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A Clinical Comparison of Sliding rate of Canine Teeth Using Nickel-Titanium close coil Springs Versus Super Slick Elastomeric Chains

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Abstract

Aim: Space closure after extraction of teeth is one of the most challenging steps in orthodontic treatments. Nickel-titanium close coil springs are used as a superior appliance in the said field for space closure, but high expenses associated with them have pushed dentists toward using elastomeric chains. This study was planned to compare nickel-titanium to one of the newest reinforced types of elastomeric chains – Super Slick.

Methods: This research was planned as a prospective analytical study with a split-mouth design, and was performed on 11 randomly selected participants referring to the specialty clinic of Guilan University of Medical Sciences. After leveling and alignment, patients were referred for simultaneous extraction of first premolars. For closing the space after extraction, randomly, the nickel-titanium close coil spring was assigned to one quadrant and the Super Slick elastomeric chain to the other. Patients were followed-up every month for three months, and in every session using a digital caliper the rate of space closure resulting from extraction of first premolars was measured from the distogingival wing of the canine bracket to the mesiogingival wing of the second premolar bracket. The monthly rate of space closure was calculated in millimeters, and the results regarding Super Slick Chains and nickel-titanium springs were compared and statistically analyzed using the t-test and nonparametric tests.

Results: Based on the results of the t-test, the rate of the premolars extraction space closure in the first month, second month, and third month showed no significant differences between Super Slick elastomeric chains (1.82±0.27) and nickel-titanium close coil springs (1.90±0.4). Also, based on the said test, the general speed of space closure during the three months was not meaningfully different (p=0.489).

Conclusion: Considering that there was not a significant difference in the rate of space closure between elastomeric chains and nickel-titanium close coil springs during the three months of the study, it can be concluded that with time, the strength of the reinforced elastic chains for retraction of canine teeth is similar to that of the nickel-titanium springs. A look at the results shows that the claims of the manufacturers of reinforced elastic chains regarding force conservation are not very far from reality.

Keywords: Elastomeric chains, Force degradation, Nickel-titanium springs

1. Background

Nowadays, the demand for a pleasant smile and straight teeth has increased, and orthodontic treatments have become widely accepted by individuals for achieving the said demand (1). In recent years, the quality achieved by fixed orthodontic appliances and their improved ability to achieve progress has proved their superiority over moving orthodontics, which could explain the reason for the higher popularity of this method (2).

Fixed orthodontic treatments are usually available in two forms: extraction and non-extraction (3). The former consists of three stages: first is teeth alignment in the dental arch, the second is the closing of the space resulting from teeth extraction, and the third and final would be achieving an ideal occlusion (4, 5). The first stage of non-extraction requires teeth alignment by fixed tools that demand a balance between acceptable movement of teeth and limiting possible lesions to the teeth and periodontal structure. The result of this would be normal contact and relation between neighboring and opposite teeth (6).

As mentioned before, space closure is the second stage in the extraction method, and is one of the most challenging parts of orthodontic treatments. Tooth extraction, distalization of molars, enlarging dental arches, and limiting proximal space are some of the mentioned challenges that require essential skills (7). Moreover, to have precise control of tooth movement in all three dimensions while closing the space, choosing the most suitable treatment plan is of utmost importance for achieving satisfactory results.

There are two essential biomechanical strategies for space closure, namely friction mechanics (sliding) and frictionless mechanics (segmental) (7, 8). In the segmental mechanism, the teeth are divided into two segments active and inactive (anchorage), then force is applied between these two, so the space resulting from tooth extraction closes (6, 8). In the sliding mechanism, the force between two teeth or dental segments is applied in a way that its slide or movement creates a great deal of friction between the straight wire and brackets. This method provides a higher level of control for closing the space while causing fewer side effects such as tipping and rotation. Higher levels of ease for the patient and averting the application of excessive force are among other benefits of sliding mechanics (4).

The common tools for space closure are nickel-titanium close coil springs and elastomeric products. The former is more appreciated due to providing and preserving consistency of a gentle force, but difficult clinical use, high cost, and difficulty of oral hygiene have caused it to lose ground to elastomeric chains because they can achieve similar results, providing a force of 150-200 grams (9, 10).

Apart from tensile properties and great flexibility, elastomeric chains are easy to use and reasonably priced, reduce the risk of trauma, and are well tolerated by patients. On the negative side, the formation of dental plaque happens at a much higher rate than nickel-titanium springs, and absorption of oral cavity moisture through time (as its greatest disadvantage) can cause decay of primary force and even permanent deformation of the elastomeric chains (11).

In the past decades, some of the major orthodontic companies have introduced elastomeric chains (e.g., Memory Chain by American Orthodontics), which claim to provide a lighter yet more constant force. In the year 2000, a similar type of chain was introduced called Super Slick Chains (TP Orthodontics, USA) that employs Metafix® technology. This technology uses a non-soluble hydrogen-polymer coating that, when in contact with liquids, changes into polyurethane with an elastomeric base and a smooth surface (7, 8).

The manufacturers claim that these Super Slick chains reduce friction and apply a light force to the teeth for a longer period. Contrary to the advertised features of the mentioned advanced chains, no specific studies have focused on them in the form of a clinical trial; hence, subtle information regarding their superiority or clinical advantage is not available. (10-14)

Considering the mentioned points, the purpose of the current study was to assess and analyze the rate of space closure after extraction of premolar teeth using Super Slick elastomeric chains versus nickel-titanium springs, which can be an indicator of the consistency of force that shows Super Slick Chains are capable in terms of force consistency in clinical use. This study was conducted on patients referring to the Guilan University of Medical Sciences (GUMS) specialty clinic.

2. Methods

This prospective study with a split-mouth design was performed on patients undergoing orthodontic treatments who were referred to the GUMS specialty clinic in the year 2019. The patients were randomly chosen, and their treatment plan (Cl III camouflage, Cl II camouflage, or four bicuspids extraction)required the symmetrical extraction of first premolars on both sides of the dental arch.

Panoramic radiography was prescribed for assessing the sources causing differences in teeth movement on both sides. Afterward, a sample size of 11 patients, whose left and right sides were examined, was considered for the study using the values used in Talwar and Bhat 2018 (15) with a 1% coefficient of error and a 95% confidence interval.

After obtaining written consent and reminding patients of the importance of perfect attendance in the treatment sessions, the patients were asked to chew using their teeth on both sides to the greatest extent possible (16). The reason for that was that non-synchronized chewing has been shown to affect the speed of space closure.

After the placement of orthodontic bands on the first molars, 0.022-inch slot MBT brackets (American Orthodontics -Sheboygan-WIUSA) were used for central incisors to second premolars. After finishing leveling and alignment, patients were referred for simultaneous extraction of first premolars on both sides. The process was done using a 0.018-inch stainless steel archwire, completely passively. The resulting space was closed by the sliding mechanism of the canine by 0.018-inch stainless steel archwire (American orthodontics-Sheboygan-WIUSA), which was done

on one side using the nickel-titanium close coil spring (G&H, Franklin, USA), as shown in Fig. 1 and on the other side using Super Slick Chain (TP Orthodontics) as presented in Fig. 2. To determine which side would be assigned to the control group (nickel-titanium spring) and which to the test group (Super Slick Chain), a random selection was done using the random block method.

Figure 1. Nickel-titanium close coil spring (G&H, Franklin, USA)

Figure 2. Super Slick Chain (TP Orthodontics)

The placement of closed coil springs and chains in the arches of the patients is explained. First, on the control side, a specific type of spring was placed – one that could make the most desirable force for canine retraction (150-200 g). Then, on the other side, the elastomeric chain was used so that its force difference with nickel-titanium would be a maximum of 25 grams (considering the accuracy of the force gauge). At the beginning of retraction, medium nickel-titanium (which creates a force of 160-200 g) was used for all patients. The springs were checked every session for distortion so that in the case of damage, they would be replaced with new ones. Regarding the type and size of elastics, four options of small, large, medium, and mini were available and the one with the least amount of force difference with the opposite side and the most proper number of rings was used. The measurement of forces at the time of placement of springs and elastics were done using the tension and compression gauge (Dentaurum, Ispringen; Germany) with an accuracy of 25 gram per session (Fig. 3).

After the check-up on the start of retraction, patients were visited a total of three times in three months at one-month intervals. The measurement of space resulting from the extracted tooth in all cases and from the distogingival wing of the canine bracket to the mesiogingival wing of the second premolar bracket was done by a digital caliper (Insize, Suzhou New District; China; 111-100Y-070726) with a 0.01 mm accuracy at the beginning of retraction and the three other sessions of check-ups (Fig. 4). The measurement of spaces was repeated three times, and the mean of obtained numbers was chosen as final figures. Finally, the mean rate of space closure for nickel-titanium and Super Slick Chains was calculated based on millimeters per month, and the achieved data were statistically analyzed and compared.

Figure 3. Tension and compression gauge (Dentaurum, Ispringen, Germany)

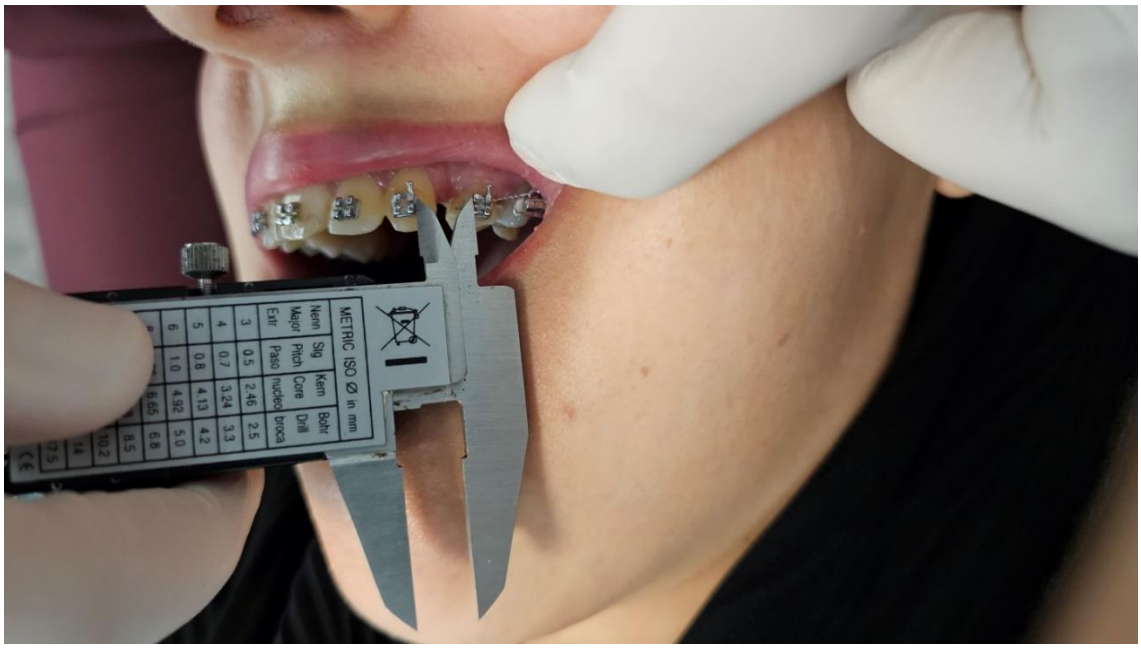


Figure4. measurement with a digital caliper (Insize, Suzhou New District, China,111-100Y-070726)

Results

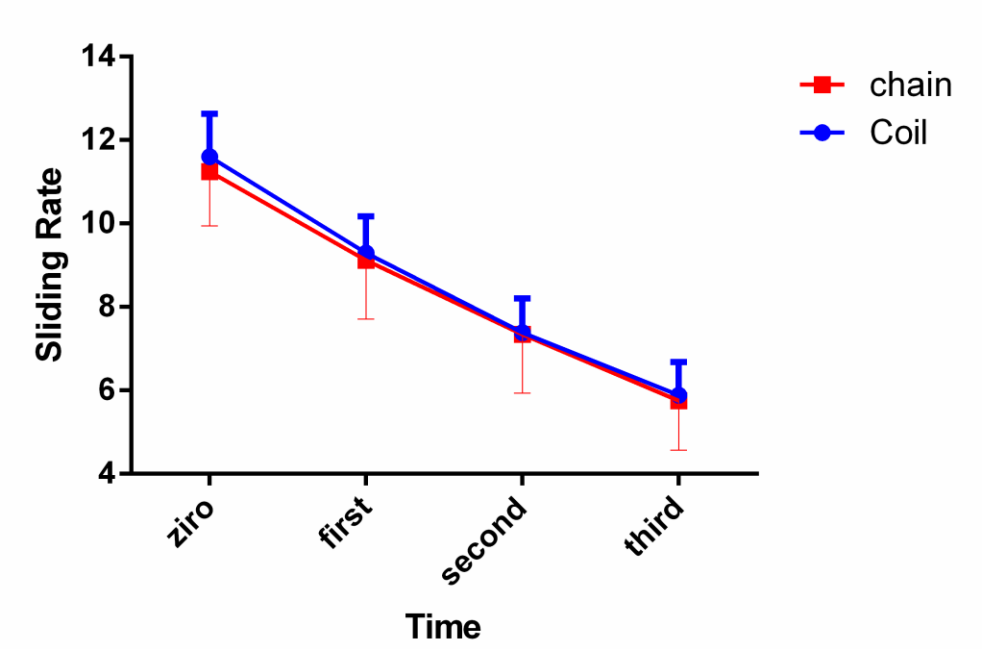
This study was performed on 11 arches in nine patients (two bimaxillary, four maxillary, and three mandibular arches). Table 1 shows the results of the study on the effect of treatment type and time on sliding speed. Based on the t-test results, there was no significant difference in closing speed between the two treatments (p=0.455). However, the closing speed was 0.218 faster in the coil method than in the chain method. Over time, the closing speed decreased significantly (p <0.001). The mean rate of space closure in both groups for the three months is presented in Graph 1.

Table 1. Summary of the results of the study of the effect of treatment type and time on sliding speed using the Generalized Estimating Equations (GEE) test

Parameter	B	Std. Error	Wald Chi-Square	Sig
Coil	0.218	0.29	0.56	0.455
chain	ref	-	-	-
time=zero	5.54	0.18	941.40	<0.001
time=first	3.34	0.16	432.07	<0.001
time=second	1.50	0.10	212.18	<0.001
time=third	ref	-	-	-

Table 2. The rate of space closure between the two groups of study (mm/month)

The mean rate of space closure during 3 months	The third month of retraction	The second month of retraction	The first month of retraction	
1.90±0.4	1.49±0.46	1.92±0.42	2.31±o.51	nickel-titanium closed coil springs
1.82±0.27	1.58±0.42	1.77±0.37	2.12±0.29	Super Slick elastomeric chains
0.489	0.894	0.408	0.197	P-value



Graph 1. The mean rate of space closure in two groups during the study period (mm)

4. Discussion

Closing of the space resulting from a tooth extraction in orthodontics with the highest speed and least damage to the teeth and surrounding tissue has long been an essential and challenging subject. Materials containing nickel-titanium alloys have become of widespread use in dentistry in the past decades because of their high memory-shape characteristics. They have also been considered the gold standard because they can cause a rather constant force over a long period. High costs associated with them, however, have limited their application. With all that said, elastomers composed of special materials, such as Super Slick Chains by TP Orthodontics, have become widely accepted by orthodontists in developed countries (14).

This study focused on comparing the sliding speed of canine teeth using nickel-titanium and Super Slick elastomeric chains in patients referring to the GUMS specialty clinic. Study results showed no meaningful difference between the two groups. The present study measured sliding force four times: the beginning of treatment, the first month, the second month, and the third month, and the results did not indicate any meaningful difference in the last three periods.

In research by Khanehmasjedi et al. in 2016, the remaining force in elastic memory (Memory Cain, American Orthodontics) in different periods were found to be very similar to nickel-titanium, and the rate of space closure was not statistically different, which is in line with the study at hand (9). on the other hand, in two separate researches by Talwar and Bhat, and Sonis, it was shown that the mean of space closure using nickel-titanium was higher than elastics, which is different from the current research and that could be due to comparing regular elastics against nickel-titanium springs. However, the retraction speed reported by Sonis was similar to the results obtained here, but the teeth movement speed associated with elastics was exceedingly different and that was due to using older types of elastics that are rarely used for closing the space of extracted teeth nowadays (9, 15).

Baratieri et al.'s study done in 2012 is the sole study that clinically compared regular and memory elastics. Three types of regular and reinforced elastics were employed and they reported the remaining force of the latter in different time intervals to be higher than the former, as only reinforced elastics created a force higher than 100 grams three weeks after the start of the trial. One of the reasons for force degradation by elastics could be the natural characteristics of materials made of polyurethane because they do not allow for total elasticity and sooner or later, they show features associated with plastic. The other reason is that the main materials used in elastics could be affected by environmental factors such as humidity, temperature, salivary enzymes, enzymes from bacteria, chewing force, and so on (9, 17). These reasons, along with various formulations employed by manufacturers could justify the difference in properties between regular and reinforced elastics (11).

Santos et al. used four different brands of regular elastics and nickel-titanium springs and reported force degradation of these eight substances after 28 days. Their statistical results showed a meaningful difference between elastomeric chains and nickel-titanium springs, which proved the superiority of the latter for teeth movement. A similar study by Oshagh et al. was performed in Shiraz, Iran in 2015 to assess the effects of environmental factors on force decadence of the nickel-titanium springs and elastomeric chains. They reported the former to be less affected by environmental factors (17, 18).

Kula and Barlow, in a systematic study, reviewed factors influencing the efficiency of sliding mechanics related to the closing of space following extraction. Ten prospective clinical trials were analyzed, and it was reported that nickel-titanium springs created a more constant force and a higher rate for space closure compared to active ligatures. Nonetheless, in the meantime, elastomeric chains have a similar rate to those springs, and such results are in line with the current study (18).

Conclusion

The findings of this study show that reinforced elastomeric chains can be used for closing the space after extraction of premolars with a similar rate to nickel-titanium close coil springs provided they are replaced with new ones monthly. Considering that in the three months of the study, space closure by nickel-titanium springs and elastics were not meaningfully different, it could be concluded that with time, the force made by reinforced elastic chains for retraction of canines would be similar to the nickel-titanium springs. Looking at the achieved results reveals that the claim made by the manufacturers regarding consistency of force in reinforced elastics is not far from reality.

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