Scholars Journal of Dental Sciences (SJDS)
Abbreviated Key Title: Sch. J. Dent. Sci.
ISSN 2394-4951 (Print)
ISSN 2394-496X (Online)

A Unit of Scholars Academic and Scientific Society, India
www.saspublishers.com
DOI:10.36347/sjds.2018.v05i05.006

Impact of change in Loop designs and it's wire materials in Orthodontics: A Review

Dr. Neha Bhandari[1*], Dr. Vasudevan S[2], Dr. Ranjit kamble[3], Dr. Sunita Shrivastav[4], Dr. Shivani Deshmukh[5]
[1]Postgraduate student of Department of orthodontics, Sharad Pawar Dental College, Wardha, India
[2]Department of orthodontics, Sharad Pawar Dental College, Wardha, India
[3]Head of department, Deparment of Orthodontics Sharad Pawar dental college, Wardha, India
[4]Professor, Deparment of Orthodontics Sharad Pawar dental college, Wardha, India
[5]Postgraduate student of Department of Orthodontics, Sharad Pawar dental college, Wardha, India

Review Article

***Corresponding author**
Dr. Neha Bhandari

Article History
Received: 27.04.2018
Accepted: 15.05.2018
Published: 18.05.2018

DOI:
10.21276/sjds.2018.5.5.6

Abstract: Extraction space closure in one of the important steps in orthodontic treatment. Number of loop configuration available in the literature. These loop designs that have been described have specific applications and when properly employed produce effective responses. They can be quite effective additional means for controlling orthodontic forces. M/F ratio and FDR of any loop are those biomechanical parameters which govern the efficiency of any retraction loop. In depth understanding of these properties is essential for efficient utilization of any retraction loop. Any type of tooth movements can be produced by the loops. They usually are included in the retraction stage of treatment. However, the loops may also be used in various treatment stages; leveling, alignment and finishing. Loops may be employed with or without helixes and can be placed by altering the length and height of the loop. This review article deals with several literature data of loop designs with their biomechanical properties in different materials and that can alter the effectiveness of the loop.
Keywords: Loop design, archwire material, and review.

INTRODUCTION

One of the major reasons for individual seeking orthodontic treatment is to improve their facial appearance. Literature search has revealed that for the correction of esthetics, extraction of teeth, especially first premolar is frequently carried out. The selection of treatment, involving any technique , material and spring or appliance design should be based on the desired tooth movement..

Well-designed loops promote a more continuous type of tooth movement by eliminating the intermittent force delivery seen in the sliding mechanics. Additionally, since loops deliver frictionless forces, the tissue of the periodontium experiences more continuous stresses [1].

While loops designs are numerous, there are many reasons for choosing one configuration over another. Preferences for a particular loop are often based on its simplicity of fabrication and delivery. The three primary characteristics of a loop are (1) the moment/force ratio which determines the centre of rotation of tooth during its movement, (2) the greatest force at yield that can be delivered from a retraction spring without permanent deformations, and (3) force to deflection rate. Literature shows us that the moment / force ratio is altered by the vertical height of the loops, horizontal length of loop, positioning of the loops, extent of activation, properties and thickness of wire used[2].

Another variable that the orthodontist has under his control is the alloy used for the archwire fabrication. There are various types of alloys used for making loops like stainless steel, cobalt chromium, Titanium Molybdenum Alloy (TMA), TiMolium, Connecticut Nanda Archwire (CNA) etc. So this article deals with, how the biomechanical properties of various loops changes by changing the loop configuration and wire material.

DISCUSSION

Robinson[3] in 1915 first gave the concept of loops for retraction as "A system of positive and painless tooth movement". Strang[4] in 1933 introduced both open and closed (reverse loop) into the edgewise system for retraction of teeth and Begg[5] in 1956 extensively used vertical loop for rotation control, space opening & closing. Various loop and wire material combination studies had been done previously. Every study indicated a different perspective towards configuration and wire material combination.

Ideal M/F ratio using loop can be generated by factors such as:

- height of loop
- horizontal loop length
- Diameter of wire which is directly proportional to moment to force ratio.
- apical length wire
- position of loop in segment
- helices incorporations
- angulation of the loop legs

The biomechanical properties of the loops depend on wire cross section, wire length, wire material and wire configuration (shape and design).

Raboud *et al*. [6] the clinical importance of the three-dimensional effects of the force systems supplied by appliance designs used for retraction by comparing the non-activated and activated vertical loops and T loops using the numerical segmental method. One problem that occurs clinically is the axial rotation of a single rooted tooth as a result of the forces being applied by the retraction device on the tooth's buccal surface. An out-of-plane reactivated bend can be used to counteract this rotation. They found that at maximum activation, vertical loops produced higher forces than T springs. None of the gabled vertical loops approached an M/F ratio required for translation. They concluded that reactivated T loops were more suitable to promote translation, especially when they were fabricated with TMA.

Burstone *et al*. [7] discussed the clinical application of frictionless attraction springs using the segmented arch technique. The material used was beta-titanium, which simplified the design and allowed for direct welding of materials. The wire cross sections should be kept as small as possible, limited by the moments needed rather than the force. In one spring, a composite spring used a heavier-base arch in order to ensure that an adequate beta moment was produced. Indiscriminant placement of wire will reduce the moment-to-force ratio.

The loop centricity affected the rate of change of the moment-to-force ratio in the alpha and beta positions. If equal rates of change are required loops should be centrally placed. Where greater moment-to-force ratio constancy required, loops should be displaced off centre in the direction of those teeth (segment) where constancy is needed.

The large inter attachment distance between the auxillary tube on the first molar and the vertical tube of the canine allows sufficient room for the large activations required.

Siatkowski *et al.* [8] used a systematic approach and fabricated a closing loop design in continuous archwires. He used the Castigliano's theorem to derive equations for moment-to-force ratios in terms of loop geometry. Further, he tested the new design, named the opus -70 loop, and compared with different loop designs such as the 8mm vertical loop and 10mm T-loop. Three designs of the opus loop were tested, with variations by altering the size of the arch wire, the material used (stainless steel and TMA) and alterations in loop height. All the designs were tested for their moment -to-force ratios in centered as well as eccentric placements. The results showed the least moment-to force ratio with the vertical loop, followed by the T-loop. The opus-70 fared better than the T-loop in most instances for both the centered and off-centered placements.

Rao *et al*. [9] carried out an FEM analysis of snail loop, opus loop and teardrop loop en mass retraction of anterior teeth using Ansys 10 and 11 software in a computer loaded with IBM. There are 13 finite element models were constructed and 14 analyses were done to evaluate the biomechanical properties of snail loop and compare it with teardrop and opus loop.

The result of the study shows that the M/F ratio produced was higher and F/D rate produced was least for opus loop compared to snail loop and teardrop loop. Conclusion of the study suggests that with incorporation of 20 degree gable bends snail loop prepared in 0.017 x 0.025 inch TMA wire is very efficient to deliver M/F ratio required for translatory tooth movement with acceptable F/D rate.

Katona *et al*. [10] Evaluated whether gable-bend influences on the generated forces and moments. In the study, they used ninety triangular loops that were divided into 9 groups with combinations of 0° and 30° first- and second-order gable bends in the anterior and posterior positions. Forces (Fx, Fy, Fz) and moments (Mx, My, Mz) generated along 3 mutually perpendicular axes—x (mesiodistal), y (occlusogingival), and z (buccolingual)—were measured, and moment/force ratios (Mz/Fx, My/Fx) were calculated. The groupings differed in the amounts of (0° or 30°) first- and second-order gable bend before activation.

Results were the magnitude of Mz/Fx increased significantly with second-order gable bends but did not change with first-order bends. The opposite was found for My/Fx. Activation distance and group (first-order v second order bends) had significant (P-.0001) effects on Fx, and here was interaction between activation distance and group. The study concluded that in triangular springs, first- and second-order gable bends produce the desired effects without interfering with each other.

As stated by Burstone *et al*. Lowering the LD by placing helices would decrease the M: F ratio changes for every millimeter of activation. Because there was not access to an orthodontic force tester, our study was limited in evaluating the M: F ration rate and the new design of T-loop with outer helices needed a further survey. Moreover finding a better position for the helix in a T- loop, to gain the more advantages of Bauschinger effect, should still be evaluated in the future studies.

Furthermore, the study of Kuhlberg *et al*. performed in 2003 should be considered as a bridge in the gap between the laboratory sector and the clinical-biological realm. They stated that the narrow tolerance and high repeatability in physics was not presented in clinics and variability was a rule rather than an exception. Although the simple T-loop has been endured in the second stage of fix orthodontic treatments, for its undeniable advantage, a revision this design would be a relevant choice for future investigations. Regarding this issues increasing length of T-loop with helices might decrease LD but the place and design of helices has not been considered a critical factor so far. Although many studies have been investigated this subject, still more future works and studies adopting new methods and machines are probably required.

Castro *et al*. [11] measured the effects each activation has on the distribution and magnitude of the horizontal force, M/F ratio, and L/D in the alpha (a) position for different preactivations in a 7-mm high T-loop. In the study, total 100 loops measuring 0.017 × 0.025 inches in cross-section were divided into two groups according to composition, either stainless steel or beta-titanium and two groups were further divided into five subgroups, 10 loops each, corresponding to the five preactivations tested: preactivations with occlusal distribution (0^o, 20^o, and 40^o), gingival distribution (20^o), and occlusal-gingival distribution (40^o).The loops were subjected to a total activation of 6-mm.

For the M/F ratio, the highest value achieved without preactivation was lower than the height of the loop. Without preactivation, the M/F ratio increased with activation, while the opposite effect was observed with preactivation. The increase in the M/F ratio was greater when the preactivation distribution was partially or fully gingival.

The highest value achieved without reactivation was lower than the vertical dimension of the loop. In most activation, reactivation bend insertion resulted in higher values for steel compared with TMA. The increase in the M/F ratio observed with the insertion of reactivation bends was highest when the location of the bends was partially or fully gingival. For the L/D ratio, a small decrease or increase of the L/D ratio occurred as the level of activation increased, depending on the reactivation present, which confirms the elastic behavior of all the loops tested.

Viecilli *et al*.[12] measured T-loop force systems made in 0.017 x 0.025-in TMA T-loops constructed with LOOP software were used. Geometric modifications were determined during controlled tipping of the 6 anterior teeth, where there was no movement of the posterior teeth, thus configuring a type a anchorage situation. Usually, T loop changes in angulation of the brackets and vertical forces the M/F ratio at the alpha end increased dramatically and at the beta end reduced. To compensate for this, certain modifications were suggested for preparing the T loop, Opening the anterior ear of the loop, as in the original design, would allow us to decreased height and horizontal wire dimensions yet would increase MF ratio in the anterior unit can reduce working range, because the effect will already be a result of the geometry affects the final force system, ultimately increasing it.

Chiang *et al*. [13] validated en masse retraction or two-step retraction could provide more effective torque control of the anterior teeth when varying the degree of gable bend in loop mechanics. 3D FEM models were made and the forces and moments delivered by 10 mm high teardrop loops with gable bends of 0, 5, 10, 15, 20, 25, and 30˚ were calculated by the tangent stiffness method. Result were the moment to force (M/F) ratio generated by activation of closing loops increased as the degree of gable bend was increased from 0˚ to 30˚. The degree of lingual crown tipping increased in en masse retraction, whereas it decreased in two-step retraction as the degree of gable bend was increased. He concluded that effective torque control of the anterior tooth in two-step retraction seen by incorporation of gable bends into closing loops.

Kumar *et al*. [14] observed amount of anterior en mass retraction using T loop and mushroom loop made of TMA and CNA archwire and vertical and angular changes in canine during retraction after single activation. Subjects were divided into 4 groups of 7 each. In Group I, en mass retraction was done with 0.017” X 0.025” Beta-titanium wire incorporating the continuous T-loop design. In Group II, en mass retraction was carried out with 0.017” X 0.025” Beta titanium wire incorporating the continuous Mushroom loop design. In Group III, en mass retraction was carried out with 0.017” X 0.025” CNA wire. Preformed mushroom loop arch wires were used. In Group IV, en mass retraction was carried out with 0.017” X 0.025” CNA incorporating the continuous T-loop design. Results showed mean anterior retraction with the T loop made of TMA was 1.52mm while the mushroom loop design of the TMA wire was 1.86 mm. The T loop and mushroom loop designs of the CNA wire showed an equal mean retraction of 2.2mm. The study concluded that anterior retraction was faster with CNA wires as compared to TMA wires. The design of the loop made no difference to the rate of retraction and the vertical change in canine position was lesser with CNA wires as compared with TMA wires. The angular change in canine position was similar in all the four groups studied.

Proffit [15] described three major characteristics, which influence the performance of a closing loop. These include the spring properties, moments generated by the loop and the location of the loop. The second problem was that many of the experiments cited failed to control the type of tooth movement. In most experiments, tipping tooth movement has been performed, which meant that an uneven distribution of stresses and strains were invoked within the periodontal ligament. The third consideration that contributed to confusion on the relationship between force and rate of tooth movement is that orthodontic tooth movement could be divided into several phases, in many studies, tooth movement was evaluated over a relatively short period of time, leading to data pertaining only to the first two phases of the process and not to the post lag or linear phase in which true orthodontic tooth movement is recognized in both human research and animal experiments.

Chen *et al*. [16] measured the load components produced by T-loop springs, and the effects of design variations. A 0.016 inch x 0.022–inch stainless steel wire was used to bend the T-loop springs on a template jig. The vertical (v) and horizontal (h) dimensions were 6 or 7 millimeters and 6, 7, or 8 millimeters, respectively. For statistical reasons, 10 specimens of each design (60 totals) were fabricated. The same springs were also tested with 30˚ gable preactivation and stress-relieving heat treatment (GPH) at 700 ˚ F for 11 minutes followed by bench cooling. In this way, a parametric study was performed to investigate the effects of spring dimensions and GPH. Here, an instrument was built and calibrated to measure orthodontic load components. Spring activation was achieved by displacing the moving frame along the x-direction. The moment (Mz) and forces (Fx and Fy) on the left side were recorded from the transducer outputs that had, 0.1 N resolution. The springs with no GPH were tested first. Since the deformations were below the elastic limit of the stainless steel, GPH was done on the same spring and the test was repeated. The effects of vertical and horizontal dimensions and activation distance on Fx, Mz, and Mz/Fx were compared for the T-loop using repeated measures analysis of variance models.

Results showed that in without gable preactivation and stress-relieving heat treatment, the activation and vertical dimension had insignificant effects on the Mz/Fx ratio. However, the shortest springs generated approximately 10% higher Mz/Fx. In with GPH with activation, the average horizontal force, Fx, increased from approximately 1.5 to 4.3 N .Increasing the vertical dimension from 6 to 7 mm lowered Fx by about 20% with 2 and 3 mm of activation. The 6-mm horizontal dimension produced about 25% higher Fx than the 8 mm at all activations. Stiffness was about 1.4 N/mm. The highest Mz/Fx ratios were at 1 mm activation. The loops with the largest horizontal dimension (8 mm) exhibited 17% lower ratios. The range for all springs was 5.0–6.8 mm. Conclusion was GPH may be clinically useful as a means of increasing Mz/Fx; however, the consensus appears to be that even our highest achieved value, 5.7 mm, is insufficient for bodily translation. So that the moments and forces generated by a T-loop spring are functions of its geometry and gable angle combined with heat treatment. In general, increasing its vertical or horizontal dimension reduces the load-deflection rate and the moment-to-force ratio. Gable preactivation and stress relieving heat treatment has the opposite effect.

Coimbra *et al*. [17] evaluated the use of computer simulation to predict the force and the torsion obtained after the activation of teardrop loops of 3 heights. Seventy-five teardrop retraction loops of stainless steel, 0.019x0.025-in rectangular wire were bent and divided into 3 groups based on the height of the loops. The groups were divided into teardrop loops of 6, 7, and 8 mm heights. The teardrop loops were separated into finite elements, and an average of 237 elements was used for modeling the various heights. Results showed after mechanical testing, the 6-mm teardrop loop had the highest force and torque results at all activation levels.

Rose *et al*. [18] investigated the loads (forces), moments and moment-to-force ratios (M:F) generated during the activation and deactivation of T closing loops made of rectangular nickel-titanium (NiTi) and titanium-molybdenum alloy (TMA) wires incorporating either 0˚, 15˚, or 30˚ of preactivation. All TMAT- loops showed significantly greater moments as preactivation increased, and this tended to be in a linear fashion. The moments produced by the Niti loops initially showed the same trend until 3mm of activation, after that, the moment of the 0˚ Niti loop exceeded that of the 15˚ Niti loop, although this difference was not statistically significant. A higher mean M:F ratio over the range of activation and deactivation for the TMAT loop was observed as the preactivation increased, So the study concluded that the optimum M:F ratios for orthodontic translation can be achieved by using preactivated NiTi and TMA T-loops, with NiTi loops maintaining the optimum M:F ratio over a greater range of deactivation.

In all the above studies, different results obtained regarding M/F ratio and F/D rate. Many more studies had been conducted for the proper evaluation of the loop from all points of view.

CONCLUSION

Extraction is the commonest treatment option used in orthodontics. Frictional mechanics have their own merits and demerits but frictionless mechanics are more efficient in decreasing the anchorage loss. In order to overcome this, frictionless system is effective. Again frictionless system also has its demerits because of complexity of loop forming and sometimes it is not comfortable to the patient. In addition, minor errors in loop can result in major differences in tooth movement. Important advantage of retraction with closing loop mechanics is precise control over tooth movement and predictable force level which helps for the desired tooth movement. If loop mechanics is chosen for retraction, then operator should be able to make proper loop designs for the betterment of the treatment.

REFERENCES

1. Chakravarthy CH, Kumar PK. 'Loops in Orthodontics'—A Review. Indian Journal of Mednodent and Allied Sciences. 2014 Feb;2(1):57-63.
2. Nanda, Ravindra. Biomechanics and esthetic strategies in clinical orthodontics. Elsevier Health Sciences, 2005.
3. Robinson RD. A system of positive and painless tooth movement. International Journal of Orthodontia. 1915 Oct 1;1(10):497-509.
4. Stoner MM, Lindquist JT. The edgewise appliance today. Current orthodontic concepts and techniques. WB Saunders Company, Philadelphia. 1969.
5. Begg PR, Kesling PC. Begg orthodontic theory and technique. WB Saunders Company; 1977.
6. Raboud DW, Faulkner MG, Lipsett AW, Haberstock DL. Three-dimensional effects in retraction appliance design. American journal of orthodontics and dentofacial orthopedics. 1997 Oct 1;112(4):378-92.
7. Burstone CJ, Koenig HA. Optimizing anterior and canine retraction. Am J Orthod. 1976 Jul 1;70(1):1-9.
8. Siatkowski RE. Continuous arch wire closing loop design, optimization, and verification. Part I. American journal of orthodontics and dentofacial orthopedics. 1997 Oct 1;112(4):393-402.
9. Rao PR, Shrivastav SS, Joshi RA. Evaluation and Comparison of Biomechanical Properties of Snail Loop with that of Opus Loop and Teardrop Loop for en masse Retraction of Anterior Teeth: FEM Study. Journal of Indian Orthodontic Society. 2013 Apr 1;47(2):62.
10. Katona TR, Le YP, Chen J. The effects of first-and second-order gable bends on forces and moments generated by triangular loops. Am J Orthod Dentofacial Orthop 2006 Jan 31;129(1):54-9.
11. Viecilli RF. Self-corrective T-loop design for differential space closure. American journal of orthodontics and dentofacial orthopedics. 2006 Jan 1;129(1):48-53.
12. 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. The Korean Journal of Orthodontics. 2015 Jul 1;45(4):198-208.
13. Chiang PC, Koga Y, Tominaga JY, Ozaki H, Hamanaka R, Sumi M, Yoshida N. Effect of gable bend incorporated into loop mechanics on anterior tooth movement: comparative study between en masse retraction and two-step retraction. Orthodontic Waves. 2015 Sep 1;74(3):55-61.
14. Kumar V, Vignesh K, Chitranjan AB. An Evaluation & Comparison of Anterior En Masse Retraction UsingT-loop with TMA & CNA Wires & Mushroom Loop with CNA & TMA Wires After Single Activation.
15. Proffit WR, Fields Jr HW, Sarver DM. Contemporary orthodontics. Elsevier Health Sciences; 2006 Dec 8.
16. Chen J, Markham DL, Katona TR. Effects of T-loop geometry on its forces and moments. The Angle Orthodontist. 2000 Feb;70(1):48-51.
17. Coimbra ME, Penedo ND, de Gouvêa JP, Elias CN, de Souza Araújo MT, Coelho PG. Mechanical testing and finite element analysis of orthodontic teardrop loop. American Journal of Orthodontics and Dentofacial Orthopedics. 2008 Feb 1;133(2):188-e9.
18. Rose D, Quick A, Swain M, Herbison P. Moment-to-force characteristics of preactivated nickel-titanium and titanium-molybdenum alloy symmetrical T-loops. American Journal of Orthodontics and Dentofacial Orthopedics. 2009 Jun 1;135(6):757-63.