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Original Article

Comparison of Canine & Molar Rotation Caused by NiTi Coil Spring and Elastomeric Chain in Treatment of Class II Division 1 Extraction Cases in a Tertiary Hospital

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ABSTRACT

Introduction: Understanding the effects of NiTi coil springs and elastomeric power chain methods in canine retraction and comparing their outcomes can help improve orthodontic treatment results by increasing the efficiency of the treatment. **Materials and methods:** This quasi-experimental study was carried out among 20 participants, including both males and females, aged between 13 to 25 years, with Class II division 1 malocclusion requiring upper first premolar extractions, who were selected by purposive sampling technique. After obtaining written consent, a study model was obtained before initiation and after completion of space closure. During canine retraction, a power chain was placed at one side while a coil spring was placed in other side of upper jaw of each participant. Elastomeric chain was changed after every 3 weeks whereas the NiTi coil was only changed if it was broken. After completion, data were recorded and analyzed through data management descriptive statistics including mean and standard deviation (SD) for all measurements. Paired t-tests were used to assess the data after a normality test was completed. A p-value<0.05 was considered statistically significant. **Results:** This current study revealed that NiTi coil springs showed higher mean rotation of canine (5.1°) and molar (1.1°) than the power chain group. However, the p-values for all comparisons—canine rotation (p=0.077) and molar rotation (p=0.805)—indicated that the differences were not statistically significant. The results also showed no significant differences between the age groups or genders. **Conclusion:** This study demonstrates that NiTi coils had slightly more canine & molar rotation than power chain group. Although the two methods did not significantly differ in their treatment effects between the age groups or genders.

KEYWORDS: *Canine retraction, Elastomeric chain, NiTi coil springs, Canine rotation, Molar rotation*

INTRODUCTION

In orthodontic treatment, canine retraction and space closure are thought to take the longest duration which could be accelerated to shorten the duration of treatment to increase patient compliance and minimize any potential adverse effects [1]. To shorten treatment times, many attempts have been made to manipulate tissue response and tooth biomechanics. Furthermore, a great deal of research has been done on the effectiveness and safety of various force systems and canine retraction techniques [2]. There are various methods available for canine retraction at the moment. NiTi closed coil springs and elastomeric power chains are two methods that are frequently employed. In orthodontics, elastomeric power chains are frequently utilized as they are efficient, user-friendly, colorful, and comfortable for patients [3]. Despite the fact that these chain's primary function is to stretch back to its initial length when applying force, a number of studies have shown that this force is reduced after application both in vivo and in vitro use [4]. They can exert strong, sporadic force. On the other hand, NiTi coil springs use a light continuous force to provide comparatively more stable extraction space closure [2]. Two circular eyelets are attached to each side of the coil to make its application easier. In an in vitro investigation, it was shown that whereas the force of elastomeric chains dramatically dropped after two hours, but the force of NiTi coils dropped after eighteen hours and stayed steady for twenty-one days [3]. Elastomeric power chains are relatively consistent in producing tooth movements, but have several drawbacks like rapid decay of forces whereas NiTi coil springs have been shown to produce a constant force over varying lengths with no decay [2]. Using CBCT-based measures, Barsoum et al. [2] recently examined canine and molar rotation and tilting between

elastomeric chains and NiTi coils and found no discernible differences. Their utilization of TADs as a skeletal anchoring for canine retraction is the primary distinction between their investigation and the present one. This explains the reports of negligible effects on the first molar. Additionally, they accomplished space closure on 0.017x0.019 inch stainless steel (SS) wire and connected coils and chains to the lengthy hooks, which applied force close to the canine's center of resistance. Both have an impact on how much the canine rotates. Lastly, the canine's rotation during retraction may be influenced by its ligation procedure. Canine rotation can be reduced with self-ligated brackets [5]. Additionally, the tooth's mobility and rotation might be affected by a tighter or looser ligation [4]. A comparative study of space closure rate in canine retraction by Ni-Ti closed coil spring and elastics power chain has been conducted previously in Bangladesh [6]. However, the negative consequences of these two methods of space closure, such as canine and molar rotation, were not mentioned in that study.

The aim of this study was to compare the amount and degree of adverse effect, such as canine and molar rotation caused by these two techniques in Class II division 1 extraction cases in subjects taking orthodontic treatment at a tertiary hospital in Bangladesh. The data were useful to compare the results of this study with the other data reported in different populations and also will be helpful in orthodontic treatment planning.

MATERIALS AND METHODS

This quasi-experimental study was carried out at Department of orthodontics, BMU, Shahbagh, Dhaka, from March 2024 to February 2025. Study sample were Class-II division 1 malocclusion subjects, within the age of 13-25 years, who were receiving fixed orthodontic treatment in the Department of Orthodontics, BMU. Purposive sampling procedure technique was followed for this study according to criteria for inclusion and exclusion.

Criteria for sample selection

Inclusion criteria

i) Generally healthy subjects
ii) Age ranging from 13 to 25 years
iii) Class II division 1 malocclusion which needs extraction of the maxillary first premolar as a component of orthodontic treatment
iv) Fixed orthodontic appliance of Roth system
v) During canine retraction, neither anchorage control nor inter-arch elastic are used.
vi) Without taking into account the second and third molars, all permanent teeth are present and have erupted.
vii) Subjects who had completed first stage (leveling and alignment) of orthodontic treatment.

Exclusion criteria

i) Systemic illness that could influence movement of tooth
ii) Taking drugs that could influence movement of tooth
iii) Subjects who received segmental canine retraction technique
iv) Pregnancy
v) Except for class II division 1 malocclusion, all other malocclusions
vi) Class II division 1 malocclusion where extraction is not necessary
vi) Subjects who will not attend regular follow up sessions
vii) Subjects with buccally, or, palatally impacted canine, or, molar
viii) Subjects who had significant root resorption, or, periapical lesion beneath canine, or, molar teeth.

Sample size was calculated and sample size was 40. According to inclusion and exclusion criteria, 40 samples (20 patients, 2 quadrants) were collected from study population by purposive sampling method. A split mouth technique was utilized with NiTi closed coil springs on right side and elastomeric power chain on the left side in the same patient. So, a total of 40 samples were obtained from 20 patients through split mouth technique and was divided into 2 groups named Power chain groups (20 in number) and NiTi closed coil spring groups (20 in number). The sample included natives of Bangladesh.

Ethical approval by The Institutional Review Board (IRB) of BMU was taken prior to the start of this investigation. The Helsinki Declaration's ethical guidelines was followed in every step of the investigation.

Data collection procedures:

Clinical treatment of the participants were done under the supervision of an expert orthodontist. An impression was taken and study model was made before initiation of treatment. An Orthopantomogram (OPG) was obtained using a x-ray machine in a radiology centre by an expert technologist before initiation of space closure. Each and every patients were bonded with pre-adjusted Roth system brackets made of stainless steel (SS) and buccal tubes with a slot size of 0.018x0.022 inches. Standardized bracket positioning protocol was followed for placement of brackets in all teeth, including canine and molars. For levelling and alignment, 0.012 inch stainless steel (SS), 0.014 inch stainless steel (SS) and 0.016 inch stainless steel (SS) wires were used subsequently. Tooth extraction was done before bonding and space closure was performed after proper levelling and alignment before going into canine retraction phase. For space closure, a thread of elastomeric chain was used on the left side and a 9 mm NiTi closed coil spring was used on the right side. Both the NiTi coil and the elastomeric chain were connected to the buccal tube hook on the first molar from the canine hook. Stainless steel (SS) ligature was used to secure canine brackets to the wire. A Correx force gauge was used to measure the force in both techniques, which came out to be about 200 grams. The study did not employ inter-arch elastics or anchorage control techniques. Patients were recalled after every 3 weeks (21 days) and observations were made comparing how much space closure associated with rotation and tipping has occurred at each side. The NiTi closed coil was only replaced at each visit if it was damaged or could not regain its original length. The elastomeric power chain was replaced after each visit. When the canine showed excessive distopalatal rotation rather than mesiopalatal rotation in subsequent visit, the bracket positioning was rechecked and bracket placement was done again according to standard protocol if needed. Again, an impression was taken and study model was made after completion of space closure. An SLR digital camera (Canon EOS 700D, Tokyo, Japan) was used to capture a digital image of the study cast's occlusal view. A photo-quality color ink tank printer (HP ink tank 315 series) was then used to print the photos to actual size in order to produce a colorful occlusal view. The angle between their mesiodistal height of contour and midpalatal raphe was then measured on research model occlusograms to evaluate the rotation of canines and first molars before and after space closure (figure-1).

Canine rotation can be measured on a study model occlusograms through the following landmarks.

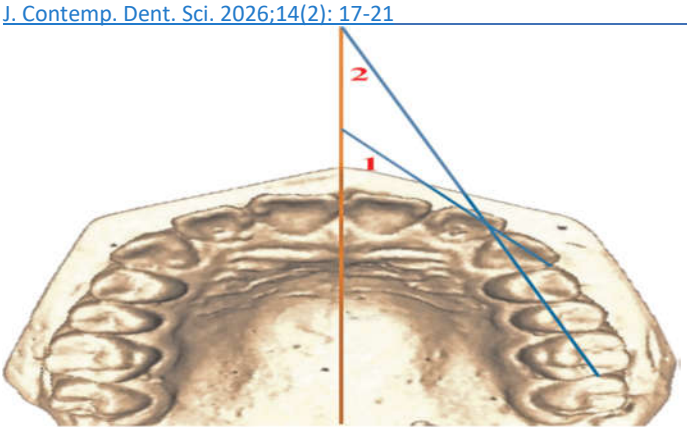

Figure-1: Measurement of tooth rotation using dental casts. 1. the angle created by the midpalatal raphe and the canine height of contour; 2: the angle created between the midpalatal raphe and the height of contour of the first molar. (Figure-1 Courtesy : Hashemzadeh et al. [3])

The final value was subtracted from the beginning value to determine the tooth rotation. An experienced orthodontist took every measurement. Measurements of 20 participant's models were done and all the necessary data were acquired.

analysis procedures:

There was a per-protocol analysis. The two canine retraction techniques' means were compared. The Shapiro-Wilk test showed that the data for molar and canine rotation had a normal distribution ($P > 0.05$) and the paired t-test was used to determine difference in measurement between two groups. All of the statistical analysis were carried out by principal investigator using specialized statistical software, SPSS v.18 (SPSS, Chicago, IL) at a significance level of 0.05. Data collection sheets underwent pre-testing procedures. Each and every step of study model measurement and sample grouping were conducted by same investigator (PI). The guide provided direct supervision over every step of the study. To investigate the reliability of study models analysis, 40 sample's data were traced twice by same investigator at an interval of 1 month. All data were entered and analyzed by principal investigator.

RESULTS

Age distribution of the study participants

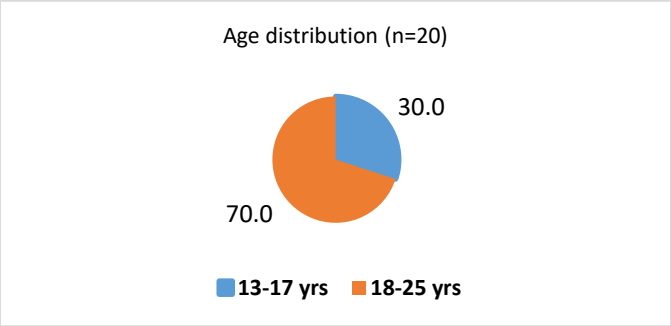

Figure-2: Pie diagram showing Age distribution of the study participants

The pie diagram shows the age distribution of the study participants. Out of the 20 participants, 70% were in the 18-25 years age group, while 30% were between 13-17 years old.

Sex distribution of the study participants

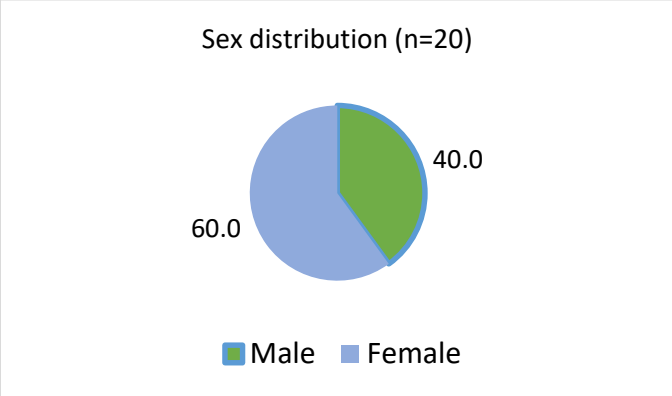

Figure-3: Pie diagram showing the sex distribution of the study participants

The pie diagram illustrates the sex distribution of the study participants. Out of the 20 participants, 60% were Female, while 40% were Male.

Table-1: Test of normality

	Shapiro-Wilk		
	Statistic	df	Sig.
Canine Rotation Initial	.956	20	.475
Canine Rotation Final	.952	20	.394
Molar Rotation Initial	.964	20	.626
Molar Rotation Final	.932	20	.169

Table-1 shows the results of the Shapiro-Wilk test for normality applied to various clinical parameters in the study. The test assesses the normality of data distribution for initial and final canine rotation, molar rotation. The p-values for all parameters are greater than the significance threshold of 0.05, indicating that the data for all these parameters follow a normal distribution.

Table-2: Comparison of the effects of orthodontic treatment on the Power Chain group's canine and molar rotation at the initial and final stages (n=20)

Variables	Initial (n=20)	Final (n=20)	Changes	p-value
Canine Rotation	21.30±5.98	29.35±8.25	8.05±6.55	0.004*
Molar Rotation	21.75±9.90	22.40±4.25	0.65±10.27	0.846

Mean±SD and range were used to express the data.
p-value from the paired t-test; p<0.05 was regarded as a *significant level.

Table-2 presents the comparison of orthodontic treatment effects on canine rotation, molar rotation in the Power Chain group between the initial and final stages. A statistically significant improvement was observed in canine rotation, with a mean change of 8.05±6.55 (p=0.004), indicating that the treatment had a positive impact on this parameter. However, no significant changes were found in molar rotation (p=0.846), as their respective p-values exceeded the threshold of 0.05.

Table-3: Comparison of the effects of orthodontic treatment on the NiTi Coil group's canine and molar rotation at the initial and final stages (n=20)

Variables	Initial (n=20)	Final (n=20)	Changes	p-value
Canine Rotation	18.50±5.62	31.70±6.53	13.20±5.71	<0.001*
Molar Rotation	20.70±7.83	22.45±7.65	1.75±9.33	0.567

Mean±SD and range were used to express the data.
p-value from the paired t-test; p<0.05 was regarded as a *significant level.

Table-3 shows the comparison of orthodontic treatment effects on canine rotation, molar rotation, canine tipping, and molar tipping in the NiTi Coil group between the initial and final stages. A significant change was observed in canine rotation (p<0.001) with mean change of 13.20±5.71. However, molar rotation (p=0.567) showed no significant changes, with mean changes of 1.75±9.33.

Table-4: Comparison of changes after orthodontic treatment in the Power Chain Group Versus NiTi Coil group (n=40)

Variables	Power Chain (n=20)	Niti Coil (n=20)	p-value
Canine Rotation	8.05±6.55	13.20±5.71	0.077
Molar Rotation	0.65±10.27	1.75±9.33	0.805

Mean±SD and range were used to express the data.
p-value from the paired t-test; p<0.05 was regarded as a *significant level.

Table-4 compares the changes in orthodontic treatment effects on canine rotation & molar rotation between the Power Chain and NiTi Coil groups. The changes observed in the Power Chain group were slightly lower than in the NiTi Coil group for all variables, but the differences were not statistically significant. The p-values for all comparisons—Canine rotation (p=0.077), molar rotation (p=0.805)—indicate that both treatment methods had similar effects on the measured parameters.

Table-5: Comparison of changes after orthodontic treatment in the Power Chain Group Versus NiTi Coil group between two age groups (n=20)

Variables	13-17 years (n=6)	18-25 years (n=14)	p-value
Canine Rotation	13.50±7.06	9.39±6.15	0.206
Molar Rotation	4.58±10.09	2.25±4.21	0.466

Mean±SD and range were used to express the data.
p-value from the paired t-test; p<0.05 was regarded as a *significant level.

Table-5 compares the changes in orthodontic treatment effects on canine rotation & molar rotation between two age groups: 13-17 years (n=6) and 18-25 years (n=14). The results show no statistically significant differences between the age groups for any of the measured variables, with p-values for canine rotation (p=0.206), molar rotation (p=0.466), indicating similar treatment outcomes.

Table-6: Comparison of changes after orthodontic treatment in the Power Chain Group Versus NiTi Coil group between male and female (n=20)

Variables	Male (n=8)	Female (n=12)	p-value
Canine Rotation	10.00±7.03	11.04±6.48	0.737
Molar Rotation	3.56±12.85	2.38±3.45	0.763

Mean±SD and range were used to express the data.
p-value from the paired t-test; p<0.05 was regarded as a *significant level.

Table-6 compares the changes in orthodontic treatment effects on canine rotation & molar rotation between male (n=8) and female (n=12) participants. The results showed no statistically significant differences between genders for most variables, with p-values for canine rotation (p=0.737), molar rotation (p=0.763), indicating similar treatment effects.

DISCUSSION

Comparing two traditional techniques for canine retraction was the goal of the current investigation. The findings demonstrated that NiTi coils exhibit slightly more Molar rotation than Power Chain but the differences were not statistically significant. This slightly higher rate of NiTi Coil group may be due to the fact that elastomeric chains experience considerable force decay, NiTi coils produce light continuous force and very little, or, no force decay over a period. Comparable outcomes between NiTi coils and power chains—which have a longer force delivery duration—were reported by Khanemasjedi et al. [7].

The current study's intriguing conclusion was that more canine rotation were linked to the NiTi coil spring group but the differences were not statistically significant. The p-values for all comparisons—Canine rotation (p=0.077), molar rotation (p=0.805)—indicate that both treatment methods had similar effects on the measured parameters.

Similarly, Mohammed et al. [9] recently carried out a meta-analysis between the two space closure techniques of NiTi closed coils and Power chains, and revealed that there does not appear to be a substantial difference in loss of anchorage between this two techniques, while not conducting analysis on the subject. Side effects such as tooth rotation and tilting were not assessed in their review.

The current study's split-mouth design additionally examined the effects of gender and two distinct age ranges (13–17 years and 18–25 years) on the treatment outcomes of the two techniques. The results showed no statistically significant differences between the age groups for any of the measured variables. Moreover, the results showed no statistically significant differences between comparison between genders for most variables too, with p-values for canine rotation (p=0.737), molar rotation (p=0.763), indicating similar treatment effects.

Likewise, Nightingale and Jones' [10] clinical study revealed that, although the force of elastomeric chain was greater than that of NiTi coils during canine retraction, there was no discernible difference in their retraction rate. Most importantly, there was no discernible difference in the two groups' levels of anchoring loss, or the first molar mesial displacement. There were no statistically or clinically meaningful change either. Similarly, the mean rate of molar mesial

migration was 0.46 and 0.45 mm/month, according to a previous study by Bokas and Woods [11]. However, these findings could not be compared to the current study since the latter did not include an anchoring control device, whereas the former did use a transpalatal arch (TPA).

According to Bouwens et al. [12], cone-beam computed tomography (CBCT) is more accurate than panoramic imaging for angulation of the teeth. But in this investigation, the same approach was used to measure the teeth's angulation before and after gap closure, and the two space closure methods' differences in tooth angulation were compared. Additionally, the intra-examiner reliability of the tooth angulation measurement was 0.807 for the canine and 0.732 for the molar, both of which are regarded as having good reliability. Measurements could have been taken on CBCT images or in relation to a mini-implant.

However, from an ethical standpoint, these interventions are unacceptable. The operator must select from a variety of canine retraction techniques in a clinical setting. The new study's findings aid physicians in making better clinical decisions.

With more canine rotation, NiTi coils should be used cautiously. Moreover, NiTi coils are more costly than elastomeric chains, but because they provide more constant force, they can be activated at longer intervals.

With a sample size of 40 (20 patients), the present investigation was a split-mouth prospective research that attempted to address the methodological flaws in earlier research.

CONCLUSION

According to the findings of this clinical experiment, NiTi coil springs had slightly more canine rotation as well as more molar rotation than power chain group. Although the two methods did not significantly differ in their treatment effects, preventive measures should be taken to minimize rotation and tipping before using NiTi coil springs for canine retraction.

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CONFLICT OF INTEREST: The authors declare that there is no conflict of interest regarding the publication of this paper.

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