In Vitro Study of Orthodontic Elastomeric Chains for Canine Retraction

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Abstract

Objectives: The purposes of this study were: (1) to investigate the dimensions of elastomeric chains (2) to investigate the force delivery of elastomeric chains through 28 days for canine retraction and (3) to determine the proper length of elastomeric chains for canine retraction. **Materials & Methods:** The open configuration and four colors (clear, pink, jelly blue and metallic silver) elastomeric chains from Tuff® and Dynaflex® were examined the dimensions (internal diameter, external diameter, interloop distance, width, thickness and length) by using a measuring microscope Nikon MM-11C at magnification of x10. All elastomeric chains were stretched to 28 mm in Instron testing machine (Model LF Plus) and the data were recorded as the initial forces. Then the force measurements were recoded at 9 times interval through 28 days (At initial placement on the fixture, 1 hour, 3 hours, 24 hours, 3 days, 7 days, 14 days, 21 days and 28 days after the first measurement). **Results:** All tested chains were significant differences in the internal diameter, external diameter and interloop distance. However the width and thickness were not significant differences between two brands. Furthermore all measured dimensions from each company were significant differences among different colors. The elastomeric chains which generate the initial and the final force in the range of 350 to 100 grams were 7 loops in both tested products as well as 8 loops of Dynaflex elastomeric chain. The mean percentage of extension for Tuff and Dynaflex elastomeric chain was 30.73% and 25.84% of original length, respectively. **Conclusion:** The results of this study showed all elastomeric chains from each company were significant differences in the dimensions. The length of elastomeric chains which generate the proper force for initial canine retraction at 28 mm. were 7 loops in both Tuff's and Dynaflex's elastomeric chains as well as 8 loops of Dynaflex's elastomeric chain.

Key words: Orthodontic Elastomeric Chains / Canine Retraction / Force delivery

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บทคัดย่อ: การศึกษาโซ่อีลาสโตเมอร์สำหรับดึงฟันเขี้ยวในทางทันตกรรมจัดฟัน
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วัตถุประสงค์: เพื่อ (1) เปรียบเทียบขนาดของโซ่อีลาสโตเมอร์ 2 ยี่ห้อ ได้แก่ ทัพฟ์®และไดนาเฟก® และเปรียบเทียบขนาดของโซ่อีลาสโตเมอร์ 4 สี (ใส, ชมพู, ฟ้าเจลลี่ และบรอนส์เงิน) ในแต่ละยี่ห้อ (2) ศึกษาขนาดแรงที่ปลดปล่อยจากโซ่อีลาสโตเมอร์ทั้งสอง ตลอดระยะเวลาของการศึกษา 28 วัน และ (3) ศึกษาความยาวของโซ่อีลาสโตเมอร์ซึ่งสามารถปลดปล่อยแรงที่เหมาะสมในการดึงฟันเขี้ยว(350-100 กรัม) **วัสดุอุปกรณ์และวิธีการศึกษา:** โซ่อีลาสโตเมอร์แบบสั้น, 4 สี (ใส, ชมพู, ฟ้าเจลลี่ และบรอนส์เงิน), ความยาว 5, 6, 7 และ 8 ห่วง จาก 2 ยี่ห้อ ได้แก่ ทัพฟ์® และไดนาเฟก® อย่างละ 10 ตัวอย่าง (320 ตัวอย่าง) ทำการสุ่มมาวัดขนาดทั้ง เส้นผ่าศูนย์กลางภายใน เส้นผ่าศูนย์กลางภายนอก ระยะระหว่างห่วง ความกว้าง และความหนา ด้วยเครื่องไมโครสโครบ จากนั้นตัวอย่างโซ่อีลาสโตเมอร์ทั้งหมดจะถูกยืดไปที่ระยะ28 มิลลิเมตร (ระยะเฉลี่ยระหว่างกึ่งกลางฟันเขี้ยวและปุ่มฟันด้านใกล้กลางและด้านแก้มของฟันกรามซี่ที่หนึ่ง) และทำวัดแรงใน 9 ช่วงเวลา ได้แก่ แรงเริ่มต้น,1 ชั่วโมง, 3 ชั่วโมง, 24 ชั่วโมง, 3 วัน, 7 วัน, 14 วัน, 21 วัน และ 28 วัน ด้วยเครื่องอินสตรอน รุ่นแอลเอฟ พลัส **ผลการศึกษา:** ขนาดของโซ่อีลาสโตเมอร์ 2 ยี่ห้อ ได้แก่ ทัพฟ์®และไดนาเฟก® มีความแตกต่างอย่างมีนัยสำคัญ ในส่วนของเส้นผ่าศูนย์กลางภายใน เส้นผ่าศูนย์กลางภายนอก ระยะระหว่างห่วง และ ไม่มีความแตกต่างอย่างมีนัยสำคัญในส่วนของความกว้างและความหนา ในแต่ละยี่ห้อมีความแตกต่างอย่างมีนัยสำคัญในทุกขนาดระหว่าง 4 สี (ใส, ชมพู, ฟ้าเจลลี่ และบรอนส์เงิน) นอกจากนี้ยังพบว่าความยาวของโซ่อีลาสโตเมอร์ที่ให้แรง เริ่มต้นไม่เกิน 350 กรัมและแรงในวันที่28 มากกว่า 100 กรัม ได้แก่ 7 ห่วงของทั้ง 2 ยี่ห้อ และ 8 ห่วงของไดนาเฟก® **สรุป:** โซ่อีลาสโตเมอร์ในแต่ละยี่ห้อ มีความแตกต่างอย่างมีนัยสำคัญในทุกขนาดระหว่าง 4 สี (ใส, ชมพู, ฟ้าเจลลี่ และบรอนส์เงิน) และ ความยาวของโซ่อีลาสโตเมอร์ซึ่งสามารถปลดปล่อยแรงที่เหมาะสมในการดึงฟันเขี้ยว (350-100 กรัม) ตลอดระยะเวลา 28 วัน ได้แก่ 7 ห่วงของทั้ง 2 ยี่ห้อ และ 8 ห่วงของไดนาเฟก®
คำสำคัญ: โซ่อีลาสโตเมอร์, การดึงฟันเขี้ยว, แรงจากโซ่อีลาสโตเมอร์

Introduction

The Orthodontic elastomeric chains are used extensively in stage of space closure because they are economical, easy to use, relatively hygienic, comfortable for patients and require little or no patient cooperation[1]. They also allow patient participation through their choice of color selections[2]. Elastomeric chains, however, are not without their disadvantages. As they are themselves elastic, they could be easily extended and may have surpassed the elastic limit especially when exposed to an oral environment. After absorbing water and saliva, they become permanently stained and consequently breakdown of their internal bonds that leads to permanent deformation[3]. They also experience a rapid loss of force due to stress relaxation, resulting in a gradual loss of their effectiveness[3,4]. This loss of force makes it

difficult for orthodontists to determine the actual force transmitted to the dentition in the oral cavity. Furthermore, various in vitro studies had been reported that the forces delivered from elastomeric chains were not constant and degraded over time[3-17]. The greatest rate of force decay occurred within the first hour and the forces delivered continue to fall but at a slow rate during the next two to three weeks. Beyond this time, in general, forces delivered remain nearly constant but at a level lower than originally available[14].

The optimal force magnitude required for canine retraction is still not yet in final conclusion. Many factors affect canine movement such as the root surface area of the tooth to be moved, density of bone, friction from brackets and arch wires and age of the patient[14,18-20]. Even though orthodontists generally agree that optimal force refers to the lightest continuous force compatible with physiologically tooth movement[5,18-20]. In general the force for canine movement, many studies suggest that the force magnitudes required to bodily move canines are estimated to range from 100 to 350 grams[18-20].

Previous studies on elastomeric chains had been directed to study the force delivery and degradation properties from initial force level through 28 days, the effects of prestretching and the influence of a changing environment or composition property of elastomeric chains. In addition, a variety of elastomeric chains have been introduced recently to orthodontic treatment but little is known of number of loops, different lengths and the percentage of extension of elastomeric chains which generate proper force for canine retraction. Therefore, the purpose of this study is to investigate the dimensions, the force delivery and the proper length of elastomeric chains for canine retraction.

Materials and Methods

Materials

The open configuration of Tuff® (Glenroe technologies company, Forida, USA) and Dynaflex® elastomeric chain (Dynaflex company, St. Louis, Missouri, USA) which were currently used in orthodontic clinic, at Faculty of Dentistry, Mahidol University were used as the testing samples in this study. The details of these products were given in Table 1.

Table 1 Details of elastomeric chains

Brand name	Tuff®	Dynaflex®
Manufacture	Glenroe technologies company	Dynaflex company
Country	Florida, USA St.	Louis, Missouri, USA
Configuration	Open type	Open type
Color	Clear	Clear
Date of manufacturing	23/06/2007	12/5/2007

Methods

Elastomeric chains from both companies (Tuff® and Dynaflex®) were measured the dimensions (internal diameter, external diameter, interloop distance, width, thickness and length as shown in Fig 1) by using a measuring microscope Nikon MM-11C at magnification of x10 and has the accurate to 0.001 mm.

Each sample was transferred to the Instron testing machine and slowly stretched to the 28 mm distance (Fig 2). Force measurements were recorded as the initial forces. The force measurements were recorded at 9 times interval:

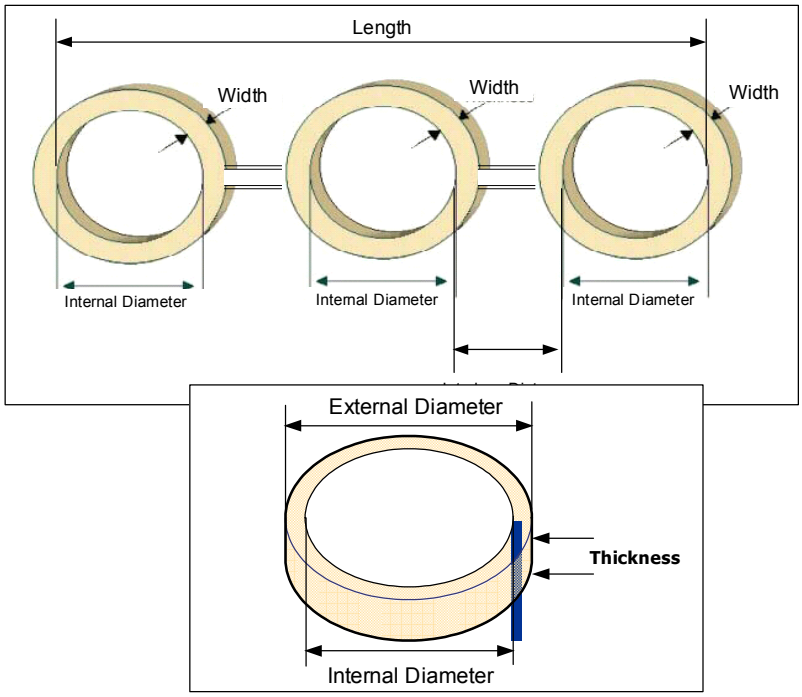

Fig 1 The diagram demonstrated the dimensions.

T1 = At initial placement on the fixture
T2 = 1 hour after the first measurement
T3 = 3 hours after the first measurement
T4 = 24 hours after the first measurement
T5 = 3 days after the first measurement
T6 = 7 days after the first measurement
T7 = 14 days after the first measurement
T8 = 21 days after the first measurement
T9 = 28 days after the first measurement

At each of measurement intervals, the elastomeric chains were transferred between the testing hook and the storage block (Fig 3) by the rubber dam forceps which fixed distance at 28 mm. [According to the study Josell et al[14] and Chung[21] suggests that a distance of 28 mm was equal to simulate canine retraction distance which representing an average distance from midpoint of the canine crown to the buccal groove of the first permanent molar. Therefore the distance of 28 mm was used to represent the initial canine retraction distance in this study.]

Table 2 Descriptive statistics (Mean, SD) and comparison of dimensions of Tuff® and Dynaflex® elastomeric chains.

Time	Tuff Mean±SD (gm)	Dynaflex Mean±SD (gm)	*P*-value
Internal diameter	1.04±0.02[a]	0.99±0.01[b]	0.003*
External diameter	3.38±0.02[a]	3.34±0.03[b]	0.001*
Interloop distance	2.32±0.01[a]	2.28±0.01[b]	0.044*
Width	2.36±0.03[a]	2.33±0.04[b]	0.709
Thick	0.56±0.01[a]	0.58±0.01[b]	0.089

* The mean difference is significant at the 0.05 level.

[a, b] Significant difference at the 0.05 level among different color.

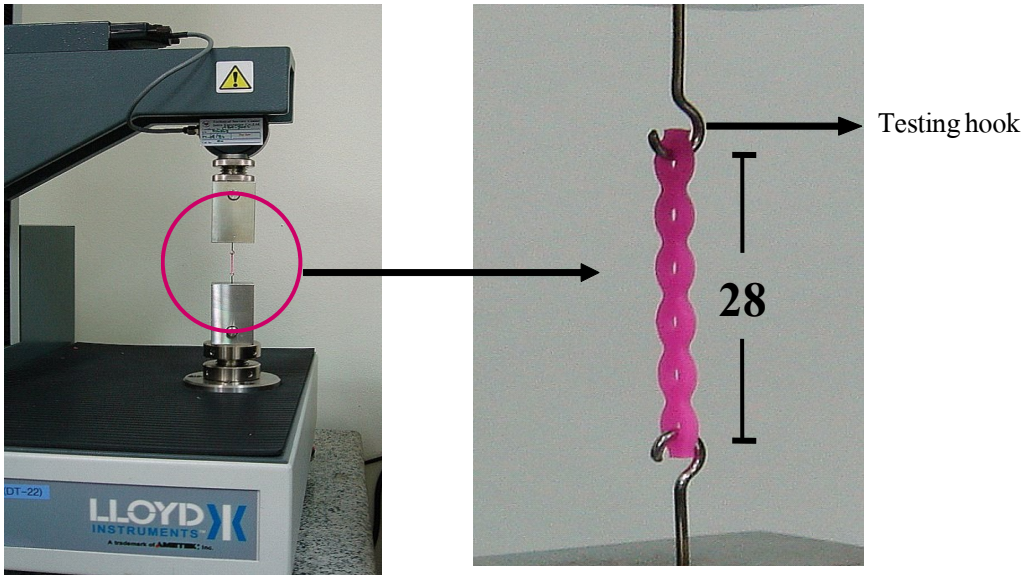

Fig 2 Force measurement by Instron testing machine (Model LF Plus)

Results

Mean, standard deviation and comparison of dimensions of Tuff® and Dynaflex® elastomeric were shown in Table 2.

All tested chains were significant differences in the internal diameter, external diameter and interloop distance. However the width and thickness were not significant differences between two brands. Furthermore all measured dimensions from each company were significant differences among different color.

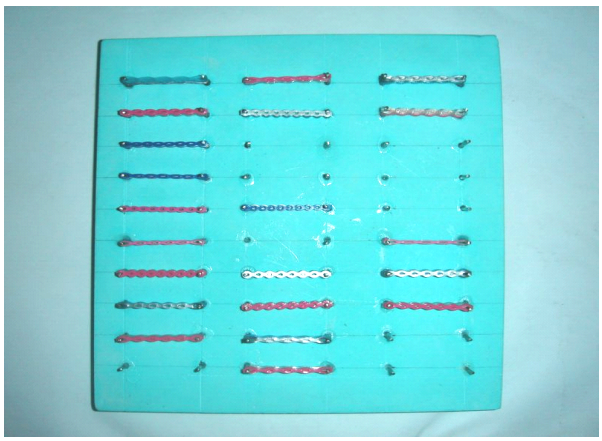

Fig 3 The orthodontic canine retraction distance template

All tested elastomeric chains were tested under Instron testing machine to measure the force that release from the elastomeric chains at 9 times interval over 28 days test period. The results in gram unit were shown in Fig 4, 5.

The elastomeric chains which generate the initial and the final force in the range of 350 to 100 grams were 7 loops in both tested products as well as 8 loops of Dynaflex® elastomeric chain. The mean percentage of extension for Tuff® and Dynaflex® elastomeric chain was 30.73% and 25.84% of original length, respectively as in Table 3.

Discussion

Tuff® and Dynaflex® elastomeric chains were used as the tested samples in this study because they were clinically application at Orthodontics clinic, Faculty of Dentistry, Mahidol University. In this study use 28 mm representing an average distance for canine retraction distance[14,21]. Even the elastomeric chains from both companies were imported from same country and similar performance but they had any different in all

Table 3 Percentage of extension for Tuff and Dynaflex elastomeric chain

Brand	No. loops	Color	Original Length	Extention to (mm)	Extension Distance (mm)	% Extension	Initial force (gm)	final force (gm)
Tuff		Pink	21.70	28	6.30	29.05	302.95	111.97
		Jelly blue	21.22	28	6.78	31.97	280.73	104.33
		Metallic	21.35	28	6.65	31.17	315.46	115.54
	7	silver						
				Mean of % extension		30.73		
Dynaflex		Clear	20.34	28	7.66	37.68	342.34	138.08
		Pink	21.01	28	6.99	33.24	317.92	129.92
	7	Jelly blue	21.08	28	6.92	32.84	285.75	161.84
		Clear	23.56	28	4.44	18.85	216.76	109.93
		Jelly blue	24.42	28	3.59	14.68	196.3	117.68
		Metallic	23.77	28	4.23	17.77	216.51	121.25
	8	silver						
				Mean of % extension		25.84		

dimensions. It could be possible that the elastomeric chains from the same company were produced by the different manufacturer. In additional it is probable that differences in manufacturing techniques, control quality of manufacture, other additives and both sterilization and storage techniques.

The force delivery behavior of Tuff® and Dynaflex® was similar curve (Fig4 and 5). In all chains, the fastest rate of force decay occurred in the first day and greatest loss occurred with first hour. Slow rate of force degradation through 3 to 7 days followed by a nearly constant force delivered through 28 days. These findings were agreement with the previous studies[1,3,10,11,13,14] in that the greatest loss of force in elastomeric chains occurred in the first hour and the forces delivered continue to fall but at a slow rate during the next two to three weeks. Beyond this time, in general, forces delivered remain nearly constant but at a level lower than originally available.

Major difference was magnitude of initial force which agreement with other studies[3,7,10-13,22]. In Tuff®, clear chains generated a highest force while jelly blue chains generated a lowest force. In Dynaflex®, metallic silver chains generated a highest force while jelly blue and pink chains generated a lowest force. So jelly blue chains from both companies generated a lowest initial force. It could be possible that effect of the filler material used in tinting elastomeric chains[5]. These imply that clinical implication should be use the force gauge in clinic for measurement the initial force or pre-stretched the elastomeric chain for reduce the initial force before apply on the teeth.

After 1 hour, 5 and 6 loops of Tuff® and Dynaflex® elastomeric chains generated force lesser than 350 gm except metallic silver (5 and 6 loops) of

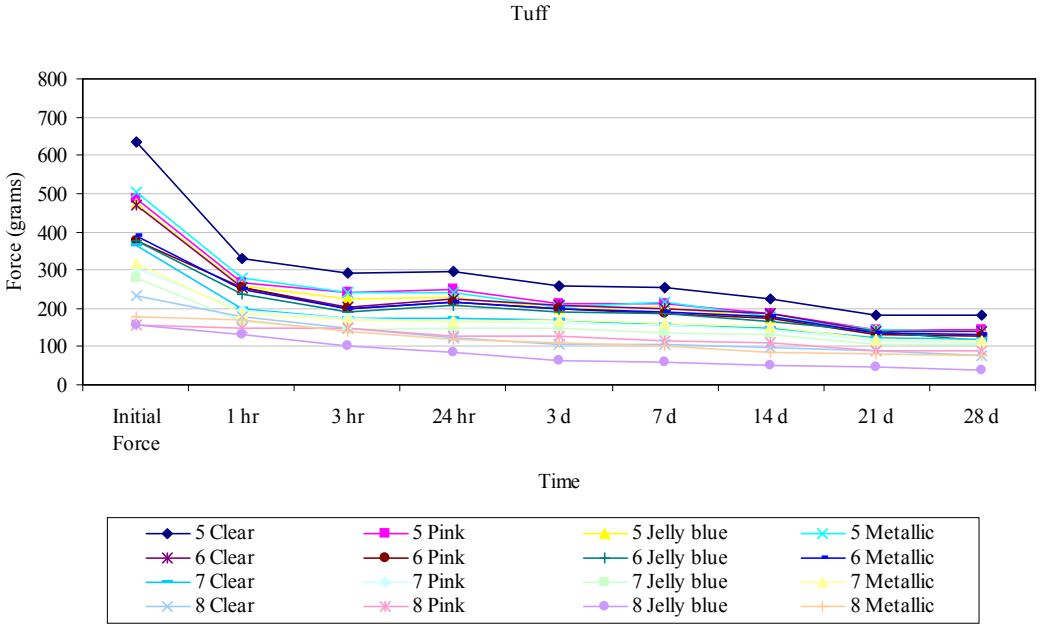

Fig.4 Graph of force delivery of Tuff® elastomeric chain through 28 days

Dynaflex® elastomeric chains. These imply that approximate 50 %- 100 % prestretching chains for 1 hour before loading on the teeth could generated nearly constant force levels were required during clinical use.

Ash and Nikolai[10] reported that chains in vivo environment exhibited significant more force decay than those kept in water and air. These imply that the final force of 7 loops of Tuff® and 8 loops of Dynaflex®

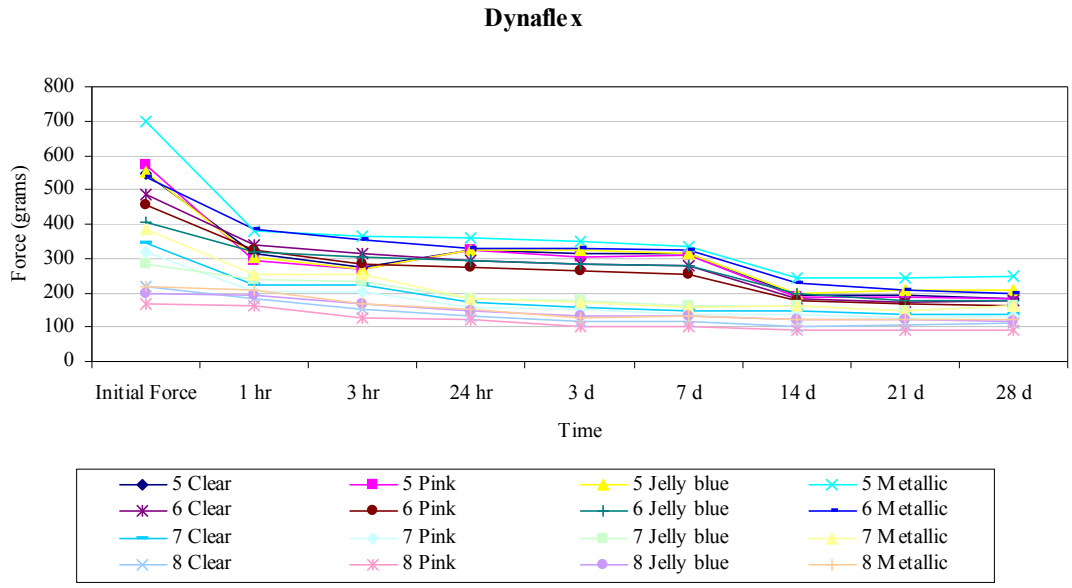

Fig.5 Graph of force delivery of Dynaflex® elastomeric chain through 28 days.

elastomeric chains which generated force nearly 100 gm may be lower than 100 gm if were tested in vivo.

Conclusion

The results of this study showed all elastomeric chains from each company were significantly differences in the dimensions. The length of elastomeric chains which generate the proper force for initial canine retraction were 7 loops in both Tuff® and Dynaflex® elastomeric chains as well as 8 loops of Dynaflex® elastomeric chain.

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