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# A comparison of orthodontic elastic forces: Focus on reduced inventory

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## Abstract:

**OBJECTIVES:** To compare orthodontic elastics with different force extension characteristics, thereby aiming to reduce the orthodontist's inventory for elastics.

**MATERIALS AND METHODS:** Thirty nonextraction class I models were used to determine extension distances. Light, medium, and heavy forced Latex elastics of size 1/4 and 3/16 (from three manufacturers) were used. Thirty elastics from each pack were selected, for a total sample size of 540 elastics. Elastic force was measured at three extensions: three times the lumen (A), first molar to opposing canine (B), and second molar to opposing canine distance (C). Force values were compared with the analysis of variance followed by the *post hoc* Scheffe test.

**RESULTS:** Mean distance for extensions B and C were 22.3 and 38.7 mm, respectively. There was a continuous but significant increase in the force of 1/4 elastics when stretched from A to extension C. A significant increase in the force level of 3/16 elastics was only noted when stretched from A to B. Overall, 1/4 elastics had a wider range of force coverage in the extensions used, compared to 3/16 elastics.

**CONCLUSIONS:** The use of 1/4 elastics is sufficient to cover the range of forces in orthodontic treatment.

## Keywords:

Force extension, orthodontic elastics, reduced inventory

## Introduction

Latex elastics have been one of the most used auxiliaries in orthodontics. Their versatile use and low cost are among their greatest advantages. Orthodontic elastics, however, come in many different sizes that are available in different strengths. Ormco (Sybron Dental Specialties, Glendora, CA, USA), for example, offers 36 different types of elastic packs, based on different force levels and diameters. American Orthodontics (Sheboygan, WI, USA) offer 33 different types, while 3M Unitek (Monrovia, CA, USA) offer 30 different types. As a result, the need for orthodontists to stock different sizes for each use has become a disadvantage.

Orthodontic textbooks tend to mention elastics as part of the various treatment

modalities. Proffit *et al.*<sup>[1]</sup> and Alexander<sup>[2]</sup> discuss specific force levels, or elastic types, to be used with specific treatment conditions. The question then becomes one about how orthodontists can calculate the force level applied when a specific elastic is used. While some orthodontists use manufacturers' force values from the elastic packs as a reference, others use their clinical judgment based on tactile senses, previous clinical success, and recommendations from other experts in selecting force levels not only for elastics but also for all appliances used during orthodontic treatment.<sup>[3,4]</sup>

According to manufacturer recommendations, force levels on elastic packs are obtained when the elastics are stretched three times their lumen size. Oesterle *et al.*<sup>[4]</sup> however, found that force levels on elastic packs were closest to a two-time stretch of the lumen diameter. Other studies found similar results.<sup>[5,6]</sup> Furthermore, when elastics are loaded and

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stretched, their chemical and physical properties change, resulting in force degradation due to fatigue. Studies have shown that elastics exhibit large amounts of force degradation up to 30%, which were greatest within the first hour of use.<sup>[7-10]</sup>

Studies on orthodontic elastic properties frequently use the manufacturers’ recommendations, i.e., stretching elastics three times their diameter to test prescribed force levels. In patients, elastics are stretched many ways to obtain the desired movement. Frequently, elastics are stretched from the first or second molar to the opposing canine in class II and III corrections. This elastic stretch does not always coincide with three times the lumen size, though. Kersey *et al.*<sup>[11]</sup> tested elastics by stretching them from 19 to 43.7 mm, based on a model developed by Liu *et al.*<sup>[7]</sup> This model showed changes in the distance between the maxillary first molar and the mandibular canine, with wide opening. Other studies investigated elastics at varying distances, between 20 and 50 mm, to mimic the clinical stretch of elastics.<sup>[5,9,12,13]</sup>

The purpose of this study was to compare the force extension characteristics of different elastics at clinically relevant distances, and to then group elastics with similar force extension characteristics. Our aim was to allow orthodontists to reduce the number of elastics needed during treatment, while achieving the same results.

### Materials and Methods

Latex elastics from three manufacturers were used: American Orthodontics (Sheboygan, WI, USA), 3M Unitek (Monrovia, CA, USA), and Ormco (Sybron Dental Specialties, Glendora, CA, USA). Elastics came in sealed plastic bags and had been recently manufactured. Two sizes – 3/16 and 1/4 inch lumen – were tested. Three force values were selected for each size, as shown in Table 1.

To determine stretch distance, we used 30 study models of nonextraction completed orthodontic cases. These cases had perfect class I occlusion, according to the objective grading system’s occlusal relationship evaluation. Using an electronic gauge (Neiko Corp, Miami, FL, USA), the distance from the mid-labial of the mesiobuccal cusp of the lower molar to the middle of the upper canine, and from the upper first molar to lower canine, were taken on the right and left sides to

find the mean for the first measurement (extension B). The same process was repeated from the second molar to the opposing canine for the second measurement (extension C). These measurements reflect actual distances the elastics are stretched when used in class II and III elastics.

Recent studies on elastic force properties calculated sample sizes ranging from 5 to 15 per group, and were tested as adequate.<sup>[8,12,13]</sup> Stata statistical software (Statacorp, College Station, TX, USA) indicated that a sample size of 540 (30 per group) would have a 95% power of detecting a medium effect size of 0.25 with a significance level of 0.05.

A Dillon GL force gauge (Fairmont, MN, USA) measured the tensile force when the elastics were stretched between the hooks of the gauge [Figure 1]. Thirty randomly selected elastics from each bag were tested at three distances: three times the lumen size distance (extension A), mean first molar to canine distance (extension B), and mean second molar to canine distance (extension C). Distance A was based on the manufacturer’s instruction that the force level on the bags could be obtained when elastics were stretched to three times their lumen. The force value in grams was recorded.

Data were analyzed using the Statistical Package for the Social Sciences (SPSS Inc. Chicago, IL, USA) software. One-way analysis of variance (ANOVA) followed by

**Table 1: Elastic types and force levels in ounces and grams**

Manufacturer	Force magnitude		
	Light force	Medium force	Heavy force
3M Unitek	2 oz. (57 g)	3.5 oz. (99 g)	6 oz. (170 g)
American orthodontics	2.5 oz. (71 g)	4.5 oz. (128 g)	6.5 oz. (184 g)
Ormco	3 oz. (85 g)	4.5 oz. (128 g)	6 oz. (170 g)



**Figure 1: Dillon GL force gauge for tensile force measurements**

a *post hoc* Scheffe test was used to compare force levels between groups at the  $\alpha = 0.05$  level of significance.

## Results

Measurements from the 30 orthodontic models showed a mean distance of 22.3 mm for the first molar to opposing canine measurement (extension B), and a mean of 38.7 mm for the second molar to opposing canine measurement (extension C). Measurements for the third distance (extension A, three times the lumen) were 14.06 and 18.75 mm for the 3/16 and 1/4 elastics, respectively.

Mean elastic force extension values and standard deviations are shown in Table 2. At extension A, no statistically significant difference in force extension values was found between the 3/16 and 1/4 elastics in any group.

When 3/16 elastics were stretched from A to B, a statistically significant increase in force level was observed in all elastic groups. The heavier the manufacturer's recommended force value, the greater the increase when stretched from A to B. The smallest increase was seen with the 2 oz. Unitek elastics, while the most was with the 6.5 oz. American Orthodontics elastics, which increased by 81.17 g (2.8 oz.).

However, when 3/16 elastics were stretched from extension B to C, no statistically significant difference was seen in the force value, except for the 3M 6 oz. elastics. This may indicate that the elastic had been stretched to its maximum load at distance A, and that further stretching produced little change in force values [Table 2].

When 1/4 elastics were stretched from extension A to B, a statistically significant difference was seen in the force value of medium (3.5 and 4.5 oz.) and heavy (6 and 6.5 oz.) elastics. Light elastics (2, 2.5, and 3 oz.) did not show a significant increase. On the contrary, when 1/4 elastics were stretched from extension B to C, a statistically significant increase in force value was noted with all elastics, except for American Orthodontics 2.5 oz.

elastics. Similar to 3/16 elastics, the greater the initial force value, the greater the increase in force value when stretched from extension A to B.

## Discussion

Studies of orthodontic elastics have typically used manufacturer recommendations for extending the elastics three times their lumen when examining force extension characteristics.<sup>[8,10,14-16]</sup> Some studies used extensions of 20–50 mm, proposing it was the normal range for clinical use.<sup>[5,7,9]</sup> In the current study, extension distances were obtained from clinical cases. The mean distance from the second molar to the opposing canine was found to be 38.7 mm, which is more than double the length, compared to three times the lumen of a 1/4 elastic (18.75 mm). The mean distance from the first molar to the opposing canine was 22.3 mm, which was again larger than three times the lumen of either the 1/4 or 3/16 elastics.

During class II and III malocclusion corrections, distances would be greater initially. Further, based on a model developed by Peck *et al.*,<sup>[17]</sup> the distance between the maxillary canine and the mandibular first molar would increase during wide opening, showing an additional 24.7 mm. These findings suggest that the manufacturer's extension recommendation of force measurement is of little value in clinical use.

The results of this study show that force levels increased significantly when elastics were stretched from three times their lumen to the measured distance for class II and III corrections. Oesterle *et al.*<sup>[4]</sup> found that force levels on elastic packs were closest to the two-time stretch of the lumen diameter. Other studies found similar results.<sup>[5,6]</sup> In addition, with increased extension of elastics, there was a further increase in force value. This was greatest with medium- and heavy-forced 1/4 elastics. The 3/16 elastics, however, showed little change when they were stretched from extension B to C. These findings are opposite to those of Kanchana and Godfrey,<sup>[5]</sup> who found

**Table 2: Mean force levels (in grams of force) and standard deviations**

Company	Pack force	3/16 Elastics			1/4 Elastics		
		Extension A	Extension B	Extension C	Extension A	Extension B	Extension C
3M Unitek	2 oz.	44.67* (4.72)	61.50 (8.11)	71.50 (6.18)	51.50 (4.18)	56.17* (8.58)	70.33 (5.86)
	3.5 oz.	90.67* (5.83)	124.83 (9.05)	134.83 (15.06)	89.67* (7.42)	109.83* (6.62)	152.00 (11.34)
	6 oz.	148.33* (7.46)	219.00* (10.46)	239.17 (13.39)	155.00* (10.66)	178.83* (12.01)	243.33 (18.39)
American orthodontics	2.5 oz.	71.67* (6.20)	96.00 (9.32)	96.33 (9.90)	77.33 (8.06)	86.50 (6.45)	105.50 (8.56)
	4.5 oz.	107.50* (12.08)	147.67 (18.51)	145.50 (17.87)	122.83* (8.67)	145.00* (9.37)	185.67 (13.17)
	6.5 oz.	152.50* (13.18)	233.67 (18.05)	243.17 (18.96)	170.17* (10.29)	201.50* (11.97)	274.17 (15.03)
Ormco	3 oz.	61.33* (6.42)	86.33 (7.18)	92.50 (9.26)	60.83 (5.73)	73.17* (6.76)	90.83 (9.29)
	4.5 oz.	110.83* (9.10)	156.83 (13.16)	163.67 (12.79)	116.00* (5.47)	136.67* (5.92)	168.67 (8.99)
	6 oz.	148.00* (10.47)	203.33 (9.40)	220.17 (18.55)	162.00* (9.15)	187.83* (9.88)	243.83 (19.77)

\*Denotes a significant difference in the force value between the extension marked and the following extension

that 3/16 elastics continued to increase in force delivery up to a 55 mm extension.

Similar to other studies, we found that large variations in force level exist within a pack of elastics, as seen from the standard deviation of force values. These variations were in the range of 30 g (1 oz.). Comparisons of elastics from the same manufacturer with the same force level (tested under equal conditions in other studies) continue to show differences in force levels. Kanchana and Godfrey<sup>[5]</sup> tested Unitek 2 oz. elastics in dry conditions at an extension of 35 mm, and then recorded a force value of 159 g. The current study recorded 71.5 g for the same elastics at 38 mm. Similar findings were observed with the 1/4 elastics. Other studies have also shown a wide range of variation in the extension forces of elastics.<sup>[5,8,12]</sup>

While there are differences in the equipment used in various studies, the differences in force levels of elastics are more likely caused by inconsistencies in the manufacturing process. This finding leads us to question the need for such a large selection of elastic sizes and forces—which is coupled with the fact that orthodontists use the same elastics at different intraoral extensions as treatment progresses. In this study, we demonstrate that 1/4 elastics provide force levels over a wider spectrum, as well as at different extensions vs. 3/16 elastics. With different force levels, 1/4 elastics are sufficient to cover all range of forces for orthodontic needs. This can be achieved by increasing the extension of the elastic intraorally or by selecting a pack with a higher initial force value.

We only performed dry testing, while previous studies investigated elastic force characteristics under wet and other conditions.<sup>[9,14,18]</sup> The general finding is that there is an elastic force degradation, which is greatest within the first few hours of use, regardless of the type of elastic or force used. This should be taken into consideration when selecting elastics, given the findings of the current study.

Force levels have been of great importance in orthodontic treatment. Applying only the amount needed to obtain healthy tooth movement has always been the goal of treatment. Reitan<sup>[19,20]</sup> found that excessive force causes necrosis and unwanted cellular change. The primary goal when using any type of elastic is to obtain the level of force needed to move the teeth when stretched a specific distance. Nevertheless, the idea that all patients with similar class II malocclusions should respond to exactly the same forces during corrections seems unrealistic in lieu of force levels that change by a few grams. It may be advisable to initiate treatment with lighter forces, with a subsequent gradual increase in force level used. Oesterle *et al.*<sup>[4]</sup> showed that orthodontists have differing opinions

about force levels. Ultimately, orthodontists use their judgment based on experience and on a case-to-case basis increasing and decreasing forces as needed.

## Conclusions

With an increase in the extension distance of elastics, 1/4 elastics continue to increase the level of force delivery. Beyond the first molar to canine extension, 3/16 elastics provide little increase in the force level delivered. Overall, 1/4 elastics covered a wider range of force levels compared to 3/16 elastics, and are adequate to cover the range of forces needed for orthodontic treatment.

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## Conflicts of interest

There are no conflicts of interest.

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