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Loops in orthodontics- An extensive review

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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.

Keywords
Loops, biomechanics, space closure

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. Group 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 wireand specially designed springs are used. 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.[2]

Loop mechanics has the same 3 phases during space closure as sliding, namely tipping followed by translation and then root movement. The difference in a properly designed appliance is greater activation range and a more constant force, moment and M/F ratio leading to a constant centre of rotation. [1] In this review article we have explained about the various loops used widely in orthodontics including ideal dimension, activation and studies conducted using the loops.

1. Materials and Methods

An electronic literature search was conducted via google scholar, PubMed, and dental associations' of different countries' website using the key word “Loops” and “Frictionless mechanics.

- Components of a loop

  Loops consists of horizontal force system, vertical force system, alpha bend, beta bend and helical component. Each loop is constructed with one or more of the above

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components. Specific component of each loop has been mentioned under the respective loop. [2]

- Classification of loops
  a. Based on configuration
     - Horizontal loops(e.g. boot loop)
     - Vertical loops
     - Combination(T Loop)

  b. Based on purpose of the loop
     - Leveling and Aligning
     - Retractione
     - Multipurpose
  c. Based on presence of helix
     - Loops without helix(e.g. vertical loop)
     - Loops with helix(e.g. Helical bulbous loop)
  d. Based on function
     - Opening loops
     - Closing loops

Biomechanical Properties of Loops

An ideal loop has a large range of action, large allowable working load and a low load deflection rate. [2] Parameters improving biomechanical properties are increasing height of the loop, additional wire at the apex of the loop and angulating loop base to apex which improves M/F ratio. 3 Off-centered placement of loop plays an important role in altering the moments generated at the alpha and the beta ends. Placement of loop towards anterior side would increase alpha moment and decrease beta moment. Differentials in M/F ratios can be very helpful in anchorage management. Thus, a higher beta moment leads to posterior anchorage augmentation. When interbracket distance is less, off-centering will affect the moment significantly, thus this distance is an important consideration for biomechanical properties of loop.[4]

Various Loops used in Contemporary Orthodontics

Vertical loop

Vertical loop was in introduced by Robert Strang in 1933. It is constructed with 0.016" SS wire and has a height of 6mm. Vertical loops can be closing or opening loops and can be used for opening or closing spaces and rotating teeth.1Modifications of vertical loops are [5]

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

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6. Horizontal T loop
7. Box loop, a combination of horizontal and vertical lever
8. Torquing loop produces labial or lingual torque

Bull loop

The Bull loop was given by Harry L. Bull in 1951. A sectional steel arch wire made of 0.0215” x 0.025” was used to retract the anteriors. A closed loop in the region of the extraction site of the first bicuspid is activated to open the loop by a millimetre after tying the arches in. A tieback loop is placed well ahead of the molar tube to activate the arch sufficiently. Dr. William Houghton modified the maxillary sectional arch by adding a small loop, distal to the closing loops for engaging the anterior end of the class II elastics.[6]

An advantage of the use of this loop when used for class II correction in conjunction with class II elastics is that they do not procline the mandibular anteriors since the closing loops restrain this effect.[7]

Dimensions of the loop for each arch[8]

Upper bull loop – Height-7mm, wire distal to loop – 18mm, wire mesial to loop -22mm, Lower bull loop – Height-5mm, wire distal to loop – 20mm, wire mesial to loop -28mm

Horizontal loop / Boot loop

Boot loop was described by Morris M. Stoner in 1960 and is formed by placing the active legs parallel to the arch wire. Incorporating a horizontal loop allows greater control over the direction of the force. [5]

The horizontal loop’s principal value is its reduction of force in the vertical plane or occluso-gingival direction, permitting immediate bracket engagement in severely positioned teeth which the operator may want to elevate or depress. It is effective in bite opening. Immediate bracket It is possible to contour the horizontal loop to press against the gingival area to develop a torquing activity on the root; however, clinically has not been found to be very effective. [5]

Efficiency of the double Horizontal Loop is best when kept on an individual tooth either above or below the line of occlusion. It can be activated in an occluso-gingival and labio-lingual plane but not in the mesiodistal plane. One loop can be contoured to elevate and the other loop can be contoured to depress, tending to tip the tooth or move the roots. [5]

Omega loop

A variation of the open vertical loop was described by Morris M. Stoner in 1960. It was called so due to its resemblance to the Greek letter omega after which it is named. Its advantage over the open vertical loop lies in its lesser fracture tendency, owing to a more even stress distribution through the curvature of the loop rather than its concentration at the apex. It is commonly used for bodily movement of the root and as a molar stop. [5]

A modified omega loop was described to close a maxillary midline diastema by Gandhi et al. by placing two crimpable hooks on the arms of the loop diametrically opposite to each other. An E-chain stretched between the hooks provided the activating force to close the midline diastema.

Loop

Loop was given by Dr Charles J Burstone 196210 According to Burstone, [9, 10, 11]

- TMA wire should be used in construction of T loop.
- Additional wire should be placed as far apically as possible to increase the activation moment-to-force ratio.
- The loop centricity in the alpha and beta positions affects the rate of change of the moment-to-force ratio.

Asymmetric T loop

Asymmetric T loop was described by James Hilger in 1992.This loop allows simultaneous bite opening and space closure. It is made of 0.016" X 0.022" TMA or 0.019" X 0.025" TMA wire with 5mm vertical step, 2mm anterior loop, 5mm posterior loop and exaggerated reverse curve of Spee. [12]

Activation of asymmetric T loop is done by compressing short mesial loop and opening long distal loop.

Double keyhole loop(DKL loop)

John Parker of Almeda, California introduced Double keyhole loop (DKL) in Roth treatment mechanics. 0.019" X 0.025" rectangular SS archwireis used for fabrication of DKL. This loop resembles a champagne bottle which is a mixed vertical and horizontal loop.

DKL consists of two symmetrical loops bilaterally near canines that resemble key eyelets. Height of the loop is 7mm and the distance between two loops of the same side is approximately 8 mm. Indispensable requisites for installation of DKL:

- The anterior sector should be diastema free and consolidated with ligature wire to maintain close proximal contact.
- Well aligned dental arches with previous arch wire sequence fully expressing torque on each tooth.
- Dimension of DKL must be similar to previous rectangular arch wire to allow an easy insertion and perfect sliding of the arch in the slots of the braces.[13-18]

Activation of DKL:

Use of the arch as a spring this activation can be done in two ways:

- Activation by distal traction of the arch By pulling the archwire for opening the loops from behind the molar tube for activation. Activation of loops should not be more than 1 mm.
- Activation with retro-ligature A ligature wire tied in between hook of the molar buccal tube and the distal loop of the DKL arch wire to activate this arch is another way

Rickett's Canine retraction spring

Rickett's canine retraction spring was described by Robert Rickett in 1976. 21 The maxillary canine retractor is a double vertical helical T closing loop with extended crossed arms. It is usually fabricated from 0.016"x0.022" SS wire of 70 mm length. It produces a canine retraction force of 50 gm for an activation of about a millimetre. An activation of 3-4 mm is required for individual canine retraction. In the mandible, the design of the spring is more compact. It is made of 0.016 x 0.016" blue Elgiloy and produces a force of 75 gm for a millimetre of activation. 2- 3 mm of activation is required for producing the necessary force. [19-22]

Opus loop

Opus loop was given by Raymond E. Siatkowski in 1977 in study which was a systematic approach to closing loop design for use in continuous arch wires. The design process uses Castigliano's theorem to derive equations for momentto-forceratio (M/F) in terms of loop geometry. [2]

Opus loop is capable of delivering M/F within the range of 8.0-9.1 mm.

Dimensions: 10 mm height, 10 mm length and 0.5 mm radius.It is constructed with 0.016 × 0.022 inch SS wire, 0.018 × 0.025 inch SS wire or 0.017 × 0.025 inch TMA wire. [23]

Variations of Opus loops are Opus 90 and Opus 70.

PG retraction spring

PG retraction spring was introduced in 1985 by PoulGjessing. The resultant spring design, made from 0.016 x 0.022 inch stainless steel wire and finalized by using a trial-and-error procedure applied to the bench testing set-up. The predominant active element is the ovoid doublehelix loop extending 10 mm apically. The spring is constructed to resist rotational and tipping tendencies during retraction and not to correct rotations and/or extreme deviations in inclination of the canine. Therefore, leveling of the buccal segments must be terminated prior to insertion of the spring.Activation to 140 to 160 grams is obtained by pulling distal to the molar tube until the two sections of thedouble helix are separated 1 mm and is repeated every 4 weeks. Minor rotations of the canine, which may take place during retraction in case of anatomic deviations in root anatomy, are easily corrected with lingual elastics subsequent to retraction. [24]

K-SIR arch

The K-SIR arch which stands for Kalra – Simultaneous Intrusion and Retraction was developed by Dr. Varun Kalra. It is a modification of the segmental arch technique as applied to continuous arches. Closed U-loops of 7mm height and 2mm width is fabricated with 0.019"x 0.025" TMA archwire at the sites of extraction. A 90 degree centred Vbend is placed at the level of each U-loop and a 60 degree V-bend located off centred with the shorter arm near the molar tube producing an increased clockwise moment on the 1st molar thereby augmenting posterior anchorage. A 20 degree anti-rotation bend is used to counter the mesiolingual rotation of the buccal segments. [25]

Trial activation reduces the stress build up in the loop and also decreases the severity of the V-bends. It exerts an extrusive moment on the molar which needs to be adequately controlled. This is overcome by the forces of occlusion and mastication. [26]

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Rectangular loop

The rectangular loop described by Drs. Vittorio Cassiafesta and BirteMelsen is versatile loops which can be used for first, second and third order corrections. Being inserted and held at both ends, it encompasses the statically indeterminate force system. TMA wire is the wire of choice in fabricating a R-loop since wires of varying dimensions can be welded together. Typically, 0.018"/ 0.017" x 0.025" wires are used for the correction of rotated and tipped teeth since they have a large working range. This loop is the most effective in correcting single tooth discrepancies in all planes of space. A good control of the desirable tooth movement along with transference of the undesirable effects to the anchorage unit is noted. [27]

Mushroom loop

Pre-fabricated mushroom loop arch-wires were introduced by Drs. Flavio Uribe and Ravindra Nanda in 2003. This looped arch-wire produces an ideal moment to force ratio for translation. Moreover, neither is there any interference of the loop with the gingival tissue nor does it distort readily thereby improving the delivery of orthodontic load. 0.017" x 0.025" β-III Connecticut new arch-wire is used at distances which have been standardized between 26-46 mm with a 2 mm increment. This measurement in millimetre denotes the distances between the distal surfaces of the lateral incisors. [28]

Snail loop

Snail loop was introduced by Dr. Pavankumar Vibhute in 2004. Snail loop is spiral shaped and designed for en masse space closure of the anterior teeth. [29] The snail loop is fashioned from 0.017"x0.025" stainless steel wire by bending a simple omega loop into a spiral shape, which provides the forces and moments. The outer portion of the snail loop is 8mm high and 6mm wide and the inner portion is 6mm high and 3mm wide. [29]

Tear drop loop

The ideal force applied to achieve movement of the mandibular incisors is approximately 2.60 N. 11,30,31 The springs that best approached this value were the teardrop springs of 6 mm height activated by 0.5 mm, which provided 2.51 N force and the teardrop loop of 8 mm height which was activated 1.0 mm provided a 2.77 N force. The teardrop loops with heights of 7 had values less than 2.60 N, heights of 8 mm had values less than 1.89 and when activated 0.5 mm had values 1.37 N. The teardrop loops with heights of 7 and 8 mm activated 1.0, 1.5, and 2.0 mm had higher forces than the ideal values for mandibular incisor movement.[30]

Bulbous helical loop

A helical bulbous loop of height 7.5mm is fabricated at the end of mandibular anchorage preparation of 0.020" x 0.025" arch wire flush against the 2order bends. The helix is wound to the lingual during fabrication. [31]

Shoe horn loop

Shoe horn loop has been described in Tweed Merrifield appliance. The height of the loop is 8mm. It consists of a long and a short vertical loop. [32]

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Cherry Loop

Cherry loop was given by Peretta Redento in 2002. It is constructed with 0.017"x 0.025" SS. A large diameter round loop of 8mm width is bent using Rouland plier. Height of the loop is 8-9mm and opens 3-4mm at occlusal end to avoid stress and deformation. Cherry loop is used in molar protraction where it is placed one half distances. [33]

Conclusion

Goals to be considered for any universal method of space closure include: Differential space closure: The capability of anterior retraction, posterior protraction or a combination of both should be possible.Minimum patient cooperation: This is achieved by eliminating the usage of head gears and elastics.Axial inclination control. Control of rotations and arch width. Optimum biologic response Tissue damage, particularly root resorption, should also be at a minimum .Operative convenience: The mechanism should be relatively simple to use, requiring only a few adjustments for the complication of space closure. [10]

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