ORIGINAL ARTICLE

Comparison of rate of retraction and anchorage loss using nickel titanium closed coil springs and elastomeric chain during the en-masse retraction: A clinical study

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ABSTRACT

Introduction: The aim of this study was to compare the clinical effectiveness of nickel titanium (NiTi) closed coil spring and elastomeric chain on rate of space closure in terms of anterior retraction and anchor loss. **Materials and Methods:** A total of 40 patients with first premolar extraction were randomly divided into two groups for space closure. Group 1 consisted of 20 patients in whom space closure was done with NiTi closed coil springs whereas in group 2 consisted of 20 patients with elastomeric chain. The amount of anterior retraction, anchor loss and rate of space closure was measured before start of retraction and at end of 4 months clinically and radiographically. **Results:** The observations obtained in the study were subjected to statistical analysis, so as to get their interpretation. All qualitative variables were compared using Fisher exact test. All quantitative variables were described using mean ± standard deviation and compared using unpaired *t*-test. $P < 0.05$ was considered as significant. The unpaired *t*-test, when applied, revealed there was a faster rate of space closure by NiTi closed coil springs when compared with elastomeric chain. Furthermore, anchor loss was more with NiTi springs as compared with elastomeric chain. **Conclusion:** The results of this study demonstrated faster space closure (with anterior retraction) along with significant anchorage loss was achieved by using NiTi closed coil springs when compared to the elastomeric chain.

Key words: Elastomeric chain, en-masse retraction, nickel titanium closed coil springs

Introduction

The orthodontic treatment is often needed to correct proclination and/or crowding of anterior teeth. Most frequently the situation demands extraction of first premolars, followed by fixed orthodontic appliance. Among the three stages of comprehensive fixed orthodontic treatment, the second stage, that is, space closure is one of the most challenging aspects as it aims to correct the molar and buccal segment relationships to provide normal occlusion, close extraction spaces, and correct excessive or negative overjet. This necessitates the use of an effective space closure mechanics for smooth retraction of the upper and lower anterior teeth after necessary alignment and leveling.[1]

The biomechanics involved in the second phase of orthodontic treatment are either friction mechanics the (en-masse retraction/sliding mechanics) or frictionless mechanics (loop mechanics). Due to certain drawbacks like extensive wire bending, difficulty in measuring exact force delivered, difficulty in measuring moment to force ratio and discomfort caused to the patient, the loop mechanics has gained less popularity. On the other hand, sliding mechanics utilizes minimal arch wire bending and is, therefore, quicker, offers better sliding of the wire through the slots and reactivation with these mechanics is simple and not dependent on space. It so has gained ground in the field of orthodontics.

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In friction mechanics, there are several commonly used methods for en-masse retraction, some of these are elastomeric chain and nickel titanium (NiTi) closed coil springs. Elastomeric are relatively consistent in producing tooth movements, but have several drawbacks like rapid decay of forces.[2-4] To compensate for this, the initial forces must often be greater than is desirable. Whereas NiTi coil springs have been shown to produce a constant force over varying lengths with no decay.[5,6]

The rate of space closure (anterior retraction) by NiTi closed coil springs, and elastomeric chain has been compared in various studies. However, no study till date has compared the most common side effect associated with space closure, that is, loss of anchorage by these two methods.

Therefore this study was undertaken to compare the clinical effectiveness of these two methods, that is, NiTi closed coil spring and elastomeric chain on rate of space closure in terms of anterior retraction and anchor loss.

Materials and Methods

Forty patients with Class I bimaxillary proclination undergoing fixed orthodontic treatment (MBT 0.022 slot) (Victory series™ Low Profile, 3M Unitek) after all first premolar extractions were randomly selected from the department.

After initial leveling and alignment by NiTi arch wires, 0.019 × 0.025 SS wire (G and H wires, USA) with hook of 8 mm in height soldered distal to the lateral incisors were engaged and left for 4 weeks[7] in all the subjects.

Patients were randomly divided into two groups:
- NiTi closed coil spring group: Consisted of 20 patients
- Elastomeric chain group: Consisted of 20 patients.

After 4 weeks en-masse the retraction was carried out in both the groups.

In 20 patients belonging to group 1 retraction was done using a NiTi closed coil springs of 9 mm in length (Leone, USA). A force of 200 g was applied by measuring with a Dontrix gauge (Leone, USA). The springs were not stretched to more than 12 mm as suggested by Manhartsberger and Seidenbusch.[8] The NiTi springs were engaged from first molar hooks to the hooks soldered on the arch wire and were not replaced during the treatment, but were activated per month to deliver force of 200 g.

In 20 patients belonging to group 2, retraction was done with narrow spaced Elastomeric Chain (3M Unitek, USA); which was placed from the first molar hook to the hook soldered on the archwire. The elastomeric chain was prestretched to approximately twice its resting length to reduce the force decay[9] and changed at each subsequent visit.[7] The elastomeric chain was stretched so as to apply a force of 200 g which was measured with the help of Dontrix gauge.

The amount of retraction achieved in both the groups was clinically measured by the available space from the cusp tip of the maxillary canine to the mesiobuccal groove of the first maxillary molar on both sides with the Vernier Calliper ([Mitutoyo, Japan] [0.01-200 mm] [500-116; SR-44] [5207972]) with 0.01 mm accuracy. The measurements were done just before the commencement of retraction (T0). The subjects were recalled at a time interval of 4 weeks and measurements were recorded for both the groups as T1 (after 1 month), T2 (after 2 months), T3 (after 3 months) and T4 (after 4 months) of commencement of space closure.

Measurement of anchorage loss was done by tracing a cephalogram taken just before the commencement of space closure (A0) and after 4 months of space closure (A4). To differentiate between the right and left side molar on lateral cephalograms, a 0.017 × 0.025 inch S.S. wire in an L-shape with 0.5 cm of vertical length and 1 cm of horizontal length was placed in buccal tube of molars. For right side molar, the jig was inserted from mesial side and was cinched distally and for left side molar it was inserted from the distal end and cinched mesially. Molar anchorage loss was checked by comparing the distance between PtV to metallic marker of the right side D1 and left side D2 on preretraction cephalogram and postretraction cephalogram or after 4 months whichever comes first. The mean was taken of both right and left side measurements.

Measurement of anterior retraction was done by substracting the anchorage loss values from total space closure values that is,

Anterior retraction = (total space closure − anchorage loss).

The observations obtained in the study were subjected to statistical analysis, so as to get their interpretation. All qualitative variables, e.g., sex were described using percentages and compared using Fisher exact test. All quantitative variables, e.g., age, space closure, anchor loss, anterior retraction were described using mean ± standard deviation (SD) and compared using unpaired *t*-test. $P < 0.05$ was considered as significant.

Results

Table 1 shows distribution of patients according to sex. A total number of 40 patients (9 male [22.5%] and 31 female [77.5%]) were included in our study. Further division of patients was done according to the groups. In NiTi closed coil group 20 patients (4 male [20.0%] and 16 female [80.0%]) were included while in elastomeric chain group 20 patients (5 male [25.0%] and 15 female [75.0%]) were included.

Table 1 shows the mean and SD for the age of the patients. Mean age of patients in the study was 19.62 years with a SD of 2.81 years. In our study, the mean age of the patients in NiTi closed coil group was 19.8 years with a SD of 2.6 years and in elastomeric chain group was 19.45 years with a SD of 3 years.

When space closure was compared between NiTi closed coil group and elastomeric chain group at T1, T2, T3 and T4 of commencement of retraction the mean value of group 1 was 0.91 mm, 0.91 mm, 0.86 and 0.81 mm whereas for group 2 was 0.62 mm, 0.62 mm, 0.62 mm and 0.62 mm respectively as shown in Table 2. The unpaired *t*-test, when applied, revealed that this difference was statistically significant ($P = 0.001$) at T1, T2 and T3. This showed that there was a faster rate of space closure by NiTi closed coil springs as compared to elastomeric chain.

For NiTi closed coil group the average anchorage loss in 4 months was 1.1 mm while for elastomeric chain group it was 0.82 mm as shown in Table 3. The unpaired *t*-test, when applied, revealed that this difference was statistically significant ($P = 0.006$). This showed that anchorage loss was comparatively more in NiTi closed coil groups when compared to elastomeric chain.

Anterior retraction was calculated as the difference between total space closure and anchorage loss (total space closure – anchorage loss).

For NiTi closed coil group the average anterior retraction in 4 months was 2.40 mm while for elastomeric chain group it was 1.66 mm as shown in Table 3. The unpaired *t*-test when applied revealed that this difference was statistically significant ($P = 0.001$). This shows that the anterior retraction was comparatively more in NiTi closed coil groups when compared to elastomeric chain.

Table 1: Distribution of patients according to sex

Groups	Patients	Age of patients		Male	Percentage	Female	Percentage
		Mean	SD				
	40	19.62	2.81	9	22.5	31	77.5
NiTi group	20	19.8	2.6	4	20.0	16	80.0
Elastomeric chain group	20	19.45	3	5	25.0	15	75.0

SD: Standard deviation, NiTi: Nickel titanium

Table 2: Comparison of mean values of the distance from cusp tip of maxillary canine to mesiobuccal groove of first maxillary molar between NiTi closed coil group and elastomeric chain group at different months of observation, that is, at T0, T1, T2, T3, T4 (unpaired *t*-test)

Observation period	NiTi closed coil group in mm	Elastomeric chain group in mm	*P*
1st month (T1)	0.91	0.62	0.001
2nd month (T2)	0.91	0.62	0.001
3rd month (T3)	0.86	0.62	0.001
4th month (T4)	0.81	0.62	0.001
Mean for 4 months	0.87	0.62	0.001

NiTi: Nickel titanium

Table 3: The inter group comparison of mean values of anchorage loss and anterior retraction between NiTi closed coil group and elastomeric chain group at 4 months of observation using unpaired *t*-test

Variables	NiTi closed coil group (mm)	Elastomeric chain group (mm)	*P*
Anchorage loss	1.1	0.82	0.006 (significant)
Overall anterior retraction	2.40	1.66	0.001 (significant)

NiTi: Nickel titanium

Discussion

Severe bimaxillary proclination needing all first premolar extraction is common. During orthodontic treatment involving extraction of teeth, there is often a need to close extraction space, after the initial de-crowding and alignment. The closure of the extraction space can be achieved by two techniques, friction (sliding) mechanics or frictionless (loop) mechanics. A variety of materials has been used as force delivery systems to close spaces between teeth as in the case of space closure after the extraction of premolars. These include latex elastics, coil springs, synthetic elastic modules, headgears and recently magnets.

The present study was designed to compare the rates of space closure, molar anchorage loss and rate of anterior retraction when using standard NiTi closed coil springs and elastomeric chains.

This *in-vivo* study was undertaken with 40 patients (31 females, 9 males) exhibiting bimaxillary proclination. After all first premolar extraction the rate of space closure

was measured between cusp tip of canine to mesio-buccal groove of the first molar using a digital caliper every 4 weeks for 4 months, after start of retraction. Clinical measurement was done so as to avoid the hazardous effects of multiple cephalograms.

Rate of Space Closure

The rate of space closure was measured and calculated for both the groups. The mean rate of space closure within 1st, 2nd, 3rd and 4th month with NiTi closed coil spring were found to be (1.91, 0.91, 0.86 and 0.813), whereas with elastomeric chain were found to be (0.616 mm, 0.621 mm, 0.624 mm and 0.629 mm). These values of the two groups when compared by applying unpaired *t*-test were found to be statistically significant ($P = 0.001$) at T1, T2, T3 and T4 [Table 3]. In this study, the NiTi closed coil springs produced rapid rate of tooth movement as compared with conventional elastomeric chain with the same amount of force. This discrepancy may be due to the fact that NiTi closed coil springs deliver a light, continuous force as shown by von Fraunhofer *et al*.,[10] Ryan,[11] Tripolt *et al*.[5] whereas there is a large amount of force degradation with polyurethane elastomeric chains as shown by Wong.[2]

Dixon *et al*.[7] conducted a randomized clinical trial to compare three methods of orthodontic space closure. The results showed that the mean rates of space closure were 0.35 mm/month for active ligatures, 0.58 mm/month for powerchain and 0.81 mm/month for NiTi springs. They concluded that NiTi springs gave the rapidest rate of space closure and may be considered as the treatment of choice. Our results were similar to the findings of this study. Our findings are also in accordance to the findings of Al-Sayagh and Ismael[12] and von Fraunhofer.[10]

Anchorage Loss

The present study attempted to compare the effect of two different force delivery systems on amount of mesial movement of the upper molars. The average rate of anchorage loss for NiTi closed coil spring was 1.1 mm, for elastomeric chain was 0.82 mm. When compared using unpaired *t*-test the results were found to be statistically significant ($P = 0.006$) as shown in Table 3. This showed that the use of NiTi closed coil springs lead to more anchor loss as compared to elastomeric chain. This may be explained due to the light constant force acting on both the anterior retraction unit as well as the reactionary unit as reported by Bennett and McLaughlin and Samuels. This is in contrast to earlier studies by Bokas and Woods[13] who found that anchor loss with NiTi closed coil spring, and Elastomeric Chain were likely to be similar. This might be because in our study en-masse retraction was carried out without anchorage reinforcement, whereas in Bokas and Woods study separate canine retraction and anchorage reinforcement with transpalatal arch was done.

Rate of Anterior Retraction

The total amount of anterior retraction was calculated by deducting the anchor loss from the total space closure. This was calculated for both the groups and the mean was found to be 2.40 mm for NiTi closed coil spring group and 1.66 mm for elastomeric chain group. The unpaired *t*-test when applied, revealed that this difference was statistically significant ($P = 0.001$) as shown in Table 3. This shows that the anterior retraction was comparatively more in NiTi closed coil groups when compared to elastomeric chain. These results might be attributed to the fact that NiTi closed coil springs provide light and continuous forces according to Melsen *et al*.,[14] Ryan,[11] in comparison with elastomeric chain where the force decays within first few days as shown by Wong,[2] Kersey *et al*.[4]

In this study, measures were taken to deliver the same amount of force at start of space closure and every monthly for both the groups. However, actual force application is difficult to be determined *in-vivo*, due to biological and mechanical reasons (tooth morphology, root length and periodontal architecture, chewing etc.). In this study, these variations were not considered.

Conclusion

The results of the present study demonstrated:

1. Faster space closure (with anterior retraction) is achieved by using NiTi closed coil springs as compared to the elastomeric chain.
2. Significant anchorage loss was also noted with NiTi closed coil when compared with elastomeric chain.

In mild to moderate anchorage cases, space closure with NiTi closed coil springs with an increased rate of anterior retraction and anchor loss can be recommended. However in critical anchorage cases, reinforcement of anchorage, while using NiTi closed coil springs for space closure, is recommended.

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