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Comparative evaluation of Nickel-Titanium closed coil spring and Elastomeric chain for canine retraction. A Randomized Clinical Trial

Aditya Talwar[1], Shweta R Bhat[2]
[1]*Study design, Sample collection, Statistical Analysis, Discussion and Results.*
[2]*Sample collection, Statistical Analysis and Discussion.*
(Department of Orthodontics and DentofacialOrthopaedics, Nair Hospital Dental College, India)
Corresponding Author: Aditya Talwar

Abstract:
Introduction:*Preadjusted Edgewise appliance (MBT) has popularized the use of sliding mechanics, which has become the most commonly used method of achieving space closure in orthodontics. In the quest for the most efficient method of delivering constant retractive force to the teeth, NiTi closed coil springs and the elastomeric chains have been the most commonly used modalities. The aim of this investigation was to find out and compare the rate of mandibular canine retraction with NiTi closed coil spring and elastomeric chain delivering 200grams of force with sliding mechanics using preadjusted edgewise appliances.*
Methods:*In this Randomized clinical trial, 30 patients with bimaxillary dentoalveolar protrusion to be treated with 1st premolar extraction and high anteroposterior anchorage requirement, were included. All of them were bonded with 0.022 MBT bracket prescription. After alignment and leveling, each patient was assigned a number,then allocated into a groups with the help of computer-generated random number table. The mandibular canine retraction was started in the two groups with the help of NiTi closed coil spring and Elastomeric chain delivering 200grams of force and at each visit after 4 weeks interval, the force levels were checked and calibrated at every appointment for 3months.*
Results:*A statistically significant difference was seen between the rate of mandibular canine retractionusing NiTi closed coil spring and elastomeric chains. However, the difference seemed to be clinically non-significant.* The mean rate of space closure for NiTi closed coil spring and the Elastomeric chain was 1.62±0.14mm/month and 1.33±0.13mm/month respectively.
Conclusion:*NiTi closed coil spring was found to be more efficient in retracting the mandibular canine, the difference however was clinically non-significant. Additionally, the clinician should take into account the considerable cost factor associated with NiTi closed coil springs. Thus, Elastomeric chains present as a suitable alternative to NiTi coil spring for space closure in sliding mechanics.*

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I. Introduction

Orthodontic treatment is needed for the alignment of the teeth and correction of any pertaining malocclusion. To correct severely proclined and forwardly placed teeth, fixed orthodontic treatment is carried out afterextraction of all first premolars. In such bimaxillary dentoalveolar protrusion cases, the stage of space closure is deemed as one of the most important stages. It strives to correct the proclination and ideally positionthe anterior teeth as well as manage the extraction space by requisite movement of the posterior teeth so as to achieve the optimum treatment objectives and best facial esthetics for the patient.

With the evolution of the MBT philosophy, space closure by sliding mechanics has gained substantial popularity[1]. The friction-based technique is very commonly used due to its convenience and its high predictability of results, since the archwires dictate the direction of tooth movement[2]. In this method, there are several means for providing the retractive force, which maybe in the form of elastomeric chains, NiTi closed coil spring, active tiebacks[3].

Elastomeric chains and modules are relatively consistent in producing tooth movement but have several drawbacks like rapid force decay and permanent deformation resulting in only 30-40 percent of the original force remaining after four weeks. They, however, provide a much more economical and effective treatment option[4–6]. On the other hand, NiTi closed coil springs, which are resistant to permanent deformation have shown to produce a relatively continuous light force over varying lengths with no force decay[1,7,8]. Their major

drawback in clinical practice remains the cost of each unit and that the actual force magnitude delivered under clinical conditions may be different due to variations in oral temperature.

Previous clinical studies have compared the effectiveness of NiTi coil spring and elastomeric chains during space closure[9,10]. However, these studies suffered from methodological errors, as they did not consider the applied force magnitude and had inadequate sample size.

Storey and Smith specifically considered the relationship between the rate of tooth movement and applied force for orthodontic tooth movement. They observed maximum rates of tooth movement when forces in the range of approximately 150-250gms were applied during canine retraction[11]. When the forces were increased beyond this range, there was very little movement of canines observed initially, instead there was appreciable movement of anchor teeth.The present study was therefore designed to compare the rate of mandibular canine retractionusing either NiTi closed coil spring or elastomeric chain delivering a known amount of force using preadjusted edgewise appliance. The null hypothesis was that there is no difference between the two methods of retraction in terms of their rate of space closure.

II. Material And Methods

Study Design: Randomized Clinical Trial

Study Location: This was a tertiary care teaching hospital-based study done in the Department of Orthodontics and DentofacialOrthopaedics, Nair Hospital Dental College, Mumbai, Maharashtra, India

Study Duration: December 2017 to September 2018.

Sample size: 30 patients.

Sample size calculation: The sample size was estimated from the available literature[7,12], mean and Standard deviation were used to calculate the effective sizeof the two groups. The confidence interval of 10% and a confidencelevel of 95%was assumed. The sample size actually obtained for this study was 11 patients (22 teeth) for each group so it wasplanned to include 30 patients {15patients(30 mandibular canines) each inGroup I and II} to account for a 20% drop out rate.

Subjects & selection method: The study population was drawn from consecutive patients who presented to Department of Orthodontics and Dentofacial Orthopedics, Nair Hospital Dental College, Mumbai for orthodontic treatment and required extraction of First premolars in their treatment plan. 30 patients were selected who were treated with fixed appliances in the upper and lower arch. There were 10 males and 20 females with a mean age of 20.4 years (range= 15.2 to 27.5years). The preadjusted bracket prescription selected for retraction with sliding mechanics was 0.022 X 0.028" MBT (Dentos). After the initial stage of alignment and leveling the patients were kept on 0.019 X 0.025" stainless steel archwire for a month for torque expression. This was followed by collection of orthodontic study models, which served as the baseline record for the study.

Informed consent was obtained from all the patients and recommended approval was taken from the ethical committee at Nair Hospital Dental College, Mumbai.

Each patient was given a number and at this point with the help of computer generated Random number table, the sample population was divided into two study groups.

Group I (N=15 patients) –Mandibular canine retraction with 9mm closed coil spring

Group II (N=15 patients) –Mandibular canine retraction with Elastomeric chain.

Inclusion criteria:

1. Patients with permanent dentition, including erupted second molars.
2. Patients with treatment plan involving extraction of 1st premolar.
3. Patients undergoing treatment with fixed mechanotherapy. (0.022" MBT slot)
4. Initial alignment and leveling to be achieved with a series of NiTi wires.
5. Aged ≥ 18 years.

Exclusion criteria:

1. Patients with congenital abnormalities or systemic diseases causing a change in the density of the bone.
2. Patients on any medication such as bisphosphonates.
3. Patients with a systemic condition like diabetes, bleeding disorder etc.
4. Patients being treated with any other bracket prescription.
5. Patients with different extraction pattern as part of their treatment plan.
6. Patients with periodontally compromised teeth.
7. Patients with a history of drug or alcohol abuse.

Procedure methodology

A written informed consent was obtained before the commencement of the study from all the patients. A total of 30 patients (60 mandibular canines) were selected by consecutive sampling technique from patients reporting for orthodontic treatment and requiring extraction of 1st premolars in their treatment plan. After the initial stage of alignment and leveling the patients were kept on 0.019 X 0.025" Stainless steel archwire for a month for torque expression. This was followed by randomization of the patients into two groups for retraction of mandibular canine. Upper and lower study models were made at this point, which served as the baseline record.

Group I –Mandibular canine retraction with 9mmNiTi closed coil spring (G&H,Franklin, Indiana, USA) .
Group II –Mandibular canineretraction with Elastomeric chain (American Orthodontics).

The retraction force was measured and calibrated to 200gms with the help of Dontrix gauge.Elastomeric chain and NiTi closed coil spring were engaged from the mandibular first molar hook to the mandibular canine hook. Posterior anchorage was prepared by ligating the mandibular second premolar and first molar with a ligature tie. At any point, the 9mm NiTi closed coil spring was not stretched to more than 12mm[13].

After the commencement of the mandibular canine retraction on both the sides of the mandibular arch, all the patients were recalled after every 4 weeks for three visits. In all these visits the forces were checked and correspondingly adjusted to maintain a load of 200gm by monitoring sufficient activation of the NiTi coil spring and replacement of the Elastomeric chain.[14]
At the end of the experimental period, an impression of the mandibular arch was taken and study model was made to record the final measurements. The amount of retraction achieved was measured from the cusp tip of the mandibular canine to the mesial groove of the mandibular first molar on either side of the arch with a help of a Digital Caliper (at 0.01mm accuracy, Mitutoyo, Sakado, Japan).
Due to nature of the study, blinding was achieved by numbering the casts before and after canine retraction and the measurements were subsequently recorded.

Statistical analysis

Data was tabulated and analyzed with the help of Microsoft Excel and SPSS version 20 (SPSS Inc., Chicago, IL). Student's *t*-test was used to ascertain the significance difference between mean values of two continuous variables and confirmed by a nonparametric Mann-Whitney test. The level of significance was set at 0.05 for the study.

III. Result

The total retraction of the mandibular canine achieved in 3months was 4.93mm and 4.05mm in the NiTi closed coil spring and elastomeric chain groups respectively, with a mean difference of 0.88mm($p<0.05$) between the groups. Table 1 summarises the rate of space closure. The mean rate of space closure for NiTi closed coil spring and the Elastomeric chain was 1.62±0.14mm/month and 1.33±0.13mm/month respectively. With a mean difference of 0.28mm/month($p<0.05$) which was statistically significant but clinically non-significant.The maximum rate of space closure for the NiTi closed coil spring was 1.90mm/month and for elastomeric chain 1.47mm/month. The minimum rate of space closure was 1.23mm/month for NiTi closed coil spring and 0.98mm/ month for elastomeric chains.

Table II summarizes the rate of space closure in males and females, where no statistically significant difference could be observed between the two sexes.

IV. Discussion

Orthodontic space closure has traditionally been achieved with the help of space closure loops in standard edgewise techniques. However, with the development in the Preadjusted edgewise technique (MBT), the concept of sliding mechanics also gained widespread acceptance, with the latter being simpler in achieving same treatment results. In the present study, space closure in all the cases was carried out by sliding mechanics with the same initial force exerted by the spring and elastomeric chainapplied over the same duration of time. The results indicate that there was a statistically significant difference in the rate of space closure. Reitan[15] reported the importance of the biological response and the individual variation in tissue reaction due to variation in metabolic response. It was thus concluded that there was a large variation among patients precluding the formulation of simple theories regarding force and anchorage. The force magnitude required to bodily move canines is estimated to range from as low as 100gm to as high as 300-350 grams and this force is thought to be

dependent on the root surface area of the teeth being moved. Thus, the force selected for the retraction in the study was taken as 200gms.

Using a Dontrix gauge, the NiTi closed coil spring and elastomeric chains were calibrated to deliver an equal force for the same length of time. Also, with a large variation in the initial force levels produced by different elastomeric products and their variable force characteristics, many authors have recommended a high initial force (400-450grams)[1] by an initial over-extension of elastomeric chain to compensate for the anticipated force decay[16,17].

Such force levels are excessive in view of the recommendation of Reitan who recommended a force of 150-250grams for the canine retraction. Quinn and Yoshikawa[18] summarized that a force between 100-200gms would be most efficient for canine retraction.

The small difference of 0.28mm/month between the two methods of space closure is significantly less than that reported in the previous studies. While some studies have demonstrated the rate of space closure by NiTi closed coil spring to be significantly greater than elastomeric chains[1,12,19], it is still difficult to reliably compare the rate of tooth movement achieved with them. However, the study results were in concordance with the study by Bokas and Woods[20] who have applied a similar amount of force on the maxillary canine.

Also, initial high forces from elastomeric products in anticipation of their inherent force decay may have caused undue tissue hyalinization and slower tooth movement[11,15].

While all the activation was done to maintain a uniform force of 200grams on the mandibular canine for retraction, the effect of fluctuations in the temperature of the oral cavity with different food and beverages cannot be ruled out. Although standard NiTi closed coil spring was used to minimize the effect of temperature fluctuation, the effects of temperature on the elastomeric chains could not be controlled[7,21].

Also, the actual stress generated by the device may be difficult to determine due to differences in root morphology and periodontal architecture. The springs and elastics are subjected to uneven minor disturbances like chewing that could repeatedly stretch and relax them. Moreover, due to friction involved in the sliding mechanics, the amount of force ultimately delivered to the teeth is likely to be less. Lotzof et al.[22] stated that this frictional force is about 55gms and would account for an actual reduced amount of force delivered to the teeth. Finally, asit has been observed that the brackets undergo a "stick-slip" action along the archwire.Hence with the movement of the canine itself and subsequent deactivation, the initial force would fall in both NiTi closed coil spring and elastomeric chains.

Although Nattrass et al[23] stated that force decay with NiTi springs was less than elastics and the space closure rate was faster, Bennett et al[23] have recommended the use of Elastomeric modules for space closure to prevent torque loss in incisors due to rapid space closure.

As per the statistical finding of the study, the space closure by NiTi closed coil spring may not be better or more efficient than elastomeric chain. Considering that NiTi closed coil springs are more expensive than elastomeric chains, they must be considered as an equally effective method of space closure.

V. Conclusion

Within the limitations mentioned, the following conclusions may be drawn:

1. The difference in the rate of mandibular canine retraction using NiTi closed coil spring and Elastomeric chain delivering the same initial amount of force is statistically significant, with faster retraction of the mandibular canine with NiTi Closed coil spring. Although, NiTi closed coil spring seems to have a higher rate of mandibular canine retraction as compared to Elastomeric chain, the mean difference is not clinically significant.
2. However, these findings seem to be applied only if these devices are checked and reactivated after 4 weeks interval to deliver approximately the same magnitude of clinical force.

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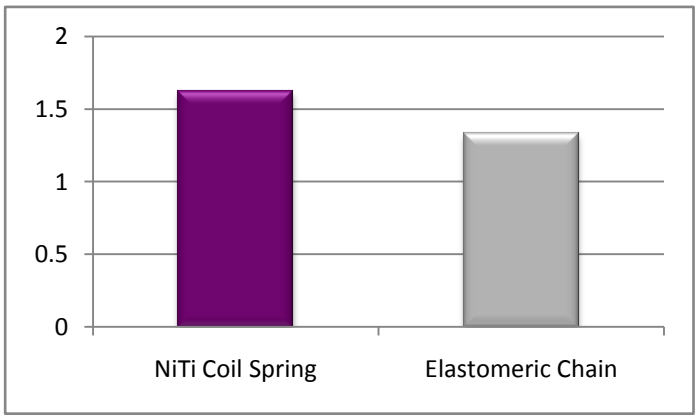
Table 1 showing the mean rate of space closure in Group I and Group II.

Table I	Group I NiTi Coil Spring	Group II Elastomeric chain
Mean	1.62	1.33

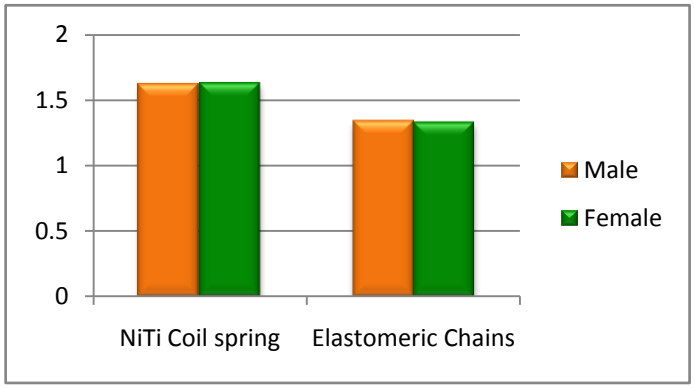
Table 2 showing the mean rate of space closure in Group I and Group II.

Table II	Group I NiTi Coil spring		Group II Elastomeric Chains	
	Male	Female	Male	Female
Mean	1.62	1.63	1.34	1.33

Graph 1: Bar diagram depicting the rate of tooth movement in mm/ month in NiTi Coil spring and Elastomeric chains.



Graph 2: Bar diagram depicting the rate of tooth movement in mm/ month among Males and Females in NiTi coil spring and Elastomeric chains.



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