Loops in Orthodontics: A Review

Preetika Lakra[1]*, Ankur Kaushik[1], Amit Sanghi[2], Nikita Gupta[3], Anubhav Bansal[4], Anand Sharma[5]

[1]Department of Orthodontics and Dentofacial Orthopedics, Faculty of Dental Sciences, P. D. M University, Bahadurgarh, Haryana, India.
[2]Department of Orthodontics and Dentofacial Orthopedics, Private Practitioner, Bhiwani, Haryana, India.
[3]Department of Orthodontics and Dentofacial Orthopedics, Private Practitioner, Jammu, Jammu and Kashmir, India.
[4]Department of Orthodontics and Dentofacial Orthopedics, Private Practitioner, Najafgarh, New Delhi, India.
[5]Private Practitioner, Patna, Bihar, India.

Abstract

Extraction therapies are commonly done in patients with protrusion and/or crowding which demands a thorough understanding of biomechanics. Two basic types of space closing mechanics are friction/sliding and frictionless/loop mechanics. In the former, the wire and position of the bracket are important factors in tooth movement but the simplicity of friction mechanics is offset by the binding between bracket and archwire and may be associated with undesirable side effects such as uncontrolled tipping and deep bite. In frictionless mechanics, specially designed springs are used which provides the required moment to force ratio (M/F ratio) in three dimensions and they are more predictable and versatile. An electronic literature search was conducted through Google scholar, PubMed, and dental associations' of different countries' website using the key word "Loops" and "Frictionless mechanics. Different configuration of loops has been used in orthodontic treatment and a comprehensive review of types of loops commonly used in retraction has been highlighted in this article.

Keywords: Frictionless mechanics, Loops, Space closure, T loop.

Introduction

Extraction therapies are frequently necessary in patients with protrusion or crowding. Once extraction is decided, antero-posterior position of incisor must be established and determination of the force system is to be done. Differential space closure is divided into Group A, Group B, and Group C mechanics. Groups A and C mechanics is more challenging than Group B mechanics. 1 Two basic types of space closing mechanics are friction/sliding and frictionless/loop mechanics. In frictionless mechanics, there is no guide wire and specially. The spring provides required M/F ratio in three dimensions and as no force is lost due to friction they are more predictable and versatile. The recent trend in orthodontic practice is to use "straight" arch wires, especially since the introduction of the highly elastic and super elastic alloy. However, bending orthodontic loops is still an essential part of orthodontics. Advances in the field of biomechanics have shown that in certain situations a loop may be superior to a straight arch wire because it delivers the appropriate force system for efficient tooth movement in the required direction.[1,2]

Discussion[1,2]

Loop design is an integral part of orthodontic treatment, proper design gives predictable force systems and therefore predictable tooth movement. One way of generating a predefined force system is by using loops as part of free-end mechanics, that is, not bent into a continuous arch but either part of a cantilever are added to a bypass. By varying the design and position of minor bends, Burstone and Koeing showed how the desired combination of moments and forces could be obtained for a specific tooth movement. Inserting loops into the wire makes it easier to produce the necessary activation for a special force system. For major correction loops are needed for: To lower the load-deflection rate, to eliminate friction, to deliver a predictable force system with respect to the moment to force ratio, and to dissociate forces and moments. A typical wire loop is characterized by the size, shape, and material from which it is fabricated. The initial alignment of irregular anterior teeth when using fixed appliances is often undertaken by incorporating multiple loops into the arch wire. The objective is

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Address for correspondence: Dr. Preetika Lakra, Department of Orthodontics and Dentofacial Orthopedics Faculty of dental Sciences, P.D.M University Bahadurgarh, Haryana, India.
Email: lakra.preetika87@gmail.com

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to increase the wires flexibility and ability to deflect elastically at the sites of the irregularities, whilst retaining the necessary rigidity in other parts of the arch to maintain the

The three important characteristics involving active and reactive members:

- The moment to force ratio
- The load deflection rate and
- The maximum force or moment of any component of the appliance.

General properties of the loops[3,4]

David lane (Angle orthodontist 1980)

- No loop exerts a truly continuous force.
- Loops may be contoured to open or close up on activation.
- The use of any loop will result in reduced stiffness and greater range of activation because of increased length of wire between brackets.
- Loop stiffness may be decreased by incorporating helices in the loop or reducing cross sectional dimensions of the wire of the loop.
- Elastic range of loop is increased if the loop is activated in the same direction as it is formed.

Classification of Loops[2,5]

- Based on geometry or design - 4 basic configuration:
    - Vertical
    - L Loop
    - T Loop
    - Rectangular Loop.
- Based on incorporation of helices:
    - Loop with helices (e.g., double vertical helical closing loop)
    - Loop without helices (T loop)
- Based on function:
    - Rectangular loop - T and L loop
    - Uprighting loop - T loop
    - Molar distalizing - K loop
    - Used as stops - Omega loops

Loop design: Sitkowski 1997

- Translation of a free body occurs when a net applied force has a line of action that passes through the body's center of mass. A constrained body translates when the forces line of action passes through its center of resistance. Because of anatomic limitations in the oral cavity, it is usually not possible to devise an intraoral mechanism to deliver force whose line of action passes through the tooth's center of resistance. There are two approaches that can be used to apply force that is necessary to trigger the biology, that result is space closing movement of individual tooth or group of teeth "en masse."[6]

Force generated is determined by[7]

- Material properties of the wire, Length of the loop, Preactivation bends placed, Flexibility of the arch wire largely depends on bending in the vertical limb and torsion in the loop.
- Deformation can be due to
    1. Radial loading.
    2. Vertical loading.

       Where maximum flexibility is sought that the loop base should be as wide as possible; however, care must be taken not to allow the vertical limbs contact the teeth where they can interfere with the intended teeth movement.

U-loop[8]

Burstone and Koenig (1976) reported the couples produced by activating symmetrical open U-loops of differing design. He also calculate a yield force for a standard U-loop with a loop height of 6mm assuming the stress generated at the apex of the loop exceeded the conventional yield stress. The ability of an appliance to resist distortion in use is neglected but important spring characteristic, since lack of this ability will undermine the efficiency of clinical treatment. An important cause of variability in the load-deflection behavior of identical loops is the inherent variation in wire radius and degree of cold work within wires.

Vertical loops[1,2]

The standard vertical loop can be altered by increasing or decreasing the height and the radius of the bends; however, these effects have been shown to be relatively minor. The addition of the single apical helix has the overall effect of reducing the levels of both the force and the moment for any given activation. The lateral helix lowers both the force and moment magnitudes at any activation, they have a greater reducing effect on the moment and as a result, the M/F ratio is actually lower than the standard system.

Modifications of vertical loops[9]

1. Double vertical loop used for labial/lingual movement and rotation correction
2. S loop- similar to vertical loop without undermining occlusal/gingival thrust
3. Omega loop which gives bodily thrust to the last tooth in the arch
4. Horizontal loop used for bite opening and easier bracket engagement
5. Double horizontal loop used for tipping and root movement
6. Horizontal T loop
7. Box loop, a combination of horizontal and vertical lever
8. Torqueing loop produces labial or lingual torque.

T-loop[10]

The application of differential moments between teeth is recognized as an effective means of achieving desired tooth movement. Variation in the force and moment magnitude and the moment to force ratio are important determinants of the resulting tooth movement. The force system produced by a segmented T-loop spring consists of several components - the alpha moment, the beta moment, horizontal forces, and vertical forces. Horizontal activation of the "T" loop was studied by

Koenig *et al*. (1980). The moment to force ratio was found to deviate from the experimental value by <2%.

Continuous arch T-loop

The T-loops one on each side is made distal to the cuspids, desired alpha and beta moments are placed anterior and posterior to the T-loop vertical legs. Recommended beta activation for anchorage is 40°, 30°, 20° respectively. A 14 year old boy presented with mesially tipped lower second molars due to early extraction of first molars because of caries. The treatment plan involved uprighting of second molars to create space for relief of crowding in the anterior section. T-looped springs made of 0.018 × 0.025" spring hard rectangular wire, were used to upright the molars. The distal arm of T-looped spring was angled gingivally approximately 30° to rotate the molar at the center of rotation located in the middle of molar tube and move the root mesially. The mesial arm was passive and engaged the brackets on the premolars and canines. The time taken for uprighting was 1 month.

Opus loop

This new design delivers a non-varying target M/F within a range of 8.0–9.1 mm inherently, without adding residual moments by twist or bends anywhere in the arch wire or loops before insertion (siatkowski 1997.[6] Opus loop can be fabricated from 16 × 22, 18 × 25, or 17 × 25 TMA wire. The design of the loops calls for an off center positioning with the loop 1.5 mm from the mesial canine bracket. It is activated by tightening it distally behind the molar tube and can be adjusted to produce maximal, moderate or minimal incisor retraction (Siatkowski 2001).[11]

K-loop[12]

Introduced by Kalra (1995), this appliance consists of a K-loop to provide force and a Nance button to resist anchorage. K-loop is made of 0.017" × 0.025" TMA wire with each loop being 8 mm long and 1.5 mm wide and is placed between the first premolar and first molar

- Activation is by 20 degree bends in appliance that produce moments that counteracts the tipping moments created by the force of appliance. Thus molar undergoes translatory movement instead of tipping. Root movement continues even after the force has dissipated. Single activation produces 4 mm distal molar movement in 6–8 weeks and 1 mm anchorage loss is seen during 4 mm molar distalization.
- Advantages of K-loop are:
    1. Simple yet efficient.
    2. Controls the moment to force ratio to produce bodily movement, controlled tipping, or uncontrolled tipping as desired.
    3. Easy to fabricate and place.
    4. Hygienic and comfortable for the patient.
    5. Requires minimal patient cooperation.
    6. Low cost.

Niti canine retraction spring[13]

0.016 × 0.022 titanium wire with anti-tip and anti-rotation incorporated. Ability to deliver continuous forces and moments over a broad range of activation.

Ricketts maxillary canine retractor[14]

- Combination of double closed helix and an extended crossed T. In critical anchorage case, 45° gable bends and 0–5 g/mm of activation (Ricketts 1974).

PG spring (Paul Gjessing 1985)[15]

- This spring offers excellent control of force and moments and the most effective current design.

Double ovoid specialized spring with a small loop occlusally to lower the level of activation in the brackets in the short arm. About 30° sweep was incorporated into the distal leg and mesial leg was angulated by 15°. The standardized PG spring produce force system required for translation movement of canines and incisors without changing the morphology of the spring. The Gjessing loop was modeled which was limited to the section between the premolar and the canine, thus disregarding most of the sweep of the distal spring leg. Preactivation bends of 15° and 12° were placed on the posterior and anterior legs, respectively. The loop was activated from the neutral position by 1, 2, and 3 mm. a load deflection of 64 gf/mm reported experimentally. A study was conducted (Divakar Karanth and V. Surendra Shetty. JIOS 2002) to analyze the horizontal force exerted and the load deflection characteristics of the T-loop retraction spring and PG retraction spring which were fabricated from different dimensions of stainless steel, cobalt chromium, beta titanium, and titanium niobium wires and to compare them. The springs were fabricated on a template for standardization purpose and horizontal forces exerted by these springs were measured for every millimeter of activation till 6 mm. The results of the study revealed that PG springs exerted relatively low magnitude of force and relatively constant load deflection rate when compared to T spring. Beta titanium and titanium niobium springs showed force values closer to the optimum force required for translation of canines.

Monkey hook[16]

- The Monkey hook consisted of a short section of wire with open loops on opposite ends. Intraoral elastics, elastic chains, elastic thread, or NiTi coils can be attached to these open loops to produce forces to direct the eruption or rotation of teeth. The loops can be closed with pliers when linking one hook to another to form a chain or when connecting the Monkey hook to a bondable "loop-button." The loop button or bondable eye consists of a 1 mm helix of round wire that has been welded or braised to a small diameter bondable base. A Monkey hook can be "linked" to the loop button prior to bonding and then this combination is bonded to the tooth with the helix positioned parallel to the roots of the adjacent tooth.
- Mode of action:

- Vertical eruptive forces: This force can be created using an intermaxillary elastic stretched from the Monkey hook to a hook on the arch wire or bracket on a tooth in the opposing dental arch. This arrangement does unfortunately introduce the unpredictable factor of patient compliance with elastic wear.
- Lateral eruptive force: If anchorage is unavailable from an opposing arch, then intra arch mechanics can be produced using multiple Monkey hooks added to the same loop button attachment. Elastic chain is attached to one end of the Monkey hook and directed to adjacent teeth, creating a "sling Shot" effect. A closed coil spring is placed on the base arch wire to prevent tipping of the adjacent teeth toward the impacted tooth.

Kilroy spring[17]

- The Kilroy Spring is a pre-formed module that simply slid onto a rectangular continuous arch wire at the site of an impacted tooth. A stainless steel ligature is then placed through the helix at the apex of the vertical loop of the Kilroy and then this loop is directed toward the impacted tooth.
- Mode of action:
- The Kilroy spring is supported by-1) the rectangular base arch wire, 2) reciprocal force from the incisal one-third of the adjacent teeth contacted by the lateral extensions of the Kilroy Spring.
- Kilroy 1 spring was designed to produce both lateral and vertical eruptive forces for palatally impacted canines.
- Kilroy II spring produces more vertical forces and was created for buccally impacted teeth.

Conclusion

Optimal force provides the periodontal tension which generates maximum cellular and biomechanical activities responsible for tooth movement. Extension of this load beyond this level can lead to root resorption, loss of anchorage and alteration in movement to force ratio. Hence, identification of the force in relation to activation of the spring is of utmost importance.

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