

Comparison of canine retraction by *in vivo* method using four brands of elastomeric power chain

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Abstract

Objective: To investigate the amount of space closure by movement of canines into the extraction spaces using four brands of elastomeric power chains (EPCs) by intraoral application with pre-adjusted appliance for 6 weeks.

Materials and Methods: The sample size calculation was based on the studies of Boester and Johnston and also with repeated measures analysis of variance (ANOVA) continuous data for force degradation, standard deviation of 24.9 g, and also from a pilot study, which totaled to around 17 patients with a mean age of 20 ± 2 years and receiving fixed orthodontic treatment that required retraction of canines into the premolar extraction spaces in all four dental arch quadrants. Four brands of EPCs, namely the Ormco, 3M Unitek, Rocky Mountain, and Highland, which were closed-link with five loops delivering less than or equal to 250 g were used. The rates of canine retraction were measured between the attachment points on the canine bracket hook and first molar hook using a Mitutoyo Digital Vernier Caliper at the time of first application, after 3 weeks of use, and at the end of 6 weeks of use, and were subjected to statistical calculations. **Results:** The distances recorded from canine retraction were similar with slight differences noticed in the four brands of EPCs. However, no statistically significant difference was observed in relation to the EPCs. **Conclusion:** Although all brands of the EPCs produced space closure of canines, it was observed that not much of a significant difference existed among the products tested.

Key words: Canine retraction, elastomeric power chain, premolar extraction

INTRODUCTION

Arch-length-to-tooth-mass discrepancy patients require extraction of teeth and closure of those spaces to correct their malocclusion. There are different mechanical methods used in orthodontic practice to move teeth,

such as using various types of elastic materials and coil springs.^[1] During the past few years, elastomeric power chains (EPCs) have been used in preference to other retraction orthodontic materials because of their elastic properties, ease of application and requiring no patient co-operation, low cost, being relatively hygienic, and their irritation-free nature due to their smooth surface.^[2]

Although these EPCs offer several advantages over other materials, *in vitro* tests (which fail to simulate *in vivo* intraoral conditions, including the amount of force applied initially, the action of oral flora and their by-products, and the possible synergistic effects of these variables) and some *in vivo* studies have reported decay of applied force over time.^[1-3] This force decay has been related to the period of use, as well as the amount of stretch given to the EPCs.

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Even though this force decay was found to be significant *in vivo*, only a few studies^[4-7] have cited the possibility of differences in force decay properties of EPCs from two different manufacturers. Moreover, polyurethanes, from which EPCs are made by thermosetting polymer products of a step-chain reaction polymerization process, possessing a $-(NH)-(C=O)-O-$ unit, are not inert materials; they are strongly affected by heat, moisture, and prolonged contact with enzymes.^[8]

The varied and patented formulations of these materials also suggest that there may be variations in the *in vivo* performance of EPCs from different manufacturers, but the clinician has no way of predicting the performance of the EPCs other than by comparative trials. At the end of a 6-week time period, it would be desirable for the orthodontist to know the remaining space compared with the amount that is considered desirable for ongoing tooth movement. However, there is no information available so far, comparing the effects of four brands of EPCs on the rate of canine retraction during clinical use when they are usually left in place during tooth movement on using them for a period of 3-6 weeks. It was, therefore, felt to be of value to test the amount of space closure *in vivo* using four different brands of EPCs.

MATERIALS AND METHODS

The sample size calculation was based on the repeated measures analysis of variance (ANOVA) continuous data for force degradation, standard deviation of 24.9 g,^[8] and also from a pilot study, which totaled to around 17 patients with a mean age of 20 ± 2 years. Informed consent letters were given to the subjects who were willing to participate. The inclusion criteria were subjects undergoing extraction of their premolar teeth and retraction of their canines to correct crowding or protrusion of incisor teeth by fixed orthodontic treatment at the Orthodontic Clinic of the Faculty of Dentistry, Khon Kaen University.

Four brands of closed loop EPCs were tested as shown in Figure 1a and 1b, since it has been observed that a more consistent force level is likely to be delivered by a closed loop chain.^[9,10] The four brands were chosen since they were readily available without any waiting time.

An initial load/deflection test of the four brands using the Lloyd universal testing machine (LR30K; Lloyd instruments Ltd, Hampshire, UK) was carried out during the pilot test.

A Correx gauge (Ispringen, Germany) was used for recording the force values. The accuracy of the Correx

gauge was checked by calibrating it with the help of a Lloyd testing machine (LR30K; Lloyd instruments LtdD). Mitutoyo Digital Vernier caliper (Japan) was used for measuring the distance between the first molar hook and the canine hook. The test was initiated after banding and bonding during the final stages of alignment with round 0.16" stainless steel arch wire insertion as the normal protocol for canine retraction. Hooks on the canine bracket and first molar band were the attachment points for five closed loops of the EPCs. The patients were asked to return at the end of the third week and sixth week for measurements considering that they are expected to cover the most common appointment recall periods used by orthodontists, but still it depends on the clinician preference.

The EPCs obtained from four different manufacturers were assigned to each of the four dental arch quadrants for the subjects participating in this study, by applying intraorally in a sequential clockwise direction.

The principal investigator recorded the forces and distances at each visit of the subjects. To test measurement reliability, the principal investigator did repeated measures of stretching force and distance using fresh elastics for five patients as a pilot study. As the canine-molar distance in the subjects' oral cavity could not be made constant, there were small variations in the stretching forces and distances.

The amount of the stretching force was recorded with a Correx gauge [Figure 2] which is a standard instrument for measuring orthodontic force. Distance between the first molar hook and the canine hook was also recorded at the same time with a Mitutoyo Vernier Caliper [Figure 3].

RESULTS

Measurements of distance changes between the canine and molar hooks

Due to loss of data, only 17 subjects' measurements were included in this analysis.

The amount of retraction force depends on the amount of extension of the EPC between canine and molar teeth, and as the canine is distalized, the retraction force of the EPCs reduces. For this reason, the changes in canine-molar distance were measured at the start and end of the third and sixth week test periods.

Descriptive statistics for distance changes between the canine and molar hooks

Table 1 and Figures 4 and 5 demonstrate the space closure achieved during 6 weeks of EPC use,

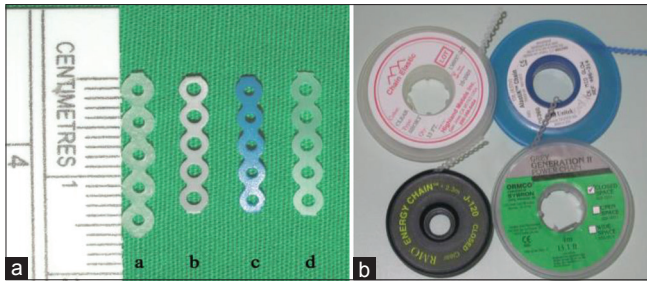


Figure 1: (a) EPCs employed in the study from left to right: a. Highland (Clear color); b. Ormco (Grey color); c. 3M Unitek (Blue color); d. Rocky Mountain (Clear color)



Figure 2: Recording the amount of stretching force with a Correx gauge



Figure 3: Recording the distance between the first molar hook and the canine hook also was recorded with a Mitutoyo Digital Vernier Caliper

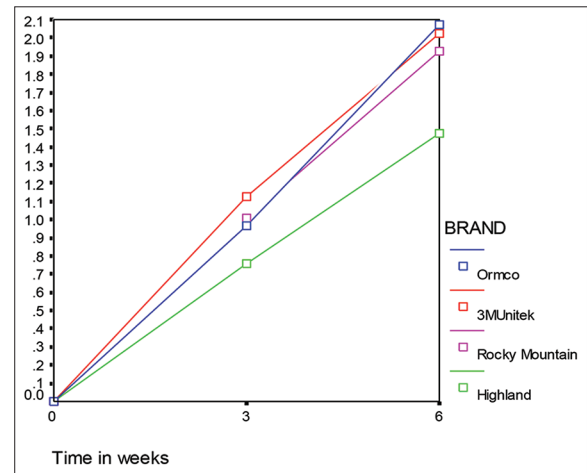


Figure 4: Graph showing the mean reduction of distance between canine and molar hook (mm) from start to end of three and six weeks of intra-oral application of EPCs. (n=17)

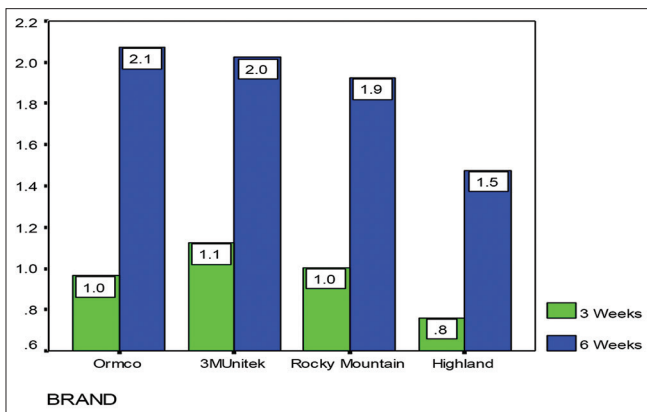


Figure 5: Bar Graph showing the mean reductions of distance between canine and molar hook (mm) from start to end of three and six weeks of intra-oral application of EPCs (n=17)

represented by the reduction in distance between hooks on canine and molar orthodontic attachments. The mean differences of space closure from the time of initial application of EPC were 0.96 mm by the end of third week and 2.07 mm by the end of sixth week for Ormco EPC; 1.12 mm by the end of the third week and 2.02 mm by the end of the sixth week for 3M Unitek EPC; 1.00 mm by the end of third week and 1.92 mm by the end of sixth week for Rocky Mountain EPC; and

Table 1: Mean reduction of distance measurements at 3 and 6 weeks use of EPCs stretched between the canine and molar hooks (N=17)

Brand	Week 3L	Week 6L
Ormco		
Mean	0.96	2.07
Std. deviation	0.37	0.81
3M Unitek		
Mean	1.12	2.02
Std. deviation	0.70	1.02
Rocky Mountain		
Mean	1.00	1.92
Std. deviation	0.41	0.81
Highland		
Mean	0.76	1.47
Std. deviation	0.45	0.95
All brands		
Mean	0.96	1.87
Std. deviation	0.51	0.91

EPCs = Elastomeric power chains

0.76 mm by the end of third week and 1.47 mm by the end of sixth week for Highland EPC.

Repeated measures ANOVA for comparing the mean reduction of distance between canine and molar hooks

Repeated measures ANOVA [Table 1] showed no significant differences on comparing the mean reduction of distance measurement at 3 and 6 weeks after placement for the four different brands of EPCs.

Multiple comparisons [Table 2] showed that no significant differences ($P > 0.05$) existed after 3 and 6 weeks time intervals in the mean reduction of distance measurement for the four different brands of EPCs.

Measurement of distance reduction based on percentage of initial distance recorded between canine and molar hooks

Descriptive statistics for distance reduction based on percentage of initial distance recorded between canine and molar hooks

To standardize the data and compensate for the variability in the initial distance among different subjects, the percentage reduction of distance from the time of placement till the end of test period in the oral cavity was calculated at 3 and 6 weeks intervals for each brand. Means and standard deviations of percentage reduction of distance during the 3 and 6 week test periods are presented in Table 3. There were not much notable variations between the different brands of EPC, both at 3 and 6 weeks intervals. After 6 weeks, the mean percentage reduction of distance among the four brands of EPCs ranged from 3.36 to 4.95%.

Figure 6 depicts the distance reduction based on the percentage of initial distance measurements.

Repeated measure ANOVA comparisons among the different brands for distance reduction based on the percentage of initial distance measurement at 3 and 6 weeks after placement for the four different brands of EPCs

Repeated measures ANOVA was employed to test for any significant differences in the distance changes between canine and molar hooks based on the percentage of initial distance measurement at 3 and 6 weeks after placement for the four different brands of EPCs.

Repeated measures ANOVA and multiple comparison analysis [Table 4] showed that no significant differences ($P < 0.001$) existed after 3 and 6 weeks time intervals for the force degradation based on the percentage of initial force measurement.

DISCUSSION

It should be emphasized that the term “initial force” was reserved for the force values recorded when the material was taken from the manufacturer’s spool and first stretched between the canine and molar hooks of the orthodontic appliance without pre-stretching before use. All types and sizes of polyurethane materials, regardless of the amount of stretch, showed a decrease in force with time when compared with the corresponding initial force, which is in agreement with the report of Eliades *et al.*^[11,12]

The present study confirms the previous findings that the force of EPCs is lost progressively over the period of application.^[1,5,9,12-15] The most important property of EPC use in orthodontics depends on its ability to exert a clinically acceptable force level over a set period of clinical use.^[8] The initial force used in this study ranged between 228.18 ± 30.21 g and 202.27 ± 43.82 g, depending on the canine molar distance and the particular EPC used. This force may be

Table 2: Multiple comparisons for the mean reduction of distance measurements at 3 and 6 weeks of intraoral use of EPCs

(I) Group	(J) Group	Mean difference (I-J)	Std. error	Sig.	95% confidence interval	
					Lower boundary	Upper boundary
3M Unitek	Highland	-0.24	0.69	0.984	-2.07	1.57
	Ormco	-0.10	0.69	0.999	-1.92	1.72
	Rocky Mountain	0.49	0.69	0.890	-1.32	2.32
Highland	3M Unitek	0.24	0.69	0.984	-1.57	2.07
	Ormco	0.14	0.69	0.997	-1.67	1.97
	Rocky Mountain	0.74	0.69	0.705	-1.07	2.56
Ormco	3M Unitek	0.10	0.69	0.999	-1.72	1.92
	Highland	-0.14	0.69	0.997	-1.97	1.67
	Rocky Mountain	0.59	0.69	0.823	-1.22	2.42
Rocky Mountain	3M Unitek	-0.49	0.69	0.890	-2.32	1.32
	Highland	-0.74	0.69	0.705	-2.56	1.07
	Ormco	-0.59	0.69	0.82	-2.42	1.22

Based on the observed means, EPCs = Elastomeric power chains

classed as “high,” but there is significant variation in the recommended force for canine distalization, from 100 to 150 g,^[16] up to 250 g,^[17] and from 100 to 200 g.^[18]

Decrease in force after a period of *in vivo* use results from the permanent extension of the EPCs called hysteresis, as well as by the masticatory forces being applied to the material, tooth movement, and also from degradation of the EPC material due to exposure to the oral environment.^[19] However, the orthodontic appliance used was the same for all test patients, as described in the methodology. The primary objective of the study was to measure the overall effectiveness of the different brands of EPCs in the oral environment for 6 weeks. The other factor that can be considered during canine retraction

is the friction between the arch wire and the bracket. The movement of the canine crown can be limited by the width of the periodontal ligament and the elastic capacity of the alveolar crest, which can also be a factor for canine retraction. Rate of canine retraction can also be increased when forces are immediately applied after tooth extraction, since the regenerative bone tissue refills the extraction socket within 3 weeks and becomes resistant and solid within 3 months.^[20] The more resistant the bone tissue is, the slower becomes the rate of tooth movement.

The orthodontic EPCs with five loops were selected in this study because they clinically applied less than 250 g of initial force between the attachment points. It was noted in this study that different samples of EPC from Rocky Mountain Company when subjected to a load of 250 g on the universal testing machine showed different patterns of deflection [Figure 7], suggesting

Table 3: Comparison of the percentage reduction of distance between canine and molar hooks at 3 and 6 weeks of intraoral application of EPCs (N=17)

Brand	Percent 3L	Percent 6L
Ormco		
Mean	4.33	9.27
Std. deviation	1.73	3.62
3M Unitek		
Mean	4.95	8.93
Std. deviation	2.95	4.22
Rocky Mountain		
Mean	4.53	8.61
Std. deviation	1.80	3.24
Highland		
Mean	3.36	6.53
Std. deviation	1.94	3.99
All brands		
Mean	4.29	8.34
Std. deviation	2.19	3.85

EPCs = Elastomeric power chains

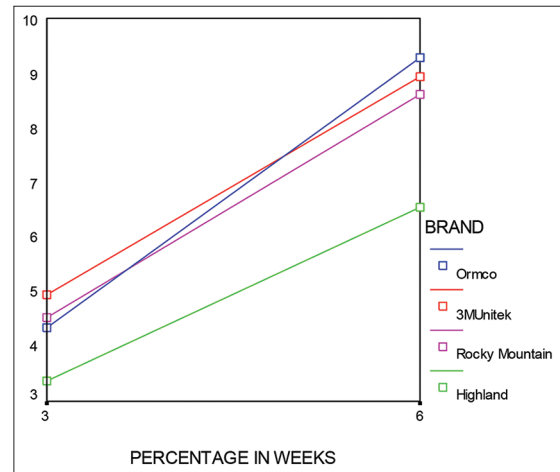


Figure 6: Graph showing the percentage reduction of distance between canine and molar hooks after three and six weeks of intra-oral application of EPCs. (n=17)

Table 4: Multiple comparisons for distance changes compared as the initial percentage reduction of distance at 3 and 6 weeks of intraoral use of EPCs

(I) Group	(J) Group	Mean difference (I-J)	Std. error	Sig.	95% confidence interval	
					Lower boundary	Upper boundary
3M Unitek	Highland	1.99	0.97	0.17	-0.56	4.55
	Ormco	0.14	0.97	0.99	-2.41	2.70
	Rocky Mountain	0.37	0.97	0.98	-2.18	2.93
Highland	3M Unitek	-1.99	0.97	0.17	-4.55	0.56
	Ormco	-1.85	0.97	0.23	-4.41	0.70
	Rocky Mountain	-1.62	0.97	0.34	-4.18	0.93
Ormco	3M Unitek	-0.14	0.97	0.99	-2.70	2.41
	Highland	1.85	0.97	0.23	-0.70	4.41
	Rocky Mountain	0.22	0.97	0.99	-2.33	2.78
Rocky Mountain	3M Unitek	-0.37	0.97	0.98	-2.93	2.18
	Highland	1.62	0.97	0.34	-0.93	4.18
	Ormco	-0.22	0.97	0.99	-2.78	2.33

Based on the observed means, EPCs = Elastomeric power chains

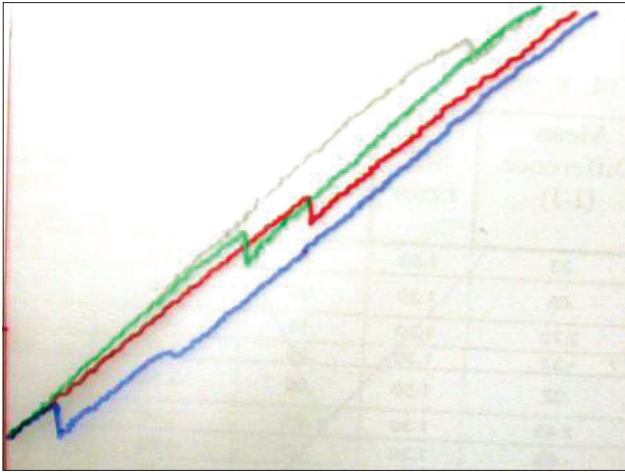


Figure 7: Illustration indicating Rocky Mountain EPC manufacturing defects

that manufacturing variations may exist in the material tested from the same spool.

Other studies^[21,22] have found differences in the elastic ligature properties. Therefore, if a strict quality control is not enforced during the manufacture of elastomeric chains, test results may be different.

CONCLUSION

- Not much significant differences were found among the four brands of EPCs used
- Regardless of the properties that EPCs possess, they are still a suitable choice as tooth-moving elements with acceptable force levels
- The clinician might have more control when using EPCs than while using elastic rings which depends on continuous reapplication by the patient. An accurate estimation of the force is more difficult with polyurethane elastomeric materials because of the inability to accurately predict the amount of decay in the force originally applied
- EPCs are fail-safe products since in the event of a patient missing the orthodontist's appointment, their timeframe of progressive degradation would preclude them from continuing to act beyond their planned effect.

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