



The Effect of Pigmentation on Latex and Non-Latex Elastics

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ABSTRACT:

Background: For more than a century, intraoral elastics have been extensively utilised in orthodontics. It has been demonstrated that over time, variations in the production process, material composition, and colour added to elastics affect force levels.

Goal: This study aimed to ascertain how pigmentation affected force levels and how they deteriorated with time in orthodontic intraoral elastics made of both non-Latex and latex.

Materials & Methods: The elastic samples were divided into 25 groups, with 10 elastic samples in each group. The groups included American Orthodontics Latex in both natural and four different colours; American Orthodontics Non-Latex in natural; Ormco Latex in both natural and four different colours; Auradonics Latex in both natural and four different colours; and Auradonics Non-Latex in both natural and four different colours. Over the course of 24 hours, data was gathered every five minutes. In order to imitate function, samples were stretched to a starting distance of 19.10 mm (as advised by the manufacturer), and then they were cycled with an additional 25 mm at 1-minute intervals. Force data was gathered while simulating the intraoral environment with a specially designed testing apparatus. Green-pigmented latex elastics broke down more quickly and produced lower force values across all manufacturers at most points.

Conclusions: Pigmentation and Material Composition had a significant effect on force levels and their degradation over time, with green pigment and Non-Latex elastics showing lower force values and greater force decay rates over time.

Introduction

Tooth movement is necessary in performing proper alignment and levelling of the dentition during orthodontic treatment. Movement typically depends on the amount of force applied to the teeth coupled with the time that force is applied.¹ Ideal tooth movement conditions involve applying a light force over a long period of time.¹ This force needs to remain in place for the most effective and predictable outcome to take place. Orthodontists utilize this force in order

to provide several different movements during treatment. This may include space closure, space creation, extrusion, intrusion, rotations or maxillomandibular relation correction.^{1, 2}

There are currently several different types of force devices. The orthodontist inserts some, which stay in place until they are taken out. Numerous others are detachable and given by the patient. These consist of elastomeric chains, elastomeric threads, intraoral elastics, coil springs, and detachable equipment, among others. To properly move teeth, the orthodontist must be aware of the limitations of the force instrument they select. This is particularly valid for novel materials or



ones that undergo substantial alterations. Over time, the majority of force delivery devices now in use experience some degree of force loss.

The material utilised determines how much and to what extent force is lost. It is imperative that the orthodontist comprehends the degree of force degradation inherent in the materials they utilise. This guarantees that the teeth receive the appropriate force to produce the intended motion of the teeth. This in-vitro study's main goal was to evaluate how pigmentation affected the force levels and gradual deterioration of intraoral orthodontic elastics. Moreover, the performance of double elastics (as opposed to single elastic wear) on force levels and deterioration over time, as well as the chemical makeup of the materials (Latex and Non-Latex), were evaluated. This study was performed over a period of twenty-five 24-hour days in an attempt to simulate the functional movements experienced by orthodontic elastics. This information will help identify whether

the addition of color to intraoral elastics has any effect on force delivery in both Latex and Non-Latex compositions, in three manufacturers.

Materials and Methods

Each tested elastic had a size of 1/4" and a reported force value of 4.5 oz. In clinical application, this is one of the sizes and force values that are recommended more frequently. Elastics made by American Orthodontics (AO) of Sheboygan, Wisconsin, USA, Ormco (OR) of Orange, California, USA, and Auradonics (AU) of Delran, New Jersey, USA were among the groups that underwent testing. The larger, more well-known orthodontic supply companies are AO and OR. A more locally known and smaller orthodontic supply firm is called AU. While OR is exclusively provided in Latex, AO and AU are supplied in both Latex and Non-Latex. Thus, a total of twenty-five groups were chosen for assessment:

American Orthodontics Latex Elastics	American Orthodontics Non-Latex Elastics	Ormco Latex Elastics	Auradonics Latex Elastics	Auradonics Non-Latex Elastics
Green = AOGL Orange = AOOL Purple = AOPpL Pink = AOPL Single Natural Latex = AOSL Double Natural Latex = AODL	Single Natural Non-Latex = AOSNL Double Natural Non-Latex = AODNL	Green = ORGL Orange = OROL Purple = ORPpL Pink = ORPL Single Natural Latex = ORSL	Green = AUGL Orange = AUOL Purple = AUPpL Pink = AUPL Single Natural Latex = AUSL Double Natural Latex = AUDL	Green = AUGNL Orange = AUONL Purple = AUPpNL Pink = AUPNL Single Natural Non-Latex = AUSNL Double Natural Non-Latex = AUDNL

Four distinct bright colours were available for the latex elastics from all three manufacturers: green, orange, purple, and pink. The same neon colours were also

acquired for non-Latex elastics from AU. Furthermore, Natural elastics from AO and AU were obtained in both Latex and Non-Latex forms, whereas Natural elastics



from OR were only obtained in Latex. The colour selection was determined by the makers' available stock. Every option, both coloured and non-colored, was selected for evaluation. This resulted in the testing of 25 distinct groups of intraoral elastics. There were 250 total elastic samples after ten samples from each elastic group were examined.

Testing Apparatus Fabrication

A testing equipment for automatic cycling and time-based testing of elastic force values was conceived and implemented by the author. This device was made to mimic intraoral circumstances. It had a motor to mimic jaw movements during normal speech and function, and

a water tank with a heating element to mimic body warmth. The elastic testing device was fabricated in two sections. The author worked in conjunction with Machine Services of the University of Western Ontario Engineering Department to custom design and build the frames that supported the machines. The main supports and baseplate were constructed using rigid aluminum and the tank for the water bath was constructed using acrylic sheets with a standard shut off valve for drainage. Custom milled aluminum plates were also fabricated to house the load cells and hooks utilized for the stretching of the elastics ([Figure 1](#)).

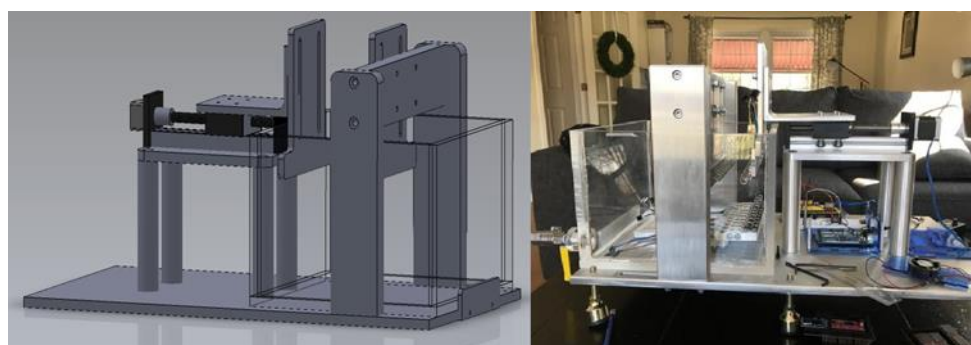


Figure 1: Stretching Apparatus - **A.** CAD/CAM rendering **B.** Completed Structure



Figure 2: Microcontroller and PCB's - **A.** Keystudio[®] Microcontroller **B.**

Stackable Shield PCB's

Ten distinct load cells in the manner of binocular beams are used to test elastic forces. When the load cells are loaded, strain gauges connected to them send the

variations in resistance values to ten analog-to-digital converters (HX711), which amplify the signal. The Keystudio[®] microcontroller then reads these signals and stores them on a microSD card. ([Figure3](#)).

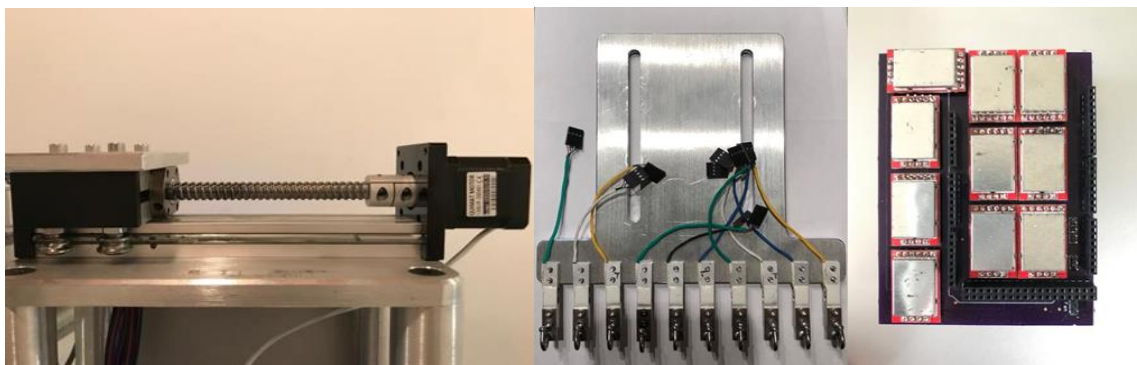


Figure 3: Load Cells and HX711 - A. 10x - 1Kg Load Cells B. 10x - HX711 ADC's **Figure 4:** Linear Slide Rail with Nema 17 Stepper Motor



Figure 5: LCD Touch Screen Display



Figure 6: Microsoldering - A. Microsoldering Station B. Microsoldered Components

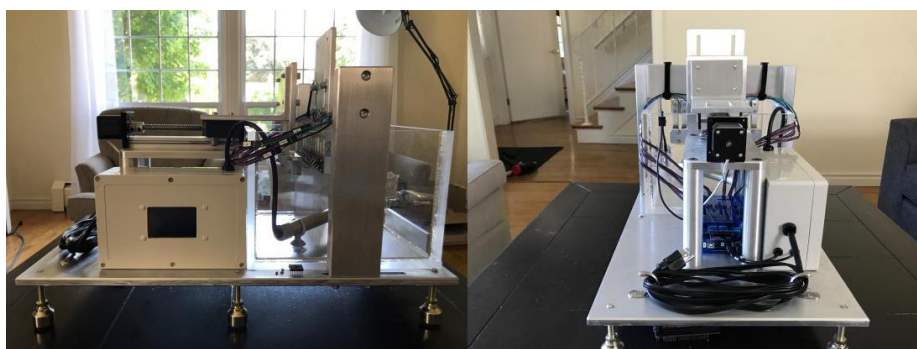


Figure 7: Completed Stretching Apparatus



Verification of Apparatus Accuracy and Reliability

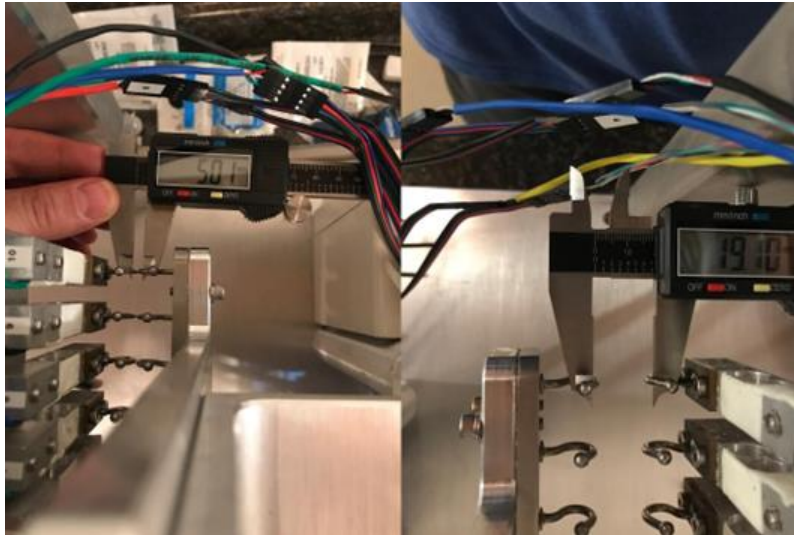


Figure 8: Distance Verification - **A.** Resting Distance **B.** Initial Stretch Distance.

Statistics

Verification of Data was done by compiling all recorded data into the statistical software program SPSS version 24.0. Mean and standard deviations (SD) were calculated for each machine used at every time point. Normality, for distribution of data, and lack of significant outliers was confirmed with histograms and boxplots. Pearson Correlation ($r=0.88-0.98$, $p<.001-.04$) was performed to confirm that data displayed similar force patterns between devices at all tested time points. Paired t-tests were also performed to ensure there was no significant differences in force values obtained between the Instron and the testing apparatus. Level of significance was set to $p<.05$ and all time points showed no significant differences ($p=.13$ to $p=.89$) between recording devices.

Testing Conditions and Data Recording

Until they were ready to be placed on the testing device, elastic pouches were kept sealed and stored within the corresponding cardboard boxes or lined bags. Five elastics were chosen at random from each matching lot number from the samples that were available. To make sure there was no obvious gross disparity in the shape, size, or thickness of the elastics, they were visually

examined. Extended tweezers without any serrations were used to load elastics. The initial separation distance of 5mm was achieved by attaching each elastic to a pair of 2mm stainless steel hooks spaced 1mm apart. The elastics were submerged in a water bath filled with distilled water ($\text{pH}=5.9$) that was kept at a constant 37°C for the duration of the experiment. Water levels were often monitored due to evaporation, and more water was injected to keep levels steady during testing. Each elastic was stretched to three times its initial lumen diameter (19.10mm) before testing started. The manufacturer supplied values are given at this distance, thus that's why it was picked. This was the first distance that was used. Elastics were stretched farther and then relaxed an additional 25.0mm once each minute at a cycle speed of 1 second in order to replicate intraoral jaw movements during function and speech.

Results

Comparison of Colored Latex Elastic Force Levels

There were significant differences noted in force levels, at each timepoints, between all of the Latex elastic groups tested ($p<.001$). There were also significant differences noted in force levels between time points within all the Latex elastic groups ($p<.001$). The pairwise comparisons for each elastic manufacturer are described below.



Time Point	AOGL	AOOL	AOPpL	*AOPL	*AOSL
T1min	117.3 (4.5)	117.2 (7.5)	116.0 (8.3)	119.6 (8.5)	120.2 (9.5)
T5min	95.2 (4.1)	98.0 (6.4)	98.6 (7.4)	101.1 (7.6)	102.3 (8.3)
T30min	87.2 (4.4)	91.5 (6.4)	92.6 (7.2)	95.7 (7.3)	96.7 (7.8)
T1h	83.8 (4.4)	88.9 (6.2)	90.0 (7.3)	94.2 (7.4)	94.9 (7.4)
T3h	79.4 (5.7)	84.7 (5.9)	86.2 (6.8)	92.0 (6.8)	92.5 (6.6)
T6h	78.1 (8.1)	83.6 (6.3)	83.9 (7.5)	89.8 (7.1)	91.7 (6.9)
T12h	74.4 (8.0)	82.7 (7.8)	83.5 (7.8)	89.0 (6.1)	88.8 (6.1)
T24h	69.8 (6.8)	78.0 (5.3)	76.0 (7.3)	83.6 (5.4)	84.4 (5.3)

*n=9 per group **Table 1: AO Latex Elastic Mean Force in grams (SD)**

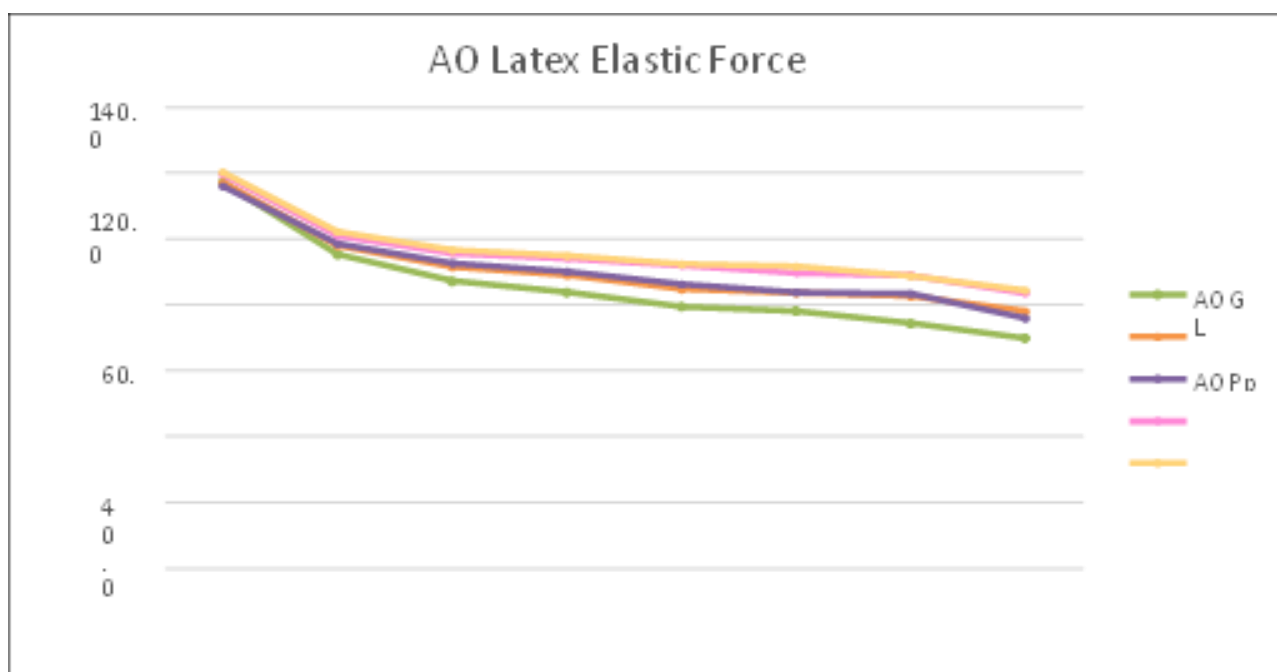


Figure 1: AO Latex Elastic Decay Over

Time Point	AUGL	AUOL	AUPpL	AUPL	AUSL
T1min	99.4 (10.3)	101.0 (14.3)	97.9 (19.1)	106.6 (22.1)	124.1 (5.7)
T5min	80.0 (8.5)	81.9 (11.4)	82.6 (16.1)	89.6 (18.2)	104.0 (5.0)
T30min	74.8 (7.8)	77.5 (11.5)	78.9 (15.3)	85.1 (17.5)	98.3 (4.8)
T1h	72.8 (7.5)	75.8 (11.4)	77.9 (15.2)	83.7 (17.3)	95.8 (4.9)
T3h	70.6 (8.3)	71.8 (10.4)	76.1 (16.2)	81.9 (16.6)	92.1 (5.4)
T6h	70.9 (9.1)	70.8 (11.7)	75.9 (15.8)	80.0 (14.9)	91.2 (5.2)
T12h	70.1 (9.8)	72.7 (10.9)	76.3 (12.9)	77.0 (15.7)	88.9 (3.5)
T24h	65.9 (7.4)	65.7 (8.0)	71.2 (13.1)	78.5 (15.9)	83.5 (4.6)

n=10 per group unless otherwise stated



Figure 2: AU Latex Elastic Decay Over Time

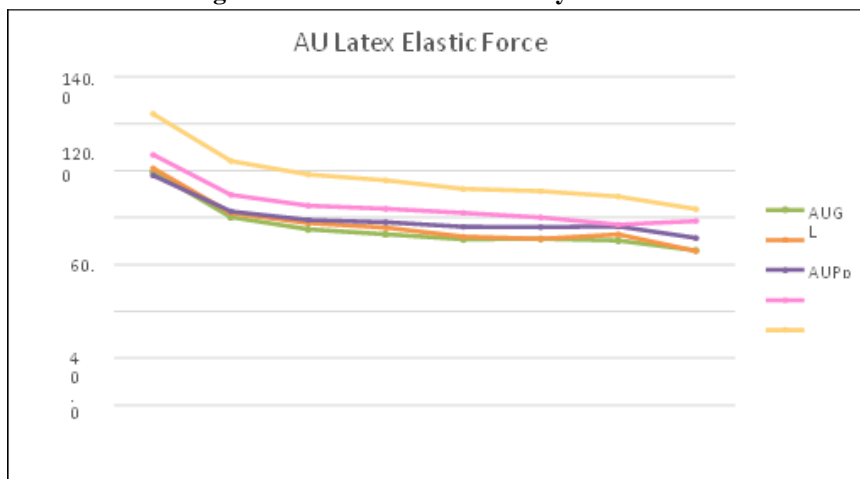


Table 2: AU Latex Elastic Mean Force in grams (SD)

Time Point	*ORGL	*OROL	ORPpL	ORPL	ORSL
T1min	115.1 (7.8)	116.5 (8.3)	108.1 (4.6)	108.2 (7.2)	122.7 (12.7)
T5min	92.8 (6.5)	95.5 (6.9)	91.3 (3.8)	90.4 (5.6)	101.1 (10.7)
T30min	86.6 (6.9)	89.6 (6.6)	86.5 (4.2)	85.8 (5.8)	94.4 (9.3)
T1h	84.6 (6.8)	88.0 (6.3)	85.1 (4.9)	84.3 (6.2)	92.3 (8.3)
T3h	81.2 (5.7)	86.8 (6.1)	83.9 (6.7)	82.0 (6.4)	89.4 (7.1)
T6h	77.9 (6.5)	84.9 (6.1)	82.7 (5.9)	81.1 (5.8)	89.2 (7.4)
T12h	77.4 (6.5)	83.4 (6.0)	82.0 (4.0)	78.3 (5.6)	85.1 (8.4)
T24h	66.0 (5.0)	76.9 (6.1)	77.4 (4.2)	76.1 (5.0)	81.8 (9.7)

*n=9 per group

Time Point	AUGNL	AUONL	AUPpNL	AUPNL	AUSNL
T1min	119.1 (13.1)	128.8 (9.3)	121.3 (9.6)	115.7 (9.8)	114.5 (4.9)
T5min	102.9 (11.7)	111.6 (8.2)	103.9 (8.4)	99.5 (8.9)	98.9 (4.0)
T30min	95.6 (11.1)	103.2 (7.8)	96.3 (7.9)	92.0 (8.4)	91.5 (3.7)
T1h	92.2 (10.7)	99.6 (7.4)	92.6 (7.5)	88.2 (7.9)	88.2 (3.3)
T3h	85.9 (9.6)	90.0 (6.3)	87.3 (6.6)	81.3 (7.2)	82.1 (2.6)
T6h	80.8 (7.7)	81.8 (5.4)	83.4 (6.2)	76.8 (6.3)	77.6 (2.5)
T12h	76.7 (6.5)	75.7 (4.4)	77.3 (6.1)	68.3 (3.1)	69.4 (2.2)
*T24h	*68.6 (8.9)	*62.9 (N/A)	*66.1 (2.9)	*66.6 (0.8)	*48.8 (N/A)

Table 3: OR Latex Elastic Mean Force in grams (SD)

Group

n=10 per group unless otherwise stated *Reported values are for remaining elastics only, n<10 in all groups (see [Table 15](#))

**Table 4: AU Non-Latex Elastic Mean Force in grams (SD)**

Group

Time Point	†AOSL	AODL	AUSL	AUDL	AOSNL	AODNL	AUSNL	AUDNL
T1min	120.2 (9.5)	234.3 (10.0)	124.1 (5.7)	243.0 (8.8)	139.0 (5.5)	279.8 (7.9)	114.5 (4.9)	225.0 (9.3)
T5min	102.3 (8.3)	199.2 (8.7)	104.0 (5.0)	193.8 (7.6)	117.6 (4.6)	236.2 (7.2)	98.9 (4.0)	194.8 (7.9)
T30min	96.7 (7.8)	189.1 (8.2)	98.3 (4.8)	189.1 (7.3)	108.9 (4.2)	218.7 (6.7)	91.5 (3.7)	180.5 (7.5)
T1h	94.9 (7.4)	185.6 (7.8)	95.8 (4.9)	183.0 (7.1)	104.3 (3.9)	210.3 (6.8)	88.2 (3.3)	174.0 (7.4)
T3h	92.5 (6.6)	177.9 (7.6)	92.1 (5.4)	182.0 (6.3)	96.0 (3.5)	193.0 (6.6)	82.1 (2.6)	160.9 (7.5)
T6h	91.7 (6.9)	174.5 (7.7)	91.2 (5.2)	176.0 (8.3)	91.0 (3.7)	179.1 (6.1)	77.6 (2.5)	150.7 (7.3)
T12h	88.8 (6.1)	172.0 (8.6)	88.9 (3.5)	170.9 (7.8)	82.5 (4.8)	158.7 (6.2)	69.4 (2.2)	140.0 (6.7)
T24h	84.4 (5.3)	162.5 (8.2)	83.5 (4.6)	170.6 (10.3)	*59.9 (8.2)	††0.0 (N/A)	*48.8 (N/A)	††115.5 (10.2)

n=10 per group unless otherwise stated

†n=9 per group

*Reported values for Single Non-Latex are for remaining elastics only, n<10 in all groups

†† Reported values for Double Non-Latex are for remaining double pairs only, n<10 in all groups

Discussion

There are many different ways to use force to shift teeth nowadays. Every approach has advantages and disadvantages, and no one approach is noticeably better than the others. The same kinds of tooth movements can be achieved by a variety of techniques, which are selected according to a practitioner's comfort level, knowledge, and experience. Over the course of several decades, intraoral orthodontic elastics have gained widespread acceptance among orthodontists.^{3,4} Despite the fact that their force levels have been demonstrated to deteriorate over time, their affordability, biocompatibility, simplicity of insertion, and range of force levels and sizes make them extremely well-liked.^{5, 6,7,8,9,10,11}

According to the research's percentage of force remained AO Latex elastics maintained 80% of their initial force levels at T30min, and by T12h, only 74% of those levels remained. By contrasting the amount of force lost in this study with research that assessed comparable testing settings, we may observe that Kersey discovered remarkably comparable percentages of remaining force.

According to their research, the force residual percentage was 81.5% after 30 minutes and declined to 75.5% after 12 hours. The forces in the two studies were within 1.5% of one another. The AO Non-Latex elastics' remaining force level percentages at T30min (78%) and T12h (59%), compared favourably to those discovered by Kersey at 30min (77.8%) and 12h (60.5%). For both trials, the remaining percentages were within 1%.⁵

From this study it appears that Latex and Non-Latex elastics behave similarly, with regards to force degradation, but have some clear distinctions. All Non-Latex elastics appear to undergo a quicker rate of force decay, higher overall force loss and a larger percentage loss than the Latex elastics. This finding is consistent with most other studies.^{12, 5, 31,6,7,8} Manufacturer differences are apparent between Latex and Non-Latex elastic force delivery. Some manufacturers Non-Latex elastics deliver higher initial force levels than Latex, as in American Orthodontics in this study. Others, such as Auradonics, show an opposite relationship. This difference was observed at all



time points for the AU Non-Latex elastics and was present up until the T6h time point for AO Non-Latex. At T12h the AO Non-Latex elastic forces were only 6g below the AO Latex elastics. The Natural Non-Latex elastic groups (AO and AU) were separated by about 15-20g of force at each time point throughout the study. This manufacturer difference is important to note, when choosing elastics, as it indicates that not all elastics are equal, and this variation may exist among other manufacturers as well. In fact, previous research has shown this difference for manufacturers and elastic sizes between Latex and Non-Latex elastics.^{12,6,9,11,13}

Conclusions

The current study tested the effect of pigmentation on force levels and rate of force decay of intraoral elastics from three different manufacturers, in both Latex and Non-Latex forms, over a period of 24 hours. The following conclusions were made.

1. Elastic pigmentation can affect force levels and decay over time, but this is not consistent across manufacturers, elastic composition or color.
2. Non-Latex elastics showed a greater force decay rate for all manufacturers, regardless of color. Initial force levels were sometimes higher and sometimes lower than Latex elastics, depending on the manufacturer.

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