



## Force Decay Characteristics of commonly used Elastomeric Chains on Exposure to various Mouth Rinses with different Alcohol Concentration: An *in vitro* Study

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### ABSTRACT

**Aim:** The aim of this study was to test the effect of varying alcohol concentrations of various commercially available mouth-washes on force decay of elastomeric chains in prestretched and unstretched condition.

**Materials and methods:** A total of five specimen groups were tested with a total sample size of 180 specimens. A specimen is described as a three-link, short module, clear elastomeric chain (3M Unitek, Ortho Plus, Ortho Organizer). The control and test groups were independently submerged in separate 37°C artificial saliva to simulate the oral conditions. Effects of different solution groups and time (initial, 1, 7, 14, 21, and 28 days) on three different elastomeric chains and force (cN) are analyzed with two-way analysis of variance; pair-wise comparisons are done by t-test.

**Results:** Higher mean force was recorded initially followed by 24 hours >7 days >14 days >21 days and 28 days respectively. The difference in mean force decay among the different time intervals was found to be statistically significant ( $p < 0.001$ ). Among the different solutions, higher mean force was recorded in 21.6% alcohol mixture > Listerine 8.38% > Wokadine > alcohol mixture 8.38% > artificial saliva.

**Conclusion:** In conclusion, alcohol-containing mouth rinses cause an increase in force decay of elastomeric chain over time.

**Clinical significance:** These mouth rinses are commonly recommended during orthodontic treatment. The orthodontist can know better that the alcohol content of the mouth rinses and the structural and molecular modification results in the decay of elastomeric chain.

**Keywords:** Alcohol, Elastomeric chain, Force decay, Mouth rinses.

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**Conflict of Interest:** None

### INTRODUCTION

Synthetic elastomeric chains have been used by orthodontists since the 1960s. These polyurethane materials have largely replaced latex elastics, for intra-arch tooth movement and to consolidate spaces.<sup>1</sup>

Placement and removal of chain elastics require little chair time for the clinician and minimal patient cooperation during application. The synthetic elastomeric materials have also been found to be relatively compatible with the mucosa. These factors have contributed to high degree of professional acceptance of the chain elastics in orthodontics.<sup>2</sup>

Elastomeric ligatures are manufactured in two basic forms: Injection molded and cut. The injection-molded ligature is made by injection of liquefied elastomeric material into a mold and curing, whereas the cut ligature is sliced from previously processed elastomeric tubing.<sup>3</sup>

The greatest degree of force loss occurred in the first 3 hours, with the remainder of force decay staying relatively constant over the next 21 days. In dry air, percentage of force decay after 21 days was illustrated to be 42 to 63% depending on the product brand. In addition, force decay occurred more quickly when elastomers were submerged in water bath. Another factor affecting the degree

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of force decay is the amount of initial load applied to the elastomers. As the initial load increased, the percentage of force decay also increased, the total remaining force at each time interval over 21 days was maintained at higher levels with increased initial loads.<sup>4</sup>

Mouth rinses should be used during the orthodontic mechanotherapy for antimicrobial activity, to decrease the plaque accumulation and thereby prevent demineralization. Chlorhexidine acts in a preventive manner in the reduction of bacterial plaque, in patients undergoing orthodontic treatment. It is a synthetic antimicrobial agent that presents a high level of activity, however, having secondary effects, such as staining and ulceration of mucosa. Hence, other mouth rinses, such as Listerine and Wokadine gargle are recommended during orthodontic treatment. The alcohol content of the mouth rinses has shown to cause structural and molecular modification, which results in the decay of elastomeric chain.<sup>4</sup>

However, the effect of ethanol at different concentrations as available in various mouthwashes on force degradation of elastomeric chains in prestretched and unstretched conditions needs further study.

Hence, the purpose of this study was to test the effect of varying alcohol concentrations of various commercially available mouthwashes on force decay of elastomeric chains in prestretched and unstretched condition.

## MATERIALS AND METHODS

This study was carried out in the Department of Orthodontics and Dentofacial Orthopedics, Siddhartha Dental College, Tumkur, India. Sample for this study comprised 180 specimens. Alcohol-contained mouth rinses and elastomeric chain with short module, prestretched and unstretched, were included in the study. Mouth rinses that are expired and physically damaged (broken) elastomeric chains were excluded from the study.



**Fig. 1:** Clear short elastomeric chains – 3M Unitek, Ortho Plus, Ortho Organizer

A total of five specimen groups were tested with a total sample size of 180 specimens. A specimen is described as a three-link, short module, clear elastomeric chain (3M Unitek, Ortho Plus, Ortho Organizer) (Fig. 1). Specimens were mounted on custom-made test jigs. Five custom-made jigs, each with 18 mm apart for unstretched and 22 mm apart for prestretched elastomeric chains were used to hold stretched elastomeric chains at a constant length.

The control and test groups were independently submerged in separate 37°C artificial saliva to simulate the oral conditions. The formulation of the saliva solution was made by Goran Pharma Pvt. Ltd. (Gujarat, India). It was housed in an incubator and maintained at room temperature using thermostat. Similarly, the test specimens were submerged in the respective test solutions, i.e., artificial saliva, Listerine, Wokadine, alcohol mixture 21.6%, and alcohol mixture 8.38% (Figs 2A and B) for 60 seconds, twice a day, for the entire 28-day test period.

Each 60-second exposure of the test specimens was measured using a digital clock and the two daily exposures were separated by 9 hours. After being submerged in the respective solutions, specimens were dipped in



**Figs 2A and B:** Mouth rinses (test and control solutions)



Fig. 3: Measurement of force

separate, distilled water baths for 10 seconds to simulate rinsing of the mouth rinses from the oral cavity. These specimens were then placed back into artificial saliva at 37°C. The control group underwent the same protocol; however, these elastomeric chains were only exposed to artificial saliva.

Six test measurements of the remaining force were made at the following time intervals: Initial (0), 1, 7, 14, 21, and 28 days. Force measurements were obtained with a digital force tester (Lutron FG-5000; Lutron Electronic Enterprise Co., Ltd., Taipei, Taiwan) (Fig. 3). Before the initiation of the study, the force tester was calibrated by measuring the weight of known items, to ensure the reliability of the instrument. After each measurement, the force tester was reset to a zero reading before taking the next measurement. During force measurement, the jigs were securely bound to a bench top using a vice clamp.

Measurements were made by leaving one end of the elastomeric chain secured on the pin and fixing the other to the force tester, allowing for the measurement of the tensile force. Measurement readings were taken with the elastomeric chain stretched to the same 18 mm apart in unstretched and 22 mm apart in prestretched elastomeric chains length that the jig pins had previously maintained them. All chains were handled and measured in the same manner at the same vertical and horizontal distance on the jig board to ensure consistent measurements.

With five groups, each having six specimens at six time points, a total sample size of 180 specimens (36 specimens per group) were tested. Specimens were discarded after measurements were made. In the case that any elastomeric chains were to break during testing, an additional ten specimens were added to the control and test groups. Therefore, 230 specimens were used. The effects of group (artificial saliva, Listerine, Wokadine, alcohol mixture

21.6%, and alcohol mixture 8.38%) and time (initial, 1, 7, 14, 21, and 28 days) on force were analyzed with a two-way analysis of variance (ANOVA).

### Statistical Analysis

The statistical software namely SAS 9.2 and Statistical Package for the Social Sciences 15.0 was used for the analysis of the data. Statistical analysis was performed using descriptive statistics, such as mean, standard deviation, and standard error to describe the mean scores of the respondents. Effects of groups (artificial saliva, Wokadine, Listerine, alcohol concentration 21.6%, and alcohol concentration 8.38%) and time (initial, 1, 7, 14, 21 and 28 days) on three different elastomeric chains (3M Unitek, Ortho Plus, Ortho organizer) and force (cN) are analyzed with two-way ANOVA; pair-wise comparisons are done by t-test.

### RESULTS

As shown in Table 1 in Listerine, at 24 hours, highest force decay was recorded by prestretched Ortho Plus (57.75%) and least by unstretched Ortho Organizer (40.58%). At 28 days, among unstretched and prestretched elastomeric chains, unstretched has highest force decay than prestretched.

Table 2 reveals that in Wokadine, at 24 hours, highest force decay was recorded by unstretched Ortho Organizer (58.35%) and least by prestretched 3M Unitek (39.92%). At 28 days, among unstretched and prestretched elastomeric chains, unstretched has highest force decay than prestretched.

In alcohol mixture 21.6%, at 24 hours, highest force decay was recorded by unstretched Ortho Organizer (55.18%) and least by prestretched 3M Unitek (39.87%). At 28 days, among unstretched and prestretched elastomeric chains, unstretched has highest force decay than prestretched (Table 3).

In Table 4 (alcohol mixture 8.38%), at 24 hours, highest force decay was recorded by unstretched Ortho Plus (49.17%) and least by prestretched 3M Unitek (39.87%). At 28 days, among unstretched and prestretched elastomeric chains, unstretched has highest force decay than prestretched.

As shown in Table 5, in artificial saliva, at 24 hours, highest force decay was recorded by unstretched Ortho Plus (48.98%) and least by prestretched 3M Unitek (39.45%). At 28 days, among unstretched and prestretched elastomeric chains, unstretched has highest force decay than prestretched.

Table 6 reveals that among the durations, higher mean force was recorded initially followed by 24 hours >7 days >14 days >21 days and 28 days respectively.



Force Decay Characteristics of commonly used Elastomeric Chains on Exposure to various Mouth Rinses

**Table 1:** Mean force decay (cN) recorded in Listerine during different time durations for all elastomeric chains

<i>Listerine</i>	<i>Measurement time points (days)</i>	<i>Mean ± SD</i>	<i>Standard error of mean</i>	<i>Minimum</i>	<i>Maximum</i>
Unstretched 3M Unitek	1	273.31 ± 3.66	1.49	269.6	278.9
	7	243.51 ± 4.44	1.81	239.6	249.7
	14	219.7 ± 3.46	1.41	215.3	224.4
	21	206.18 ± 7.19	2.93	198.7	215.1
	28	174.75 ± 4.90	2.00	168.7	180.8
Prestretched 3M Unitek	1	211.5 ± 2.33	0.95	209.2	215.4
	7	201.6 ± 3.06	1.25	198.3	205.6
	14	176.91 ± 1.59	0.65	174.8	178.8
	21	157.06 ± 2.53	1.03	152.2	158.9
	28	143.96 ± 3.13	1.28	140.4	147.8
Unstretched Ortho Plus	1	269.8 ± 6.67	2.72	258.3	276.4
	7	236.83 ± 3.40	1.38	230.3	239.6
	14	201.98 ± 1.97	0.87	200.2	205.0
	21	189.8 ± 1.32	0.54	187.8	191.1
	28	167.05 ± 2.30	0.94	164.2	170.0
Prestretched Ortho Plus	1	210.95 ± 2.46	1.006	208.3	215.5
	7	197.7 ± 1.81	0.74	193.5	198.7
	14	173.85 ± 1.54	0.63	172.2	176.1
	21	157.05 ± 2.36	0.96	152.9	159.8
	28	147.18 ± 3.20	1.30	142.9	150.6
Unstretched Ortho Organizer	1	263.94 ± 5.58	2.49	258.7	270.8
	7	243.01 ± 3.901	1.59	239.2	249.3
	14	216.25 ± 4.30	1.75	210.8	220.7
	21	206.2 ± 7.04	2.87	198.8	215.3
	28	174.7 ± 4.76	1.94	168.9	180.4
Prestretched Ortho Organizer	1	209.7 ± 5.05	2.06	200.10	215.0
	7	196.66 ± 2.26	0.92	192.7	198.6
	14	175.78 ± 3.50	1.42	170.7	179.7
	21	155.11 ± 3.39	1.38	150.7	159.6
	28	145.9 ± 3.16	1.29	140.6	148.9

SD: Standard deviation

**Table 2:** Mean force decay (cN) recorded in Wokadine during different time durations for all elastomeric chains

<i>Wokadine</i>	<i>Measurement time points (day)</i>	<i>Mean ± SD</i>	<i>Standard error</i>	<i>Minimum</i>	<i>Maximum</i>
Unstretched 3M Unitek	1	294.2 ± 3.71	1.51	290.1	298.5
	7	263.36 ± 4.42	1.80	259.2	269.4
	14	244.9 ± 7.43	3.03	136.4	254.5
	21	228.58 ± 8.12	3.31	218.7	238.8
	28	195.05 ± 5.08	1.66	188.5	200.5
Prestretched 3M Unitek	1	224.8 ± 2.45	1.002	220.7	227.4
	7	201.6 ± 3.06	1.25	198.3	205.6
	14	191.58 ± 2.61	1.066	188.5	195.7
	21	165.46 ± 4.46	1.82	159.6	170.7
	28	141.0 ± 5.81	2.37	136.0	149.4
Unstretched Ortho Plus	1	289.7 ± 5.79	2.36	279.7	296.8
	7	157.43 ± 1.42	0.58	256.0	259.3
	14	225.6 ± 4.07	1.67	221.2	231.4
	21	216.51 ± 5.34	2.18	210.1	225.5
	28	183.93 ± 7.84	3.20	168.7	190.8

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<i>Wokadine</i>	<i>Measurement time points (day)</i>	<i>Mean ± SD</i>	<i>Standard error</i>	<i>Minimum</i>	<i>Maximum</i>
Prestretched Ortho Plus	1	226.2 ± 1.83	0.74	223.4	228.6
	7	201.55 ± 3.93	1.60	197.2	106.7
	14	190.41 ± 4.20	1.71	185.4	195.6
	21	162.76 ± 3.82	1.56	158.6	168.5
	28	146.38 ± 3.13	1.27	140.4	149.2
Unstretched Ortho Organizer	1	306.8 ± 3.86	1.73	300.3	310.0
	7	262.15 ± 2.91	1.19	258.4	266.4
	14	236.15 ± 4.43	1.81	230.6	240.9
	21	228.3 ± 8.39	3.42	218.1	238.8
	28	196.5 ± 4.42	1.80	188.7	200.9
Prestretched Ortho Organizer	1	227.7 ± 1.86	0.75	224.7	229.7
	7	202.03 ± 3.34	1.36	196.2	205.5
	14	170.51 ± 3.27	1.33	164.8	174.5
	21	163.3 ± 3.57	1.45	158.8	168.8
	28	148.2 ± 1.80	0.73	145.6	150.7

SD: Standard deviation

**Table 3:** Mean force decay (cN) recorded in alcohol mixture 21.6% during different time durations for all elastomeric chains

<i>Alcohol mixture 21.6%</i>	<i>Measurement time points (day)</i>	<i>Mean ± SD</i>	<i>Standard error</i>	<i>Minimum</i>	<i>Maximum</i>
Unstretched 3M Unitek	1	254.45 ± 7.24	2.95	249.4	268.3
	7	243.75 ± 3.98	1.62	238.5	243.5
	14	227.28 ± 4.93	2.01	220.1	232.4
	21	203.5 ± 2.16	0.88	200.7	205.8
	28	173.21 ± 2.40	0.98	170.8	176.7
Prestretched 3M Unitek	1	213.51 ± 1.67	0.68	210.7	214.9
	7	200.3 ± 2.82	1.15	197.4	205.6
	14	190.75 ± 1.55	0.63	188.8	192.7
	21	164.55 ± 5.05	2.06	158.2	170.5
	28	142.88 ± 5.81	2.37	136.0	149.4
Unstretched Ortho Plus	1	250.01 ± 6.63	2.70	238.6	256.7
	7	240.65 ± 2.97	1.21	236.2	245.0
	14	245.53 ± 4.65	1.90	239.4	250.3
	21	191.38 ± 2.52	1.02	188.4	195.3
	28	163.38 ± 4.17	1.70	158.6	168.5
Prestretched Ortho Plus	1	213.68 ± 2.06	0.84	210.8	216.4
	7	201.11 ± 2.87	1.17	197.5	205.6
	14	191.41 ± 2.44	0.99	188.7	195.7
	21	163.5 ± 3.92	1.603	158.8	169.6
	28	141.1 ± 2.40	0.98	138.5	145.2
Unstretched Ortho Organizer	1	243.64 ± 5.72	2.55	238.0	250.4
	7	241.5 ± 2.57	1.05	238.6	245.7
	14	214.45 ± 4.07	1.66	210.10	219.5
	21	201.7 ± 2.28	0.93	198.9	205.6
	28	181.38 ± 2.47	1.01	178.8	185.7
Prestretched Ortho Organizer	1	213.41 ± 1.07	0.44	212.3	215.1
	7	202.25 ± 4.2	1.71	197.5	208.2
	14	191.20 ± 3.29	1.344	186.5	194.4
	21	163.35 ± 5.49	2.24	155.1	169.5
	28	142.7 ± 3.24	1.34	138.6	146.8

SD: Standard deviation

## Force Decay Characteristics of commonly used Elastomeric Chains on Exposure to various Mouth Rinses

**Table 4:** Mean force decay (cN) recorded in alcohol mixture 8.38% during different time durations for all elastomeric chains

<i>Alcohol mixture 8.38%</i>	<i>Measurement time points (day)</i>	<i>Mean ± SD</i>	<i>Standard error</i>	<i>Minimum</i>	<i>Maximum</i>
Unstretched 3M Unitek	1	305.23 ± 4.51	1.84	300.3	310.4
	7	274.93 ± 3.67	1.49	270.4	279.3
	14	255.28 ± 1.76	0.71	252.1	256.4
	21	247.85 ± 25.88	10.56	235.4	300.6
	28	211.00 ± 3.92	1.6	300.7	310.8
Prestretched 3M Unitek	1	222.08 ± 1.581	0.64	220.7	224.4
	7	204.51 ± 5.33	2.17	197.6	210.9
	14	185.53 ± 6.28	2.56	188.8	192.7
	21	173.16 ± 3.98	1.62	168.7	179.7
	28	151.6 ± 2.30	0.94	148.7	154.4
Unstretched Ortho Plus	1	276.48 ± 1.67	0.68	274.4	279.3
	7	265.96 ± 3.54	1.44	260.7	269.5
	14	233.48 ± 2.11	0.86	230.6	235.7
	21	216.08 ± 4.87	1.99	210.10	220.7
	28	196.9 ± 2.67	1.09	193.6	200.7
Prestretched Ortho Plus	1	219.21 ± 9.28	3.78	200.6	225.7
	7	202.85 ± 2.97	1.62	197.8	209.1
	14	184.36 ± 5.07	2.07	176.7	189.0
	21	190.7 ± 4.72	1.92	185.3	196.6
	28	152.05 ± 3.45	1.40	148.0	156.7
Unstretched Ortho Organizer	1	306.8 ± 3.86	1.73	300.3	310.0
	7	275.1 ± 3.22	1.31	270.4	279.5
	14	244.16 ± 3.61	1.47	240.5	249.9
	21	233.10 ± 2.82	1.15	230.4	237.3
	28	208.3 ± 6.92	2.82	200.7	216.3
Prestretched Ortho Organizer	1	223.73 ± 4.89	1.99	220.0	233.2
	7	200.95 ± 2.84	1.15	197.7	205.6
	14	185.45 ± 5.34	2.18	178.10	190.9
	21	172.48 ± 5.31	2.17	165.6	179.6
	28	155.5 ± 2.68	1.09	152.8	159.2

SD: Standard deviation

**Table 5:** Mean force decay (cN) recorded artificial saliva during different time durations for all elastomeric chains

<i>Artificial saliva</i>	<i>Measurement time points (day)</i>	<i>Mean ± SD</i>	<i>Standard error</i>	<i>Minimum</i>	<i>Maximum</i>
Unstretched 3M Unitek	1	284.9 ± 4.001	1.63	280.3	289.8
	7	283.23 ± 3.58	1.46	280.1	289.0
	14	283.98 ± 2.72	1.10	281.5	288.4
	21	263.35 ± 2.50	1.02	260.4	266.4
	28	272.91 ± 2.77	1.13	270.4	276.8
Prestretched 3M Unitek	1	215.4 ± 1.93	0.78	212.3	217.4
	7	210.83 ± 3.46	1.41	205.9	215.7
	14	212.31 ± 3.88	1.58	206.5	215.7
	21	193.15 ± 5.93	2.42	185.7	200.6
	28	185.4 ± 3.84	1.56	179.6	189.7
Unstretched Ortho Plus	1	277.5 ± 2.87	1.17	274.1	281.3
	7	274.51 ± 3.46	1.41	270.5	279.5
	14	274.08 ± 3.47	1.41	270.10	279.5
	21	259.08 ± 1.58	0.64	256.8	260.9
	28	258.75 ± 2.79	11.42	205.5	289.1

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<i>Artificial saliva</i>	<i>Measurement time points (day)</i>	<i>Mean ± SD</i>	<i>Standard error</i>	<i>Minimum</i>	<i>Maximum</i>
Prestretched Ortho Plus	1	214.98 ± 2.15	0.88	212.4	268.2
	7	208.65 ± 5.34	2.18	212.7	215.6
	14	214.08 ± 3.28	1.34	210.3	218.5
	21	190.7 ± 4.72	1.92	185.3	196.6
	28	185.53 ± 2.61	1.06	182.4	189.6
Unstretched Ortho Organizer	1	284.58 ± 4.63	2.07	280.0	289.0
	7	283.68 ± 3.57	1.45	280.6	289.1
	14	283.35 ± 2.79	1.14	280.5	288.1
	21	253.5 ± 23.52	9.6	205.8	266.9
	28	273.06 ± 2.62	1.071	270.6	276.8
Prestretched Ortho Organizer	1	216.13 ± 1.89	0.77	213.4	218.0
	7	210.2 ± 5.54	2.26	202.4	216.0
	14	213.16 ± 4.72	1.92	205.0	218.0
	21	192.25 ± 4.57	1.86	185.5	197.0
	28	184.9 ± 3.56	1.45	179.2	189.1

SD: Standard deviation

**Table 6:** Results of the two-way ANOVA of elastomeric chain force decay for duration, solution, and interaction between variables

	<i>Measurement time points (day)</i>	<i>Sum of squares</i>	<i>F-statistics</i>	<i>p-value</i>
Unstretched 3M Unitek	1	9183.17 579.987	98.9	<0.001
	7	7766.35 406.879	119.2	<0.001
	14	15430.1 517.0	186.5	<0.001
	21	16214.7 651.1	155.6	<0.0001
	28	89811.2 347.27	1616.34	<0.001
Prestretched 3M Unitek	1	17074.9 97.52	1094.23	<0.0001
	7	430.25 335.58	8.013	<0.0002
	14	4092.59 331.17	77.23	<0.0001
	21	4568.29 514.02	55.54	<0.0001
	28	8026.07 486.72	103.06	<0.0001
Unstretched Ortho Plus	1	5097.4 664.9	47.90	<0.0001
	7	6250.2 234.5	166.74	<0.0001
	14	16876.1 292.80	360224	<0.00001
	21	18831.1 314.10	374.69	<0.0001
	28	35797.6 4348.4	51.42	<0.0001

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	Measurement time points (day)	Sum of squares	F-statistics	p-value
Prestretched Ortho Plus	1	847.37 521.92	10.14	<0.0001
	7	513.75 356.17	9.0152	<0.0001
	14	5227.54 312.143	104.67	<00001
	21	6456.4 400.42	100.777	<00001
	28	7607.57 222.5	213.6	<00001
Unstretched Ortho Organizer	1	18184.8 575.45	197.50	<0.0001
	7	8510.2 316.78	167.90	<0.0001
	14	18717.4 377.4	309.9	<0.0001
	21	10704.7 3431.4	19.49	<0.001
	28	37050.1 515.22	445.43	<0.0001
Prestretched Ortho Organizer	1	1321.73 287.95	28.68	<0.0001
	7	575.38 363.30	9.89	<0.0001
	14	7694.67 424.54	113.27	<0.0001
	21	4857.44 517.29	58.68	<0.0001
	28	7041.79 217.89	201.68	<0.0001

The difference in mean force decay among the different time intervals was found to be statistically significant ( $p < 0.001$ ). Among the different solutions, higher mean force was recorded in 21.6% alcohol mixture > Listerine 8.38% > Wokadine > alcohol mixture 8.38% > artificial saliva. The difference in mean force decay among the different solutions was found to be statistically significant ( $p < 0.001$ ). The interaction of duration and solution on mean force decay was found to be statistically significant ( $p < 0.001$ ).

## DISCUSSION

Elastomeric chains are used as the retractive force to move teeth into extraction sites, closing diastemas, generalized space closure, and correction of rotated teeth. The chains serve as ligatures to tie the archwire to the bracket.

Since the 1970s, several studies have been published on the decay of elastomers in the oral cavity during orthodontic treatment.<sup>5,6</sup> The results of various studies on orthodontic elastics have shown wide range of force decay (24–85%) after 28 days. Some of the reasons behind

these results may include difference in the media in which the samples were tested and quality of the elastomeric chains used.

Years ago, Baty et al<sup>7</sup> evaluated the behavior of elastics over 3 weeks. However, a period of 4 weeks was selected for the study because it coincides with the time interval between orthodontic consultations; the same period was observed by Motta et al.<sup>8</sup>

The mean percentage of force loss after 24 hours was 41.68 to 55.18% for the tested groups, which is comparable to that reported in the published studies for elastomeric chains.<sup>1,2,9,10</sup> Alcohol 21.6% had the highest percentage of force decay, i.e., 55.18% for short module after 24 hours due to hydrolysis caused by alcohol. Wokadine showed the lowest percentage of force decay of 41.68%.

Larrabee et al<sup>4</sup> had found a force decay of 53.0 % in Listerine mouth rinse after 24 hours. A rapid initial force loss within 24 hours could increase patient comfort and initial tissue response without affecting tooth-moving ability. Highest mean residual force was recorded in



artificial saliva followed by Wokadine, alcohol mixture 8.38%, Listerine, and alcohol mixture 21.6% respectively. The difference in mean force decay among the different solutions was found to be statistically significant ( $p < 0.001$ ).

De Genova et al<sup>1</sup> found that elastomeric chains producing higher initial forces displayed less force decay compared with the chains producing lesser initial force. However, the results obtained in the present study do not support these findings, possibly due to the methodological differences between the two studies. The forces exerted after 28 days in this study did not drop to zero as found in a clinical study by Samuels et al.<sup>11</sup>

In the Samuels et al study,<sup>11</sup> forces were tested between 5 and 8 weeks, whereas in this study, forces were tested at 28 days after exposure to a simulated oral environment.

Among the durations, higher mean force was recorded initially followed by 24 hours, 7 days, 14 days, 21 days, and 28 days respectively. The difference in mean force decay among the different time intervals was found to be statistically significant ( $p < 0.001$ ). Among Listerine and Wokadine mouth rinses, higher mean residual force was recorded in Wokadine, which has high antimicrobial activity. The interaction (joint effect) of duration and solution on mean force decay was also found to be statistically significant ( $p < 0.001$ ).

The results of this study demonstrate that active components in mouth rinses cause lesser amount of force decay in elastomeric chains exposed to 21.6% alcohol, 8.38% alcohol than when it is exposed to commercial mouth rinses as a whole. The results also confirm previous studies,<sup>1,12-14</sup> showing force decay over time, which is high initially and then reaches a plateau.

Kim et al<sup>15</sup> found effects of prestretching on time-dependent force decay of synthetic elastomeric chains. Elastomeric chains displayed less force decay (8.0%) after 24 hours; in the present study, after 24 hours in Listerine with prestretched 3M Unitek 40.58% force loss occurred and unstretched elastomeric chains show more force decay than elastomeric prestretched chains, but the results obtained in the present study do not support these findings, possibly due to the methodological differences between the two studies.

Limitations of this study are that since this study was done under static conditions and *in vitro*, it performed short of an exact picture of the degradation *in vivo*. Further studies need to be conducted in clinical situation where varied oral environment due to the different dietary habits, microbial activity, and stretching is present.

## CONCLUSION

Alcohol-containing mouth rinses cause an increase in force decay of elastomeric chain over time. At the end

of 28 days, Listerine (69.25%) showed more force decay of elastomeric chain and Wokadine (64.54%) showed less force decay of elastomeric chain. Among all three elastomeric chains at the end of 28 days, more force decay occurred in unstretched Ortho Plus and less in prestretched 3M Unitek. Unstretched elastomeric chains show more force decay than elastomeric prestretched chains.

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