Opis przypadku / Case report

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Technika łuków segmentowych „mushroom” w indywidualnej retrakcji kłów w łuku szczękowym i żuchwowym – analiza serii przypadków

Segmental Mushroom loop for individual canine retraction in the maxillary and mandibular arch - A case series

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Wkład autorów: A Plan badań B Zbieranie danych C Analiza statystyczna D Interpretacja danych E Redagowanie pracy F Wyszukiwanie piśmiennictwa

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Streszczenie

Odcinkowa retrakcja kła za pomocą techniki łuków segmentowych w przypadku znaczącego stłoczenia zębów może pomóc w uniknięciu wychylania zębów przednich, które jest zwykle związane z mechaniką ciągłą. **Cel.** Celem opracowania jest opisanie biomechanicznych zasad zamykania przestrzeni za pomocą techniki łuków segmentowych w różnych scenariuszach klinicznych. **Opis przypadku.** W pierwszym przypadku występowało stłoczenie zębów przednich szczęki oraz żuchwy, zaś w drugim proklinacja. W obu przypadkach usunięto wszystkie pierwsze przedtrzonowce szczęki, zaś retrakcję poszczególnych kłów wykonano za

Abstract

Segmental retraction of the canine with the mushroom loop spring in severely crowded cases may help avoid round tripping of the maxillary anterior teeth that is commonly associated with continuous mechanics. **Aim.** To describe the biomechanical principles on space closure with the mushroom loop spring in different clinical scenarios. **Case series.** The maxillary and mandibular anterior teeth had crowding in the first case and proclination in the second case. All the maxillary first premolars were extracted in both the cases and individual canine retraction was done with segmental M loop spring. In the third case there was an end on molar

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pomocą łuku odcinkowego z pętlą M. W trzecim przypadku doszło do zakończenia wzajemnego stosunku trzonowców po lewej stronie wraz ze stłoczeniem zębów przednich szczęki i żuchwy. Usunięto pierwsze przedtrzonowce szczęki oraz wykonano retrakcję poszczególnych kłów we wszystkich kwadrantach, z wyjątkiem lewego dolnego kwadrantu, w którym usunięto drugi przedtrzonowiec oraz przeprowadzono retrakcję trzonowców za pomocą łuku odcinkowego z pętlą M. **Wyniki.** W pierwszym przypadku translację kłów uzyskano we wszystkich czterech kwadrantach. W drugim przypadku nastąpiło przemieszczenie obu kłów szczęki wraz z łagodnym dystalnym przechyleniem kłów żuchwy. W przypadku trzecim uzyskano przemieszczenie doprzednie trzonowca w lewym dolnym kwadrancie wraz z translacją kłów. **Podsumowanie.** Rezultat kliniczny leczenia był korzystny. Technika łuku odcinkowego z pętlą M może więc być stosowana w różnych scenariuszach klinicznych z pozytywnym skutkiem. **(Felicita AS. Technika łuków segmentowych „mushroom" w indywidualnej retrakcji kłów w łuku szczękowym i żuchwowym – analiza serii przypadków. Forum Ortod 2022; 18 (2):112-21).**

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Słowa kluczowe: technika łuków segmentowych „mushroom", mechanika odcinkowa, retrakcja kłów, protrakcja trzonowców

relation on the left side with crowding of the maxillary and mandibular anterior teeth. The maxillary first premolars were extracted and individual canine retraction was done in all the quadrants except the left lower quadrant were the second premolar was extracted and molar protraction was done with a segmental M loop spring. **Results.** In the first case translation of the canines were achieved in all four quadrants. In the second case, there was translation of both the maxillary canines with mild distal tipping of the mandibular canines. In the third case molar protraction was achieved in the lower left quadrant along with translation of the canines. **Summary.** The clinical outcome was favorable. The segmental M loop spring can be used in different clinical scenarios with a positive outcome. **(Felicita AS. Segmental Mushroom loop for individual canine retraction in the maxillary and mandibular arch - A case series. Orthod Forum 2022; 18 (2): 112-21).**

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Introduction

Individual canine retraction is beneficial in patients with crowding in the upper and lower anterior teeth. One of the main advantages of individual canine retraction is the prevention of round tripping of teeth with reduction in treatment time.

Canine retraction can be done by several methods (1,2,3,4). The PG spring (3), T loop spring (5) and Marcotte spring are some of the springs that can be used for segmental retraction of the canine. All these springs have their individual advantages. Of these the segmental T loop (3,4) was introduced by Charles Burstone and several studies have been published describing its various aspects such as biomechanical principles, the forces and moments generated, clinical efficiency, etc proving its efficacy (6,7,8,9,10,11).

The design of the T loop spring is such that the ends of the loop may impinge on the soft tissue resulting in trauma and ulceration resulting in increased patient discomfort (12). Binding of the spring to the soft tissue reduces the effectiveness of the spring with delay in treatment. It was contemplated that if the end of the loop were to be rounded, this problem can be reduced. With this in mind Nanda came up with the idea of the mushroom loop. The corners of the T loop were rounded and the modified design had an apparent shape of a mushroom, hence the name 'Mushroom loop' or M loop. The mushroom loop was originally designed as a continuous loop for frictionless space closure. However, studies on the Mushroom loop archwire are not available in literature.

The basic biomechanical principles are common to all springs and involve the generation of alpha moment in the anterior region and beta moment in the posterior segment (13). The differential moment generated between the anterior and posterior segment determines the anchorage unit (13). The greater the magnitude of the moment generated, greater is the anchorage value of that particular segment. Thus, by increasing the magnitude of posterior moment, the posterior segment acts as the anchorage unit for retraction of anterior teeth. The anterior teeth can also act as the anchorage unit if the magnitude of anterior moment is increased, helping in protraction of the posterior teeth.

Generation of differential moments in the M loop spring

Differential moments can be generated in a segmental M loop similar to a segmental T loop (13,14) either by off centering the M loop spring or addition of preactivation bends.

1. Off centering of M loop spring

Placement of the M loop spring at the center of the inter-bracket distance results in generation of equal moments at both ends. A horizontal activation to the same extent at both the ends of the M loop spring placed in the center of the anterior and posterior segment will cause an angulation of both the anterior and posterior limbs of the M loop as the mushroom deforms under the influence of the applied force. The wire in both the anterior and the posterior segment deflect through the same distance generating equal moment in both the regions. This results in reciprocal anchorage with the anterior segment and posterior segment moving through the same distance towards each other (Fig. 1.). This results in Group B anchorage.

In Group A, greater moment is required in the posterior region to augment posterior anchorage. This can be achieved by off-centering the loop posteriorly. Upon horizontal activation a greater posterior moment is generated with a higher anchorage value compared to the anterior segment. Thus, the posterior segment acts as the anchorage unit with retraction of the anterior segment (Fig. 2.). The opposite of the above situation occurs in group C anchorage. The loop is off-centered anteriorly. Upon activation the wire deflects through a greater distance in the anterior region thereby acting as anchorage unit with protraction of the posterior segment.

2. Placement of pre-activation bends

Differential moments can also be generated by placing pre-activation bends in the alpha and beta segment of the loop. A greater pre-activation bend is given on the side requiring anchorage as compared to the retraction side. According to Nanda a pre-activation bend of 45^0 for group A and 30^0 for group B has been advised (12). In Group A anchorage, greater amount of bend is given in the posterior region which increases the magnitude of moment in the posterior region providing a higher anchorage value (Fig. 3.). Once the pre-activation bends are given, the two ends of the loop are held with a plier and the spring is brought to its neutral position prior to the insertion into the brackets. This is known as trial activation. It reduces stress concentration in the loop. The M loop spring is then inserted into the auxiliary tube in the posterior segment and the canine bracket in the anterior region. The mushroom loop spring after insertion, should have the same appearance and design that was present prior to the placement of pre-activation bends. This is known as the neutral position. The spring is then activated depending on the type of anchorage required.

To maintain transverse control irrespective of the manner in which the moments are generated, anti-rotation bends are placed in the M loop spring. As the point of force application is buccal to the centre of resistance of the maxillary canine and maxillary posterior teeth, there will be a distal in rotation of the canine and mesial in rotation of the posterior teeth. To counteract this rotation a 45° anti-rotation bend is given at both the corners of the M loop spring.

Fabrication of the segmental Mushroom loop spring

Height of the spring can be altered depending on the depth of the buccal vestibule. Since the mushroom loop is inserted into the auxiliary tube of the molar buccal tube the distal limb is shorter than the mesial limb by 1mm. The loop is fabricated such that it makes a smooth curve towards the apex of the loop, with an approximate height of 15 mm at the apex.

Aim

The aim of this paper is to describe the biomechanical principles on space closure with the mushroom loop spring. These following cases describe the use of the mushroom loop spring for individual canine retraction in clinical scenarios such as correction of anterior crowding, correction of proclination and for molar protraction.

Case Series

Case I - Crowding of anterior teeth

A female patient SD aged 15 years reported to the hospital with irregular alignment of teeth. She had a pleasing facial appearance. On intraoral examination she had an Angle's Class I molar relation with crowding in the upper and lower arch. The left maxillary canine was bucally placed and both the mandibular canines were rotated.

Space requirement to correct the crowding in both the arches required extraction of the first premolars in all four quadrants. Individual canine retraction with segmental mechanics using M loop spring with maximum posterior anchorage was considered. Segmental M loop spring made of 0.017"x0.025" TMA wire was placed from the auxiliary buccal tube of the permanent first molar to the canine bracket in all four quadrants (Fig. 4.). The M loop was off-centered distally by 3 mm and the anterior limb was pulled and ligated in the canine bracket to provide the necessary activation. It was contemplated that off-centering the loop will provide adequate differential moments to provide sufficient anchorage in the posterior region. In our previous experience off-centering the spring distally with a distal activation had an unfavorable effect on anchorage with a possibility of mesial movement of the posterior segment (15).

The patient was reviewed periodically. Further activation was done only when the mushroom loop spring had returned to its neutral position. Once distal movement of the canine was achieved, the M loop spring was removed and a continuous wire was placed (Fig. 5.).

Further treatment was continued and the appliance was debonded once the anterior teeth were aligned (Fig.6.).

Case II- Proclination and crowding of anterior teeth

A female patient aged HD aged 12 years of age reported to the hospital with forwardly placed upper front teeth. Extraoral examination revealed a pleasing profile. Intraoral

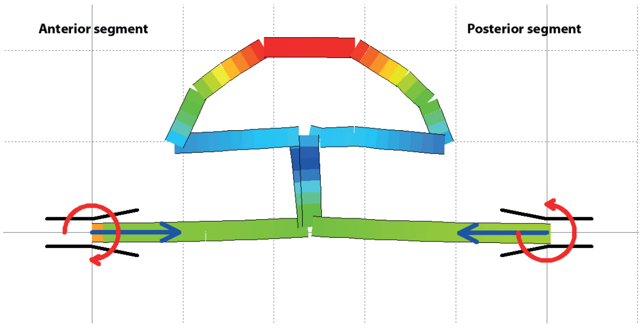

Figure 1. Group B anchorage with reciprocal anchorage in the anterior and posterior segment moving them through the same distance towards each other.

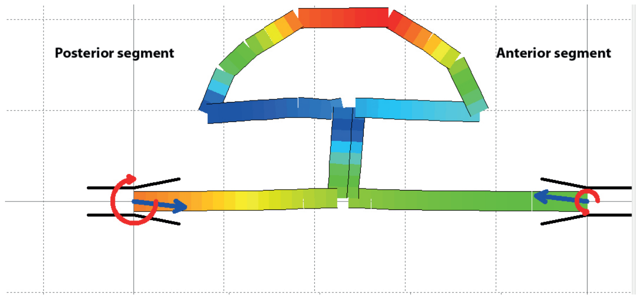

Figure 2. Group A anchorage The posterior segment acts as anchorage unit with retraction of the anterior segment. The opposite of this is seen in Group C anchorage.

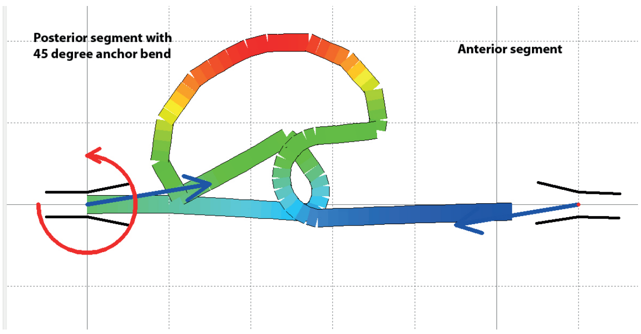

Figure 3. Group A anchorage obtained by bends incorporated in the loop, the greater the amount of bend given the particular segment, greater the anchorage value.

examination showed an Angle's Class I molar relation with mild proclination in the maxillary arch and crowding in the lower arch. The maxillary left canine had a distal in rotation and the left mandibular canine was buccally placed. The first premolars were extracted in all four quadrants to gain space and individual canine retraction was done with segmental M loop spring.

Group A anchorage was obtained in the posterior segment by consolidating the second premolar and permanent first molar and placing differential moments by off-centering the M loop spring. Individual canine retraction was done with a segmental M loop made of 0.017"x0.025" TMA wire placed in all four quadrants (Fig. 7.) from the auxiliary tube on the maxillary first permanent molar to the permanent canine bracket. The patient was reviewed periodically and re-activation was done when the loop returned to its neutral position till the permanent canine moved into the premolar extraction space. (Fig. 8.).

Proclination of and crowding of the incisors in the maxillary and mandibular arch were corrected respectively and the appliance was debonded (Fig. 9.). A midline shift of 0.5mm was present which was acceptable.

Case III- Crowding and end molar relationship

A female patient KL aged 17 years of age reported to the hospital with irregular arrangement of the upper and lower front teeth. Extraoral examination showed that the patient had a pleasing profile. Intraoral examination revealed Angle's Class I molar relation on the right side and end on molar relation on the left side with severe crowding in the upper and lower arch. The first premolars were extracted in three quadrants except the left lower quadrant where the second premolar was extracted to correct the end on molar relation.

Segmental M loop spring made of 0.017"x0.025" TMA wire was placed in all quadrants. Except the left lower segment the M loop spring in all the other quadrants were off- centered posteriorly with an anterior activation (Fig. 10.). In the left lower quadrant the M loop was off-centered anteriorly and activated with a posterior activation. Differential moments were used to protract the left lower first permanent molar and distalise the canine in the other three quadrants.

The patient was reviewed periodically and re-activation was done once the loop returned to the neutral position. Once the desired tooth movement was achieved the M loop spring was removed (Fig. 11.).

Once decrowding was achieved the appliance was debonded (Fig. 12.).

Results

In case I, at the end of retraction it can be noted that the canines in all four quadrants had translated and were upright over the basal bone and Angle's Class I molar relation has been maintained at the end of retraction (Fig.13.). The differential moment generated between the anterior and posterior segment produced translation of the canines without much anchor loss. The axial inclination of the canine was confirmed from the orthopantomogram taken prior to (Fig. 14.) and at the end of retraction (Fig. 15.).

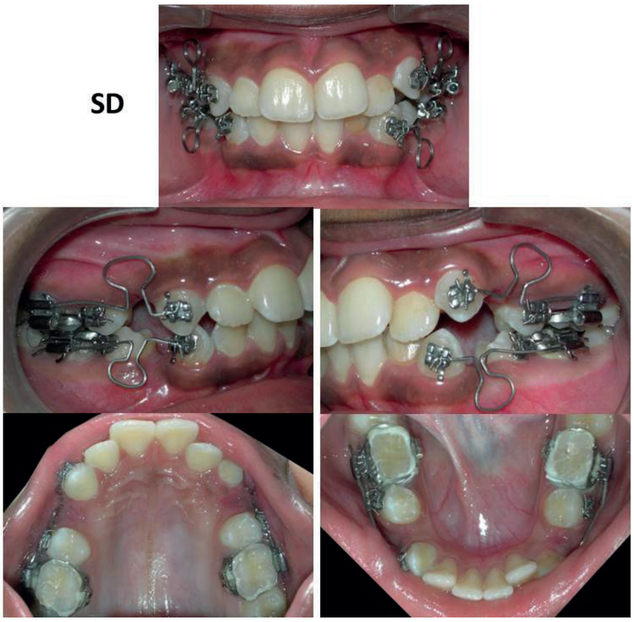

Figure 4. Patient SD with crowding in the upper and lower anterior teeth with the segmental M loop placed from individual canine retraction in all four quadrants.

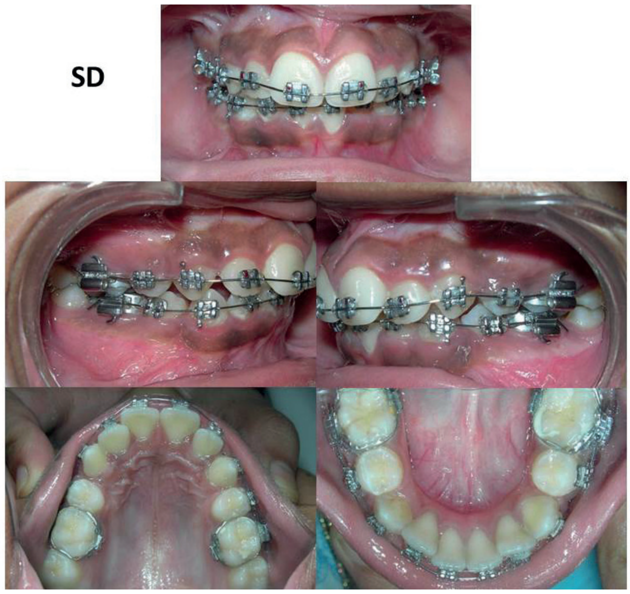

Figure 5. Patient SD, end of canine retraction and continuous arch wire placed for alignment of anterior teeth.

In case II, at the end of retraction, the maxillary canine on both sides showed translation (Fig. 16.). However, in the mandibular arch both canines showed a mild distal tipping with mild mesial in rolling of the left lower first molar (Fig.16.). This was corrected as treatment progressed.

In case III, in the maxillary arch, the canines had translated distally on both sides (Fig. 17.). In the lower arch, the left molar showed mesial movement from an end on molar relation although further finishing was required (Fig. 17.) on the right side the canine had translated distally into the premolar extraction space (Fig. 17.). The upper and lower anterior teeth showed drifting with crowding of anterior teeth (Fig. 17.).

The duration of retraction varied from 6 to 8 months in the above treated cases.

Discussion

The classical T loop spring has been extensively studied and reported in literature (5,6,7,8,9). The mushroom loop spring which is the modification of the T loop spring has not got the same attention as its predecessor. The M loop spring has been marketed primarily as a retraction loop on a continuous arch wire although an internet search did not show its current availability. Its application in segmental mechanics has not been evaluated. Hence an attempt was made to check the clinical feasibility of the mushroom loop for segmental retraction of the canine. The mushroom loop was custom made for each patient and was made of 0.017”x0.025” TMA wire. Although in theory it can be made from 0.016”x0.025” stainless steel, achieving the shape of the mushroom may prove to be more difficult than a TMA wire. Since the design of the mushroom loop involves a smooth curve and does not have the precise dimensions like the T loop, bending the Mushroom loop may require some expertise.

Care should be taken to avoid mucosal contact especially when the canine is not in alignment such as being buccally placed or rotated. Traditional segmental mechanics involves leveling and aligning the segments prior to the placement of the spring. But in the above cases the spring was placed at the beginning of treatment and necessary compensation may be placed in the anterior segment to counteract for undue forces that may be generated due the mal-aligned teeth. Inadvertent torque may be added onto the anterior tooth especially when the tooth is buccally placed and care must be taken to minimize it. Increasing the magnitude of the anti-rotation bends will compensate for distal in rotation of the anterior segment and mesial in rotation of the posterior segment. Frequent activations should be avoided as they may result in distally tipped canine, rotation of the entire segment or tooth, anchor loss and vertical discrepancy between the anterior and posterior segment.

Anchorage may be augmented if required by the addition of a trans-palatal arch and the lingual stabilizing arch. The permanent second molars may also be included in the arch to augment the posterior segment in group A anchorage.

The efficiency of the spring can be improved taking into account certain parameters such as soft tissue

Figure 6. Patient SD, intraoral photographs after de--bonding of the appliance.

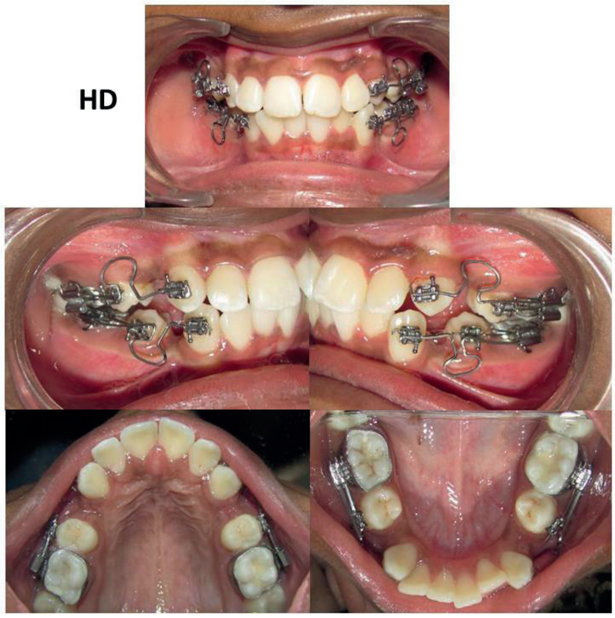

Figure 7. Patient HD showing proclination of the upper anterior teeth, crowding in the lower anterior teeth. Individual canine retraction performed with segmental M loop in all four quadrants.

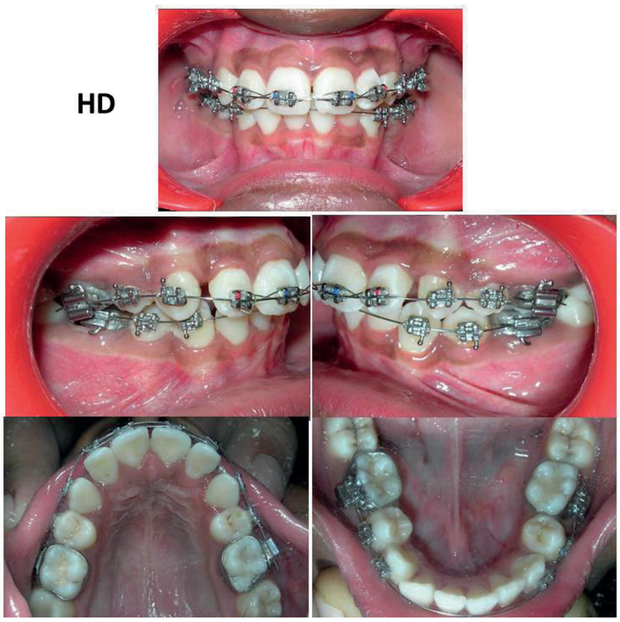

Figure 8. Patient HD, end of individual canine retraction.

Figure 9. Patient HD showing intraoral photographs after de-bonding with good inter-cuspation.

impingement, torque incorporation, controlled moments, adequate time interval between activation and inadvertent breakage of attachments. Minor changes in the position of the spring may have significant changes in the magnitude of the differential moment.

Like a T loop spring it can be expected that the mushroom loop also has three phases of tooth movement, tipping translation and root movement upon horizontal activation (13). The segmental M loop spring requires precise fabrication, proper placement and activation. As the spring is not fail safe any distortion of the spring can result in undesirable tooth movement. Also, despite the carefully designed spring, greater knowledge and skill is required in handling any loop including the mushroom loop to avoid side effects

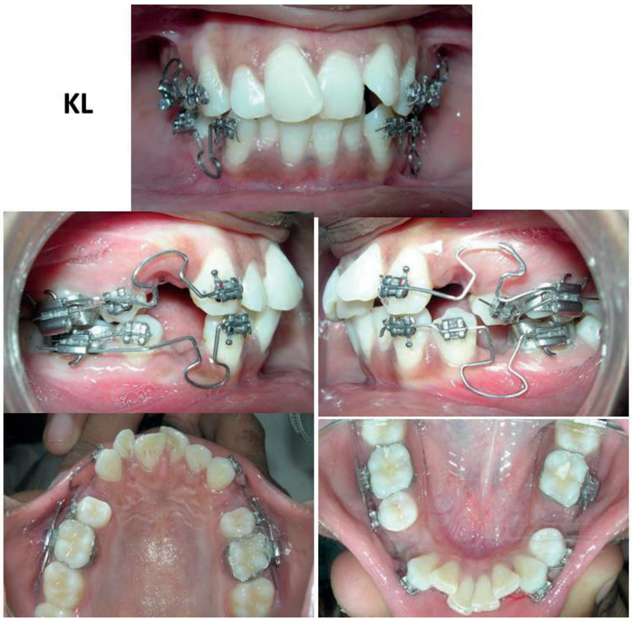

Figure 10. Patient KL with crowding the upper and lower anterior teeth with end on molar relation on the left side. Segmental M loop was placed in all four quadrants, in three quadrants for canine retraction and one for molar protraction.

Figure 11. Patient KL at the end of individual canine retraction. Note the drifting of the teeth in the anterior teeth with reduction in crowding.

like anchorage loss, bite deepening, dumping of the teeth into the extraction space and torque loss. However, its advantages of individual canine retraction in severely crowded cases may surpass all other known treatment mechanics. Individual canine retraction in severe crowded cases prevents round tripping of the anterior teeth and reduces treatment time. It is esthetic as brackets are not placed on the anterior teeth. Also, alignment of the incisors is easier and simple once the canine has been distalized into the first premolar extraction space. Sometimes, the anterior teeth move along with the canine due to the pull of the periodontal fibers resulting in correction of crowding of the incisor teeth.

Segmented arch technique consists of multiple wire cross-section and varying wire sizes that are found in different segments of the arch in contrast to the continuous arch wherein a straight wire of one particular cross-sectional dimension and material is contoured to the arch from and is attached to the adjacent brackets and tubes.

Segmental mechanics consists of a determinate force system with active and reactive units. Active units cause tooth movement whereas the reactive unit is used for stabilization. Active units are springs generating relatively constant force within an optimum range. This is brought about by a wire which has a low load deflection rate and high elastic limit. The load deflection rate can be decreased by increasing the inter-bracket distance or by incorporating more wire in the loop. This also increases the time interval between activations and produces a more constant force. High elastic limit prevents permanent deformation. The segmental arch is accompanied by light continuous force with reasonable control of the anchor units.

In contrast to the above, a continuous arch has a short inter-bracket distance found between the brackets. Lack of space limits the amount of horizontal activation in continuous arches. Load deflection rate is high. A continuous arch exerts forces on the adjacent teeth whereas in segmental mechanics the reactive forces are transferred to the entire anterior or posterior segment.

The amount of canine retraction varies among the different springs present in clinical use with the closing loops producing an average canine retraction of 1.73 mm (9) whereas the Marcotte spring exhibited a canine retraction of about 1.188 mm per month and this is greater when compared with a T loop spring during sectional canine retraction (12). The amount of tipping and anchorage loss was high with a Marcotte spring compared to a T loop spring (12). Maximum tipping was observed with the open coil spring, followed by the PG spring, the closed coil spring, and the T loop spring (16). The T loop spring may be preferred whenever minimal tipping is desired (16). The PG spring produced the highest initial displacement for a given force followed by open coil, closed coil, and T-loop (16). Different brands of TMA produce different force systems and respond differently to the incorporated bends (17).

Figure 12. Patient KL, at the end of treatment after the appliance was de-bonded.

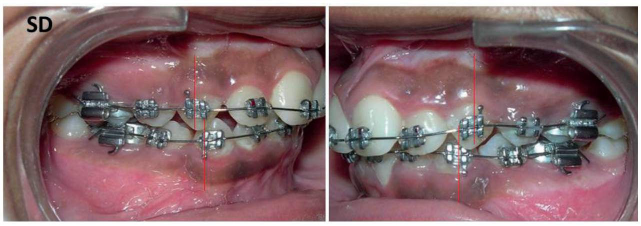

Figure 13. Patient SD showing translation of the canine without distal tipping in all four quadrants.

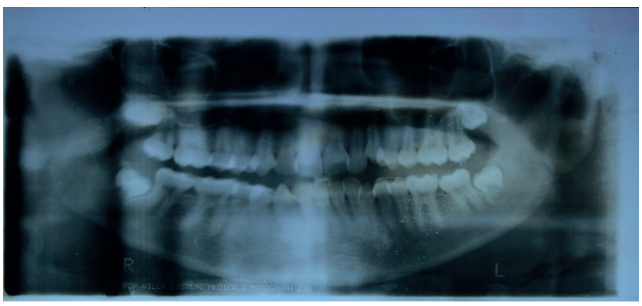

Figure 14. Pre-treatment OPG to assess the inclination of the canine.

Significant forward movement of the upper first molar occurred in cases treated by continuous arch mechanics compared with segmented arch mechanics (18). Therefore, a transpalatal arch is usually required to augment anchorage (18). The posterior anchorage bend given to the T loop spring enhances anchorage and is used to retract the maxillary canine.

Figure 15. OPG taken at the end of canine retraction showing translation of the canine.

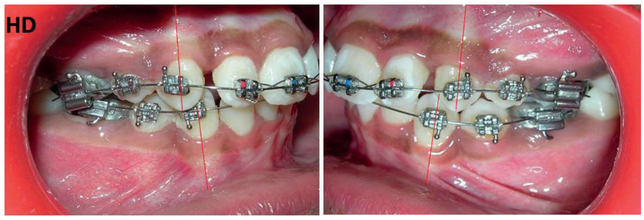

Figure 16. Patient HD, showing translation of the canine in the upper arch. Mild distal tipping of the canine was noted in the lower arch. Hence, a continuous arch wire was placed prior to the placement of the brackets in the anterior region.

Figure 17. Patient KL, showing translation of the permanent canine in the upper arch.

Comparison of anchor loss between conventional brackets and self ligating brackets with loop mechanics showed no significant difference (19). Space closure with loop mechanics in lingual orthodontics showed that the T loop spring exerted less force with an increased M/F ratio as compared to closed helical loop (20). T loop spring showed greater torque preservation in the anterior segment compared to a closed helical loop (20). When the amount of pre-activation of the T spring loop increased there was an increase in the moment, force and M/F ratio (21). The M/F ratio in a T loop spring is influenced by various factors such as addition of vertical steps, location and intensity of preactivation bends, type of alloy use, arch wire dimensions, height of the loop and presence of curvature and bends. Addition of vertical steps to the T-loops increased the M/F ratio at the posterior bracket sufficient enough to produce root movement (22). Without preactivation bends, the M/F ratio increased with activation, while the opposite effect was observed with preactivation (23). The NiTi T loop spring produced an M:F ratio of greater than 10:1 over a larger deactivation range with a force delivery of 50-150 g than for the equivalent TMA T loop spring (24). Optimum M:F ratios for orthodontic translation can be achieved with both preactivated NiTi and TMA T loop spring, with NiTi loops maintaining the optimum M:F ratio over a greater range of deactivation (24).

Compared with stainless steel archwire, TMA archwire loops can generate a higher M/F ratio due to its lower elastic modulus (6). Loops with a small cross-sectional area and high activation force can generate a high M/F ratio (6). The T loop spring preactivated by incorporation of a curvature in the horizontal limb of the spring delivered lower horizontal forces and higher moment-to-force and load-deflection ratios than those preactivated by concentrated bends (25). The larger dimension wires produced higher forces with slight increase on the moments. M/F ratio produced by the 0.016” x 0.022” wire was the highest (26). Lower M/F moves canine faster than higher M/F both on occlusal plane and in the M-D direction (27). Increasing the loop height can increase the M/F ratio of the loop (6).

Stress relaxation was greatest in T loop springs within 24 hours and gradually increased up to 12 weeks (28). Stress relaxation occurred at the bend between the vertical extensions of the springs and the base arch and the other at the preactivation bends made in the base arch (28).

There was no evident root resorption with the use of T loop spring (29). There can be various factors that affect the rate of tooth movement. Factors like bone density, bone metabolism, and turnover in the periodontal ligament, amount of force applied may be responsible for the variation. Adjunct procedures such as circumferential supracrestal fiberotomy did not have a significant increase in rate of retraction of canine in the recent extraction site compared to that without fiberotomy (30).

There was no significant anchorage loss with a mini-implant-supported Nance appliance with indirect skeletal anchorage system and a mini-implant-supported direct skeletal anchorage system during segmental distalization of canines requiring maximum anchorage (31). Although Burstone proposed a bracket with a vertical slot to insert the anterior segment of the T loop spring, the spring is routinely ligated into the horizontal slot of the canine bracket. Crimpable tube with a 90-degree bend such that it can be placed on the base wire to secure a T-loop in segmental retraction has been described in literature (32). Comparing the patient comfort of the existing springs the Marcotte spring was better compared to a T loop spring as determined with VAS scores (12).

As there is insufficient data available with the use of M loop spring the factors influencing the efficacy of the T loop can be used as a guide for the use of M loop.

As there is limited literature describing the various mechanical and clinical aspects of the M loop, further studies comparing the efficiency of the M loop with other springs used for canine retraction and anterior retraction can be considered.

Conclusion

Thus, it appears that the M loop spring can be used for different clinical situations such as individual canine retraction and molar protraction. The mushroom loop spring produced translation of the canine in most of the situation without any major effect on the posterior segment. The mushroom loop spring appears to be effective in segmental retraction of canine and can be clinically used for patients especially those with upper and lower anterior crowding.

Piśmiennictwo / References

1. Matsui S, Otsuka Y, Kobayashi S, Ogawa S, Kanegae H. Time-saving closing loops for anterior retraction. J Clin Orthod 2002; 36: 38-41.
2. Chaconas SJ, Caupto AA, Miyashita K. Force distribution comparisons of various retraction archwires. Angle Orthod1989; 59: 25-30.
3. Gjessing P. Controlled retraction of maxillary incisors. Am J Orthod Dentofacial Orthop 1992; 101: 120-31.
4. Burstone CJ. The mechanics of the segmented arch techniques. Angle Orthod 1966; 36: 99-120.
5. Manhartsberger C, Morton JY, Burstone CJ. Space closure in adult patients using the segmented arch technique. Angle Orthod 1989; 59: 205-10.
6. Cai Y. Finite element analysis of archwire parameters and activation forces on the M/F ratio of vertical, L- and T-loops. BMC Oral Health 2020; 20:70.
7. Jie Chen, David L. Markham, Thomas R. Katona, Effects of T-Loop Geometry on Its Forces and Moments. Angle Orthod 2000; 70: 48-51.
8. Viecilli RF. Self-corrective T-loop design for differential space closure. Am J Orthod Dentofacial Orthop 2006; 129: 48-53.
9. Kuhlberg AJ, Priebe D. Testing force systems and biomechanics--measured tooth movements from differential moment closing loops. Angle Orthod 2003; 73: 270-80.
10. Ferreira JB, Silveira GS, Mucha JN. A simple approach to correct ectopic eruption of maxillary canines. Am J Orthod Dentofacial Orthop 2019; 155: 871-80.
11. Kuhlberg AJ, Burstone CJ. T-loop position and anchorage control. Am J Orthod Dentofacial Orthop 1997; 112: 12-8.
12. Davis S, Sundareswaran S, James J. Comparative evaluation of the efficiency of canine retraction using modified Marcotte and T-loop retraction springs - A split-mouth, randomized clinical trial. J Orthod Sci 2019; 23: 8:9.

13. Ravindra Nanda. Biomechanics in Clinical Orthodontics. Publisher Elsevier Health Sciences-W B Saunders 1997.
14. Micheal R Marcotte. Biomechanics in Orthodontics. BC Decker Inc 1990: 19106.
15. A. Sumathi Felicita. The segmental mechanics - An efficient method to reduce treatment duration in severely crowded cases. VJO 2010: 8 (serial online).
16. Kumar YM, Ravindran NS, Balasubramaniam MR. Holographic analysis of the initial canine displacement produced by four different retraction springs. Angle Orthod 2009; 79: 368-72.
17. Martins RP, Caldas SG, Ribeiro AA, Vaz LG, Shimizu RH, Martins LP. Differences in the force system delivered by different beta-titanium wires in elaborate designs. Dental Press J Orthod 2015; 20: 89-96.
18. Alhadlaq A, Alkhadra T, El-Bialy T. Anchorage condition during canine retraction using transpalatal arch with continuous and segmented arch mechanics. Angle Orthod 2016; 86: 380-5.
19. de Almeida MR, Herrero F, Fattal A, Davoody AR, Nanda R, Uribe F. A comparative anchorage control study between conventional and self-ligating bracket systems using differential moments. Angle Orthod 2013; 83: 937-42.
20. Chacko A, Tikku T, Khanna R, Maurya RP, Srivastava K. Comparative assessment of the efficacy of closed helical loop and T-loop for space closure in lingual orthodontics-a finite element study. Prog Orthod 2018; 19: 14.
21. Girsa P, Singh AK, Kannan S, Arora N, Malhotra A. Comparative evaluation of T-Loop with different amount of pre-activation curvatures in lingual orthodontics- A finite element study. J Oral Biol Craniofac Res 2021; 11: 118-22.
22. Techalertpaisarn P, Versluis A. T-loop force system with and without vertical step using finite element analysis. Angle Orthod 2016; 86: 372-9.
23. de Castro SM, Moreira R, Braga AC, Ferreira AP, Pollmann MC. Effect of activation and preactivation on the mechanical behavior and neutral position of stainless steel and beta-titanium T-loops. Korean J Orthod 2015; 45: 198-208.
24. Rose D, Quick A, Swain M, Herbison P. Moment-to-force characteristics of preactivated nickel-titanium and titanium-molybdenum alloy symmetrical T-loops. Am J Orthod Dentofacial Orthop 2009; 135: 757-63.
25. Caldas SG, Martins RP, Galvão MR, Vieira CI, Martins LP. Force system evaluation of symmetrical beta-titanium T-loop springs preactivated by curvature and concentrated bends. Am J Orthod Dentofacial Orthop 2011; 140: e53-8.
26. Almeida L, Ribeiro A, Parsekian Martins R, Viecilli R, Parsekian Martins L. Nickel titanium T-loop wire dimensions for en masse retraction. Angle Orthod 2016; 86: 810-7.
27. Li S, Chen J, Kula KS. Comparison of movement rate with different initial moment-to-force ratios. Am J Orthod Dentofacial Orthop 2019; 156: 203-9.
28. Júnior RS, Caldas SG, Martins LP, Martins RP. Effects of stress relaxation in beta-titanium orthodontic loops: Part II. Angle Orthod 2016; 86: 386-90.
29. Makhlouf M, Aboul-Ezz A, Fayed MS, Hafez H. Evaluating the Amount of Tooth Movement and Root Resorption during Canine Retraction with Friction versus Frictionless Mechanics Using Cone Beam Computed Tomography. Open Access Maced J Med Sci 2018; 6: 384-8.
30. Kalra A, Jaggi N, Bansal M, Goel S, Medsinge SV, Abraham R, Jasoria G. Comparison of rate of canine retraction into recent extractiokn site with and without gingival fiberotomy: a clinical study. J Contemp Dent Pract 2013; 14: 419-26.
31. Ozkan S, Bayram M. Comparison of direct and indirect skeletal anchorage systems combined with 2 canine retraction techniques. Am J Orthod Dentofacial Orthop 2016; 150: 763-70.
32. Martins RP, Gandini LG Jr, Martins IP, Martins LP. Crimpable double tubes for segmental retraction. Orthodontics 2011; 12: 400-3.