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Original Research

A comparative evaluation of space closure using different force delivery systems - A Clinical Study

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ABSTRACT:

Aim & Objectives: To compare the orthodontic space closure for various force delivery systems. **Material & Method:** 40 patients of age group between 17- 25 years. They were divided into four groups: each group consisted of 10 patients. In Group I patients, space closure was done with Active ligatures. In Group II patients, space closure was done with Power E-chain. In Group III and Group IV patients, space closure was done with Nickel-Titanium closed coil spring and Stainless Steel closed coil spring respectively. The amount of space closure was measured after every four weeks with the help of digital Vernier caliper. **Result:** The mean (mm) of retraction completed at the end of 1st month in Group I was 0.597 with SD of 0.208 and in Group II was 0.815 with SD of 0.146. Whereas in Group III, the mean was 1.165 with SD of 0.198 and in Group IV was 0.928 with SD of 0.451. **Conclusion:** The order of force delivery systems according to the rate of retraction: Ni-Ti closed coil spring = Stainless Steel closed coil spring > Power E-chain = Active ligatures.

Key words: Force delivery systems, orthodontic appliances, space closure.

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INTRODUCTION

Orthodontic tooth movement requires the application of a force delivering system capable of eliciting the desired response of individual dental units within the biological ecosystem. Ideally, a force delivering system should provide an optimum and continuous force.[1] There are 3 stages in fixed orthodontic treatment - Initial levelling & alignment, Space closure and Finishing & detailing, out of which space closure is one of the most challenging aspect.[1-6]

The biomechanics involved in the space closure include either friction mechanics or frictionless mechanics.[6] Sliding mechanics for en-masse retraction have gained a substantial popularity particularly after the evolution of MBT philosophy.[7-10] Sliding mechanics requires minimal wire bending and provides an excellent control of root parallelism and arch form.[11] Pre-adjusted fixed orthodontic appliances commonly utilize sliding mechanics for space closure with force delivery systems, such as Elastomeric chains, Elastomeric modules attached to ligature wire or Intraoral elastics and Coil springs such as Ni-Ti closed coil springs and Stainless Steel closed coil springs.[12] The rate of space closure by Closed coil springs and Elastomeric chain has been compared in various studies.[12.] Still, several studies are being conducted in search of the ideal space

closure system. Since the comparative clinical performance of powerchain, active ligatures, NiTi closed coil spring ansd Stainless Steel closed coil spring has not previously been reported, the aim of the study was to compare the clinical performance of these force delivery systems in orthodontic space closure.

AIMS AND OBJECTIVES

1. To evaluate the clinical performance of various force delivery systems.
2. To compare the space closure for various force delivery systems over a period of 4 months in fixed mechanotherapy

SAMPLE SELECTION CRITERIA

INCLUSION CRITERIA

The patients were selected on the basis of following criteria:

1. The patients with age group 17-25 years.
2. A premolar extraction in each quadrant
3. Pre-adjusted edgewise appliance 0.022" x 0.028" MBT prescription was used
4. Stainless steel working arch wires in place for at least four weeks after initial leveling & alignment procedure
5. Informed written consent was obtained from the patient

EXCLUSION CRITERIA

1. Any extraction other than premolar was not considered
2. Any prescription other than MBT was not used
3. Patients with any contra-indication to orthodontic treatment were not considered.

SAMPLE SELECTION AND SAMPLE SIZE

Total of 40 patients of age group 17-25 years who underwent orthodontic treatment in the Department of Orthodontics & Dentofacial Orthopedics, Dasmesh Institute of Research & Dental Sciences, Faridkot were used in this study.

Samples were randomly divided into four groups:

Group I: Included 10 patients bonded with Pre-adjusted edgewise 0.022" x 0.028" MBT system with premolar extraction followed by initial leveling and alignment. Space closure was done with Active ligatures.

Active ligatures were constructed from one grey elastic module and a long ligature. The elastic module was stretched twice of its length and engaged to the hook on the first molar tube and the metal ligature was tied to the hook on the main archwire with the force value of approximately 200gm. The active ligatures were replaced at each visit.

Space closure in patient with Active Ligatures

Group II: Included 10 patients bonded with Pre-adjusted edgewise 0.022" x 0.028" MBT system with premolar extraction followed by initial leveling and alignment. Space closure was done with Power E-chain. Short Power E-chain was stretched twice of its resting length and engaged from the hook on the molar tube to the hook on the main archwire with the force value of approximately 200gm. The Power E-chain was changed at each subsequent visit.

Space closure in patient with Power E-chain

Group III: Included 10 patients bonded with Pre-adjusted edgewise 0.022" x 0.028" MBT system with premolar extraction followed by initial leveling and alignment. Space closure was done with Nickel-Titanium closed coil springs. Ni-Ti springs (G&H), with approximately 200gm force level were used and engaged at the hook on the first molar tube and other end was secured using the ligature wire to the hook on the main archwire. The Ni-Ti springs were not replaced during treatment but were activated as necessary.

Space closure in patient with Ni-Ti closed coil spring

Group IV: Included 10 patients bonded with Pre-adjusted edgewise 0.022" x 0.028" MBT system with premolar extraction followed by initial leveling and alignment. Space closure was done with Stainless Steel closed coil springs. Spool of Stainless Steel closed coil spring (G&H) was customized for retraction with the force of approximately 200gm and were engaged at the hook on the first molar tube and other end was secured using the ligature wire to the hook on the main archwire. The springs were stretched not more than twice of its length according to the manufacturer's recommendation. These springs were not replaced throughout treatment but reactivated as necessary.

Space closure in patient with Stainless Steel closed coil spring

DATA COLLECTION AND MEASUREMENT METHOD

At the end of leveling and alignment, 0.017" x 0.025" Stainless Steel arch wires with soldered J-hooks between lateral & canine and bite opening curves were engaged. The patients were recalled after four weeks to ensure that the archwires were passive, verified by sliding the archwire through the bracket slots. 0.017" x 0.025" SS retraction archwires were then removed and impressions were taken for the fabrication of study casts before retraction was initiated (T_0). Then, retraction archwires were re-engaged and retraction was started using various force delivery systems.

Space was measured on study casts by measuring the maximum distance between the cusp tip of the canine to the buccal groove of the first permanent molar in all the four quadrants in millimeters before the start of retraction with the help of digital Vernier calliper (T_0).

The amount of space closure was measured after every four weeks within the oral cavity with the help of digital Vernier caliper. After four months of time period, the study casts were fabricated again to measure the space closed during retraction (T_1). At each visit, the space closure mechanics was reviewed and distortion of the springs or archwires was checked.

Intra-Oral measurement by digital Vernier Calliper

Study cast measurement by digital Vernier Calliper

STATISTICAL TESTS

All the data measured was compared by statistical analysis. An ANOVA test, Tukey's HSD test and unpaired t-test were used for the comparison of various force deliver systems. For all the statistical analysis, 'P' value <0.05 was considered.

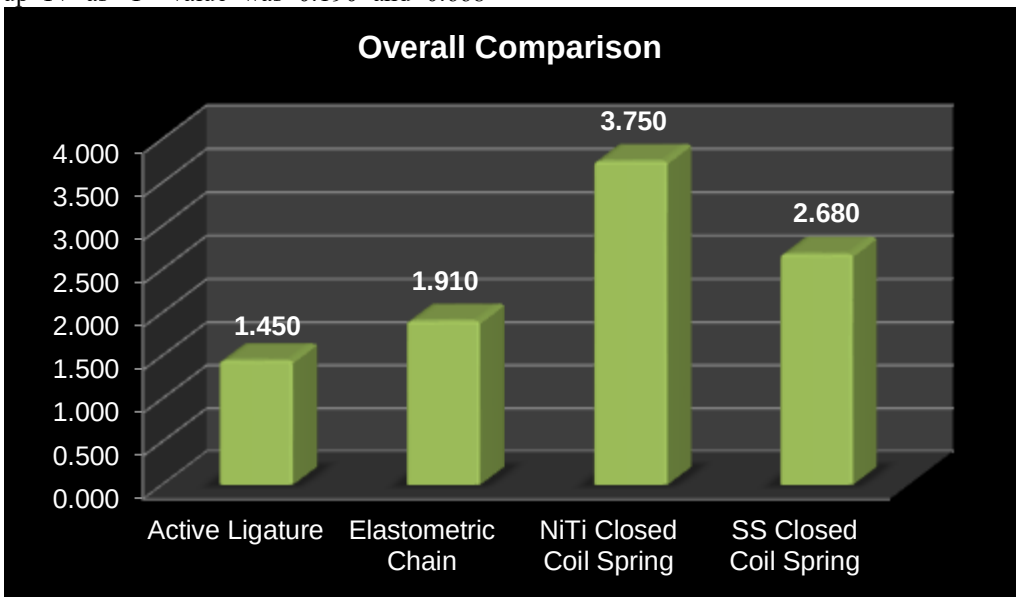
RESULTS

The study was performed on 40 patients of age group between 17- 25 years. They were divided into four groups: each group consisted of 10 patients. In Group I patients, space closure was done with Active ligatures. In Group II patients, space closure was done with Power E-chain. In Group III and Group IV patients, space closure was done with Nickel-Titanium closed coil spring and Stainless Steel closed coil spring respectively. The amount of space closure was measured after every four weeks with the help of digital Vernier caliper.

The mean (mm) of retraction completed at the end of 1st month in Group I was 0.597 with SD of 0.208 and in Group II was 0.815 with SD of 0.146. Whereas in Group III, the mean was 1.165 with SD of 0.198 and in Group IV was 0.928 with SD of 0.451.

On comparing all the four groups by use of Tukey's HSD test in overall four months of retraction, it was revealed that the difference in retraction was highly significant between Group I & Group III, Group I &

Group IV, Group II & Group III and Group II & Group IV as the 'P' value was 0.001, 0.001, 0.001 & 0.008 respectively (i.e. 'P'<0.05). Whereas the 'P' value was non-significant between Group I & Group II and Group III & Group IV as 'P' value was 0.190 and 0.668 respectively (i.e. 'P'>0.05). There was no statistical significant difference was found between the retraction in right and left quadrants of upper and lower arches and between upper and lower arches.



Overall comparison among all the four groups using Tukey's HSD test

DISCUSSION

A lot of studies had compared and evaluated the rate of Ni-Ti closed coil spring, Elastomeric chain and Active ligatures but a very few studies evaluated the rate of space closure using Stainless Steel closed coil spring and with the same force magnitudes for all the force delivery systems.

The present study was an attempt to compare and to evaluate the space closure using different force delivery systems i.e. Active ligatures, Power E-chain, Ni-Ti closed coil spring and Stainless Steel closed coil spring in the phase of orthodontic space closure.

Greater and more consistent space closure with Ni-Ti closed coil springs than with the Elastic modules and elastomeric powerchain was revealed. This results were in concordance with the study carried out by Dixon et al. (2002), Margaret, Parayaruthottam & Jyothindra Kumar (2013), Chaudhari & Tarvade (2017), Shankar et al. (2017), Espinar-Escalona et al. (2013), Talwar & Bhat (2018), Fang et al. (2017), Mohammed et al. (2017) and Samuels, Rudge & Mair (1993).

One possible explanation for better results by Nickel-Titanium closed coil spring is that Nickel-Titanium alloys possess the unique properties of shape memory and superelasticity (Cox et al. 2014). Ni-Ti closed coil spring delivers constant force unlike elastic chain which loses its force rapidly, characterized by an initial exponential decrease reaching 50% because of stress relaxation (Al-Sayagh & Ismael 2011).

Various studies like Bokas & Woods (2006), Nightingale & Jones (2003) and Al-Suleiman & Shehadah (2015) were in contrast to the present study and stated that Ni-Ti closes the space at the similar rate as that with other force delivery systems.

The results in our study revealed that no statistically significant difference was found between retraction rate of Stainless Steel closed coil spring and Ni-Ti closed coil spring. To date, there had been only one study which made direct comparison between Ni-Ti coil springs and Stainless Steel springs. The study by Norman, Worthington & Chadwick (2016) used Stainless Steel coil springs which certainly complemented the previous space closure analysis and possibly offered an alternative approach. This study had found that the Stainless Steel springs were as good as the more expensive Ni-Ti coil springs, gave the most rapid rate of space closure throughout the phase and considered to be the most cost effective method of space closure.

The present study used 0.017" x 0.025" SS as working archwire instead of 0.019" x 0.025" SS archwire in the support that they reduced the friction and contact point between the bracket & wire and closes the space faster as supported by the study conducted by Awni (2012).

The present study chose an inter-individual, parallel group design which considered the two sides of space closure to be mutually dependent on each other because they involved the same archwire.

Studies conducted by Dixon et al (2002) and Chaudhary & Tarvade (2015) support parallel group design while Bokas & Woods (2006) and Nightingale & Jones (2003) conflicted this.

The present study had selected the samples with premolar extraction and treated with sliding mechanics and en-masse retraction. Other studies using the sliding mechanics with en-masse retraction were Dixon et al. (2002), Fang et al. (2017), Mohammed et al. (2017), Mitra, Londhe & Kumar (2011), Nightingale & Jones (2003), Samara, Nahas & Rastegar-Lari (2018) and Meshram et al. (2015).

CONCLUSION

The following conclusions drawn from the study were:

1. The order of force delivery systems according to the rate of retraction: Ni-Ti closed coil spring = Stainless Steel closed coil spring > Power E-chain = Active ligatures
2. Despite of force delivery method used, retraction occurred at the same rate in the upper right and upper left quadrants, lower right and lower left quadrants
3. Clinically, there was no significant difference found between upper and lower arches during retraction

SUMMARY

Stainless Steel closed coil spring is clinically effective and cost efficient alternative approach to Ni-Ti closed coil spring. Pre-stretching of elastomeric chain helps in lesser decay of force and a cheap method of retraction. Active ligatures are as efficient as Power E-chain and no significant difference exists between the rate of retraction of the two groups.

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