	70	67
Glenroe Non Latex Light	82	76	73	71	68
Glenroe Non Latex Medium	81	78	75	71	68
Glenroe Non Latex Heavy	81	76	72	68	65

Table shows the comparison of forces generated by the elastic when stretched to 19.05mm at 0 hour with the force generated by elastics at 1hour, 6hours, 12hours, 24hours and 48hours. % of load remaining is greater in latex compared to non latex elastics. When compared between manufacturers, the % of load remaining was significantly greater in Forestadent elastics than Glenroe and GAC.

according to the Standards Association of Australia all of the elastics in the study were strong enough and extendable enough to meet clinical requirements.[3,4]

Cross-sectional area showed that there was wide variation in the morphology of elastics of the same manufacturer and same elastic type. The variation in cross sectional area could have clinical ramifications like varied forces being applied by the same type of elastics when stretched for the same distance. The heavy elastics had larger cross-sectional areas than medium elastics followed by light elastics. This is in concurrence with the study by Russell et al.[5] But there was no statistically significant difference in the internal diameter between different type of elastics.

The present study revealed that when stretched to 2 times the inner diameter, the elastics generated forces equal to or less than that of the manufacturers specified force values. Whereas, when stretched to 3 times the inner diameter, the elastics generated forces which were equal to or higher than the manufacturers specified force values. These findings were in concurrence with the results of Bales, Russell et al and Kanchana and Godfrey, who reported that the force exerted at the manufacturers recommended extension of 3 times the inner diameter was greater than stated by the manufacturer and that extensions of only 2 times the inner diameter gave clinically appropriate force levels.[6-9]

In the breaking force comparisons between different elastic forces, the heavy elastics showed greater breaking forces than medium and medium showed greater breaking forces than light for different elastic types. This is in concurrence with the study by Russell et al.[5] Breaking force of non latex elastics were significantly greater than latex elastics in all groups except in GAC medium elastics where there was no statistical significant difference between the latex and non-latex elastics. In the clinical context, this study shows that there are very less chances for the elastics to break during their application in the mouth. In the force degradation comparisons of elastics used in this study, the non-latex elastics lost more force than the latex elastics for different types of elastics of all manufacturers. This was in agreement with the studies of Andreasen and Bishara, Wong and Russell et al. Berman[3,8,10] The percentage force degradation values were in agreement with recent studies by Kanchana and Godfrey, Kersyand Russell et al.[3,6,11] The probable reason for the force degradation values in this study to be low could be attributed to the more accurate measuring methods in the tests and advances in the manufacturing process. There was little difference in the force degradation values mentioned in the study by Russell et al[5] for GAC elastics, which were used in this study. This could be attributed to the different force values for light, medium and heavy elastics in this study.

Liu et al[12] stated that the normal range of clinical use during talking and chewing is between 20mm and 50mm. Hence in our study, for load relaxation mechanical testing the elastics were mounted between two stainless steel pins of 1mm on acrylic board; the pins were set apart at a fixed distance of 19.05mm, so as to stretch the elastics to three times the marketed internal diameter.[2] The force degradation measurements were recorded by a custom built set up used in the study by Tong Wang.[13] The media in which elastics have been tested vary considerably. As early as Paulich noted that the initial force decay of elastics depended on the environment in which elastics were tested. Overall, elastics and non-latex chains have been tested at room temperature and at 37°C, in dry and moist air, in distilled water, normal saline and artificial saliva. The elastics in this study were tested in artificial saliva at 37°C, which was maintained by a thermostat.[14,15] The findings of Ash and Nikolai[16] were that saliva, especially in an in-vivo environment, had a significant effect. Ferriter evaluated the effect of pH on the force-degradation rates of chain elastics and stated that the decay rate of orthodontic polyurethane chain elastics is inversely proportional to the oral pH, with a corollary that basic ph levels are most hostile to polyurethane chain elastics.[17]

In the force degradation comparisons between different elastics, all manufacturers latex and non-latex heavy elastics showed more force degradation than medium and medium showed more force degradation than light in 1 hour, 6 hours, 12 hours, 24 hours and 48 hours except Glenroe non-latex light elastics which lost more force than medium. This result was in agreement with the study by Russell et al[5] and Andreasen and Bishara.[18,19] The greater force degradation of heavy elastic as compared to medium and medium elastics as compared to light could be attributed to the increased cross sectional area of the heavy elastics. The increased surface area in turn increases the possibility of the elastics contact with air or water leading to increased degradation.

In comparisons between elastics of different manufacturers Forestadent elastics showed less force degradation than

GAC and GAC showed less force degradation than Glenroe in all types of elastics at 1, 6, 12, 24 & 48 hours. This showed that Forestadent elastics were better in delivering force over a period of 48 hours. The percentage of force degradation of different elastics at 1, 6, 12, 24 & 48 hours is almost in agreement with the values given by Kanchana and Godfrey[6] and Mckersy[11] in their study. The mild variation could be because of the different manufacturers' and stretches used in their study.

This study shows that clinically, latex elastics are better in force delivery over a period of 48 hours. Non-latex elastics were found to lose more force than latex elastics. Hence non-latex elastics are to be used in situations where the patient is allergic to latex products. It is better to choose elastics which deliver a higher load; around 25% to 35% more load than that desired for the clinical situation. Clinically, the initial forces generated will be used for overcoming frictional forces of the wire and the bracket. The forces generated by the elastic on loading are not completely transferred onto the tooth; moreover, the maximum force degradation takes place within the first hour.

It was observed that within the first 24 hours, around 25% – 33% of force was lost. In the next 24 hours, only around 1% – 3% of force was lost in all the elastics. In comparison with the force levels at the end of 24 hours and 48 hours, a difference of only 1% - 3% was seen. This implies that force was relatively stable between the first day and the next day and only a negligible amount was lost. Hence changing elastics at the end of two days produces almost the same amount of force as it would if it was changed in one day.

Conclusion

- Non latex elastics had greater cross sectional area than latex elastics in all types of elastics (Forestadent light, medium, heavy, GAC medium, heavy, Glenroe light, medium, heavy) except GAC light elastics where there was no statistical difference between latex and non latex elastics.
- Over a period of 48 hours, there was a decrease in the loads generated by all elastics. The amount of force that was retained at the end of one day and two days was not significantly different for both latex and non latex elastics. However, the latex elastics retained larger loads than the non latex elastics and Forestadent elastics retained larger load than GAC and Glenroe. Force degradation was higher in the heavy elastics when compared with the medium and light elastics.

Latex elastics are the preferred choice, except when patients exhibit allergic manifestations to latex. Further research is needed with the aim of producing elastics with identical internal diameter, cross sectional area and force degradation parameters. Manufacturer induced variations in the dimensions of these elastics has to be minimized to produce uniform force levels irrespective of the brand the clinician chooses for his practice. In our study, force degradation was evaluated for a period of 2 days, hence further studies are needed to evaluate the amount of force that is retained over a period of time and also to check whether a clinically desirable amount of force is delivered. This would be useful in determining when the elastic should be changed in clinical situations. Clinical studies are necessary to assess the different elastic types' behaviour in terms of force degradation and stability in oral environment.

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