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# Frictionless Mechanics – A Review

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## Abstract

The closure of spaces after extraction has been the most challenging procedure in orthodontics since it involves the knowledge of biomechanics and various procedures involved in the closure of the spaces. New knowledge concerning the biomechanics of spring design, along with the development of new materials, has made possible improvements which simplify the mechanics, improve the biologic response, and offer a more hygienic appliance. This article describes the various frictionless mechanics available.

## Introduction

Extraction space closure is a particularly interesting aspect of orthodontic treatment with respect to the principles of biomechanics due to the large movement and distances involved. The technical features of the appliances, including loop or spring shape, bracket-wire interactions, and the types of forces, are important treatment considerations. However, understanding the bio-mechanic basis of space closure leads to a better ability to determine the anchorage and treatment options and the prognosis of various alternatives, and to decide on the specific adjustments that can improve the outcome of care.[1,3,4]

Orthodontic space closure short, should be individually designed based on the diagnosis and treatment plan. The selection of any treatment, involving any technique, stage, spring, or appliance design, should be based on the desired tooth movement. Consideration of the force system produced by an orthodontic device aids in determining the utility of the device for correcting any specific problem[4,5]

Retraction mechanics can be divided into two categories, friction mechanics and friction less mechanics.

In friction mechanics the extraction space is closed with the help of elastic chain which is attached to the tooth and the continuous archwire placed or otherwise, canine, through application of a force, is expected to slide distally along and is guided by a continuous arch wire.[6,7]

In frictionless mechanics retraction is accomplished with forces and couples built into the loops or springs, which offer more controlled movement than friction mechanics.

This article discusses about the various frictionless mechanics.

**Frictionless mechanics**

In frictionless mechanics, teeth are moved without the brackets sliding along the arch wire. Retraction is accomplished with loops or springs, which offer more controlled tooth movement than sliding mechanics.[4]

The force of a retraction spring is applied by pulling the distal end through the molar tube and cinching it back. The moment is determined by the wire configuration and by the presence of preactivation or of gable bends, which produce an activation moment. In general, the more wire gingival to the bracket, the more favorable the activation moment, and therefore the better the overall M/F ratio. Gable bends are placed either within the loop or where the loop meets the archwire.[7]

**Spring properties** (force delivery) of a closing loop are determined by:

Wire material: Loop bent from wire with a low modulus of elasticity, such as titanium molybdenum, will have a lower load/deflection rate than a loop of the same configuration made of stainless steel.

The M/F ratio is not influenced by the wire material.[6]

Size of the wire: Greater force levels occur with increase in wire size[7]

Distance between points of attachment

- Low load deflection rates with decrease in the interbracket span will decrease the force.[8]

Amount of wire incorporated in the loop

Addition of helices lowers the load/deflection rate without significantly affecting the M/F ratio.[7]

**Root paralleling moments** to be generated require:

1. Stiffer wire
2. Loop design in which more wire is in the horizontal than the vertical direction to deliver the moments[7]

Location of the loop, as the closing loop functions as a V-bend in the arch wire and is sensitive to its position

The preferred location is at the spot that will be at the centre of the embrasure when the space is closed. ( in a first premolar extraction case, the closing loop should be 5mm distal to the centre of the canine tooth).

**Additional design considerations**

1. Loops should fail-safe, with continuous controlled force designed to produce tooth movement at a rate of approximately 1mm per month and not more than 2mm of range
2. Complex configurations should be avoided as they are less comfortable for the patient, difficult to fabricate and more prone to breakage.
3. A closed loop will always have a greater range of activation than an open loop of the same design (Fig 19), because of the additional wire and because of the Bauschinger effect, which states that the range of activation of a loop is always greatest in the direction of the last bend. To activate an open loop, the legs of the loop are pulled apart, unbending the loop; to activate a closed loop, the legs are brought together, in the direction of the last bend of the loop.[32]

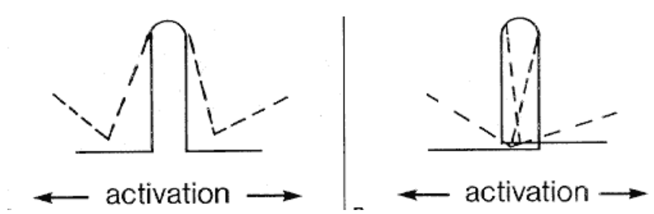


**Fig 1**

There is no real practical advantage in the range of activation of a closed loop, since loops usually are not activated to the point of permanent deformation. Furthermore, the range of activation can be increased more by using a wire with a lower modulus of elasticity than by using a closed loop instead of an open loop.[8]

**Clinical considerations**

The amount of anterior retraction or posterior protraction needed should be determined before a loop is designed.

If only anterior retraction is necessary, the retraction loop should be placed closer to the canine than to the molar, and a gable bend should be added near the molar. A gable bend that is larger in the posterior dimension will produce a larger beta moment, thus increasing posterior anchorage.

For both retraction of the anterior segment and protraction of the posterior segment, the loop should be placed midway between the posterior and anterior segments. A gable bend of equal dimensions should be used, so that the alpha and beta moments are equal and reciprocal space closure occurs.

When only posterior protraction is desired, the loop should be located closer to the posterior segment, and an anterior gable bend should be placed with a greater alpha moment than beta moment, making the anterior teeth the anchorage segment.[34]

Regardless of the initial magnitudes of the alpha and beta moments, changes in magnitude will occur during retraction. As the anterior teeth are retracted, the magnitude of the alpha moment decreases faster than that of the beta moment, enhancing posterior anchorage. Also, as the beta moment becomes relatively greater, there is a greater intrusive force on the anterior teeth and a greater extrusive force on the posterior teeth.[34]

Concurrent with the decrease in both alpha and beta moments, there is an increase in the moment-to-force ratio of the retraction spring, resulting from the lower applied force produced by tooth movement. Since the M/F ratio increases as the spring deactivates, the spring should not be reactivated too often. Frequent reactivation will not allow the spring to achieve a high enough M/F ratio to produce translation.[32]

**Advantages of Frictionless mechanics** [33]

1. It allows the clinician to achieve predetermined treatment goals; orthodontic treatment becomes doctor-determined rather than appliance-determined;

2. The force systems at the active and reactive units are relatively constant and defined; thus, their resulting movement is predictable;

3. Variable wire stiffnesses may be employed in the same arch to enhance the control of active and reactive units;

4. Prefabricated calibrated springs are used to accurately define the force systems;

5. It allows a choice of either posterior extrusion, true anterior intrusion or a combination in the correction of deep overbites;

6. Anchorage units are predetermined by the clinician;

7. The number of wire changes is reduced and wire forming is simplified during treatment;

8. Because of the low spring rates and long ranges of activation, variations in activations by clinicians are accommodated without deleterious effects to the force systems;

9. Frictional forces are eliminated; and

10. Dental asymmetries are solvable without compromise.

**Disadvantages of Frictionless mechanics**[20]

1. A good understanding of mechanics is required when using retraction loops or springs, because minor errors in mechanics can result in major errors in tooth movement.
2. More wire-bending skill and chair time are required than with sliding mechanics.
3. Retraction loops may be uncomfortable to some patients.

Retraction loops produce an undesirable mesial-out moment when individual teeth are retracted, due to the force of the spring being placed facial to the center of resistance.

**En masse Space Closure**

**The two tooth concept:** The posterior teeth are joined together to form a posterior anchorage unit. The anchorage unit consists of the right and left posterior units connected by a buccal stabilizing segment and a transpalatal arch in the upper and a lingual arch in the lower. Conceptually, there are only two teeth, the anterior (incisors and canines) and the posterior.[7,34]

**Separate canine and incisor retraction**

Anterior crowding or a midline discrepancy may at times necessitate individual canine retraction.

The force applied is buccal to the centre of resistance; a moment is produced on the canine during canine retraction causing it to rotate distal in when it retracts.

This moment can be countered by:

1. Simultaneously applying a force from the lingual
2. Placing anti-rotation bends in the attraction springs
3. Placing a cuspid to cuspid stabilizing segment
4. Using a buccal arch wire longer and wider than the normal 3-3 distance[7,34]

**1. T – Loop**

The segmented arch technique as developed by Burstone utilizes a T- loop space closure springs for anterior retraction, symmetric space closure or posterior protraction. The segmented T- loop described by Burstone and his colleagues at the University of Connecticut is one of the more versatile space closure devices available.[35]

The basic configuration of the TMA loops consists of 0.O17X0.O25"TMA wire.

To understand its design one must first understand its passive form of the spring and then its activation.

In the passive state there are no moments or forces acting on it. In its active state it applies a force system on the teeth. The activation of a spring requires forces and moments to engage the spring in its brackets and tubes.[35]

When proper pre-activation bends are placed, the spring is designed such that the spring forms a T in the neutral position

Neutral position: The neutral position is found by applying the activation moments and without any horizontal forces. In other words the ends are twisted to bring the each attachment to its respective level in the occlusal plane.

In this position the spring has zero horizontal force. The horizontal force is got by pulling the spring open from this position. The activation of the spring is always considered with respect to the neutral position.

Differential anchorage is obtained by the principle of off center V bends which results in unequal moments.The closer the V bend is to the tooth, the higher the applied moment. The segmented T loop approximates a V bend. Clinically, the spring needs to be positioned at least 1-2mm closer to one side than to the other to obtain a moment differential.[35]

6 mm of activation is needed to produce about 201 gm of force. After the canine moves distally 1 mm., the force will be reduced by 33 gm. to 168 gm. The rate of decay of the force is called the load-deflection rate, and it averages 33 gm. per millimetre[35]

At full 6mm activation tooth movement occurs in three phases: tipping, translation and root movement.

For a symmetric centered spring

- initial activation produces a M/F ratio of 6/1 which results in tipping movement of the teeth into the extraction space.

- With 2mm deactivation or spring activation of 4mm, the M/F ratio is 10/1 which results in translation of the segments towards each other.
- With 1-2mm space closure (spring activation =2mm) the M/F ratio increases to 12/1 and higher resulting in tooth movement.

Clinically the spring should not be re activated till all three phases are complete.[35]

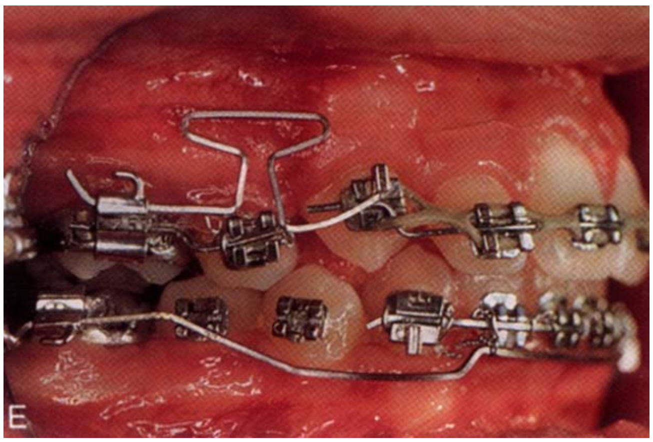


**Fig: 2**

**Symmetric space closure (group B anchorage)**

Equal and opposite moments and forces are indicated. A T-loop centered between the anterior and posterior attachments produces this force system.

The center position of the spring can be found by:

distance = (interbracket distance -activation)/2

where, distance = length of the anterior and posterior arms (distance from the center of the T loop to either the anterior or posterior tubes)

interbracket distance =distance between the canine and molar brackets.

Activation = millimeters of activation of the spring (6 mm)

With the use of a vertical tube at the canine a 90 degrees gingival bend at the calculated distance eases placement and monitoring throughout space closure.

The T loop is placed in the molar auxiliary tube and then inserted into the canine bracket. The distal end is pulled back until it is the desired length which results in the desired activation.[35]

Space closure must be monitored closely.

To check the remaining activation the spring is removed from the canine tube and the remaining activation at neutral position is checked. The activation is the distance the spring must be pulled to be inserted into the tube.

The passive spring should also be checked because alterations in the spring shape will alter the force system.

The progress of space closure is checked by observing the amount of space remaining the axial inclination on the anterior and posterior segments and the occlusal relationship. During the tipping phase the anterior and posterior segments tip towards each other which is corrected during the root movement phase. When the occlusal plane regains parallelism reactivation is indicated.[35]

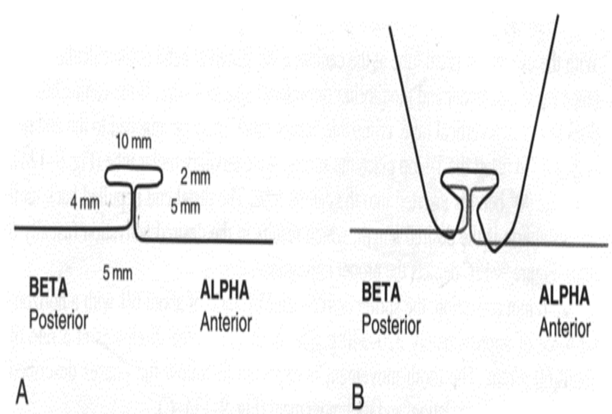


**Fig 3**

**Maximum posterior anchorage (Group A anchorage)**

- The T loop is positioned closer to the posterior segment (1-2 mm off centering) is sufficient .
- Activation of 4 mm is necessary. This reduces the horizontal forces without altering the moment differential.

- The force system acting on the anterior segment favors tipping. The moment difference remains as the space closes and the spring deactivates.
  - The spring must be re activated when 2mm or less of activation remains.
  - Because the beta moment is greater than the anterior moment a vertical intrusive force acts on the anterior teeth which can exaggerate the tipping tendency and steepen the occlusal plane. Similarly the posterior occlusal plane can be steeped by the extrusive force. Maintaining adequate horizontal force helps to reduce this effect.
  - A High pull headgear can also be used to control the posterior occlusal plane.[35]

**Maximum anterior anchorage (Group C anchorage)**

This is the most difficult of all space closures.

- The loop must be placed 1-2mm closer to the anterior teeth. The increased alpha moment has a tendency to deepen the overbite
- Care must be taken that the wire segment achieves full bracket engagement because play can reduce the moment differential.
- Space closure with tipping of the buccal segments will occur. The activation must be around 4mm and should be activated every 2mm.
- The major side effects are loss of anchorage and extrusion of the anteriors.
- Class III elastics or protraction headgear may help in the protraction of the upper buccal segments. For mandibular molars class II elastics may help.[35]

**Control of the mechanical side effects of space closure**

From the Occlusal view, the first order side effect of rotation of the molars mesial-in and canines distal-out are observed.

Rotation of the molars can be prevented by use of a transpalatal arch (rectangular wires only not round wires TPA)

Control of canine rotation can be achieved by:

- For en masse retraction a rigid anterior segment can reduce this tendency.
- A canine bypass connecting he canines but bypassing the incisors can also control rotation
- Anti rotation bend can be incorporated into the spring.

With asymmetric space closure vertical forces may be produced. These may produce undesired extrusive or intrusive tooth movements.

These vertical forces may also produce third order (buccal-lingual) side effects.

➢ With group A space closure the third order side effect on the canine is troublesome the intrusive force causes a buccal flaring which increases the overjet at the canine and/or increases the intercanine width.

➢ This can be overcome by using:

- Use of intermaxillary elastics to aid in canine eruption
- Symmetric centered T-loop with concurrent headgear anchorage control
- Palatal arches help to control the third order effects[55]

**Continuous arch T loop space closure**

Segmental T loop space closure principles can also be applied to space closure on a continuous arch. The force system is not as well defined as the segmental, but careful use of the alpha and beta moments helps to achieve comparable results especially for group B and

C anchorage cases. For group A cases high pull headgear is necessary to control tooth position.[55]

- T loops one on each side are made using preformed arch wires
- 0.017 X 0.025” TMA or 0.016 X 0.022” Stainless steel arch wire. The activations for the Stainless steel wires activation is reduced by half as that for the TMA wire.
- The T loops are made 6-7mm tall and 10mm wide and are positioned distal to the cuspids.
- Desired alpha and beta moments are placed anterior and posterior to the T loop vertical legs.
- Recommended beta activations for A, B, and C anchorages are 40 degrees, 30 degrees and 20 degrees respectively.
- After the activations are placed the loops should be open approximately 2mm before placing in the mouth.
- The wire is inserted into the molar auxiliary tube and ligated to the anterior teeth. The T loop bypasses the premolar brackets and is not inserted in them.
- For TMA loops the activation can be 3mm distal to the molar tube which gives it a range of force of 250-300gms.
- The patient should be monitored but no further activations are necessary for 2-3 months. Too frequent reactivation can prevent root movement and cause excessive tipping.[34,35]

**The asymmetrical T – arch wire**

Broussard system uses a combination closing and bite opening loop with a step between the anterior and posterior segments, achieving simultaneous torque, intrusion and retraction movements.[71]

**James Hilgers and Farrokh (JCO 1992)** modified the vertical component in the Broussard loop into a crossed T, allowing a smaller loop size and greater mechanical efficiency but is cumbersome without much working range.

The Asymmetrical T arch wire is a new loop system made of 0.016 x 0.022” or 0.019 x 0.025” TMA which has sufficient stiffness and optimum working range. The shorter, mesial portion of the loop can be closed and the longer, distal portion opened to create a step between anterior and posterior segments that allows simultaneous bite opening and anterior space closure.[71]

**Modified T- loop arch wire (Barton Tayer, JCO 1981):**

Modified "T" loop archwire achieves, maxillary anterior intrusion (bite opening), space closure, and torque that is frequently needed toward the end of active treatment. Space closure is accomplished primarily by activating the closing loops. This can be augmented by Class II elastics or maxillary intra-arch Class I elastics placed around the entire loop.[64]

**T – loops for adult patients**

TMA T loops of 0.016 x 0.022” and 0.017 x 0.025” cross sections, with angulations incorporated via concentrated bends and graduated curvature were used. In adult patients, with variations in the level of bone support, force magnitude must be reduced and the M/F ratio increased, achieved by reducing the cross section and/ or the amount of activation and augmenting the angulation of the T loop respectively.

**Jie Chen et al (AO 2000)** studied the effects of T loop geometry on its forces and moments. The moments and forces produced by the various orthodontic spring designs were measured.[37] The effects of dimension changes and the addition of gable bends with heat treatment were assessed. It was found that the moments and forces generated by the T loop spring are functions of its geometry and gable bend combined with heat treatment. Increasing the vertical or horizontal dimension reduced the load deflection rate and M/F ratio, gable preactivation and stress relieving heat treatment had the opposite effects.[37]

**M- loop (Mushroom loop) space closing arch wires**

M – loop (Fig 22) is a recent adaptation of the T – loop which is more patient friendly as it reduces the horizontal part near the vestibule.[13]

**Fig 4**

- The apical addition of the wire in the archial configuration decreases the load-deflection rate, and therefore produces lower and more continuous forces compared to simpler designs.
- The activated loop does not distort in shape and ensures better force delivery
- The archival shape has the added advantage of increasing the applied moment when the spring is activated.[13]
- The CNA beta-titanium recommended for use in the M-Ioop has a much lower stiffness than steel and promotes a more constant force delivery.

Space closure with this appliance takes advantage of the effects of loop placement.

➢ To take advantage of the positional effects of the loop, bypassing the premolar(s) and directly engaging the molar auxiliary tube is recommended which allows for force/moment delivery to the active (anterior) and reactive (molar) teeth directly. Additionally, the increased interbracket distance has the effect of reducing errors in loop placement and helps maintain force constancy.[13]

Wire dimensions M-loop archwires are 0.017 x 0.025" CNA; although, for adults requiring lower force values, a 0.016 x 0.022" may be preferred.

The loop may be activated up to 5 mm which delivers enough force to simultaneously retract all the anterior teeth en masse with little impact on posterior anchorage. Reactivation is necessary approximately every 6-8 weeks.

The archwire size of choice for a 0.022 bracket prescription is a preformed M-Ioop 0.017 x 0.025" CNA available with standardized interloop distances from 26 to 46 mm (in 2 mm increments) representing the distance from the distal surface of one lateral incisor to the other across the midline.

Preactivation of the archwire achieves the necessary moment/force ratio. This preactivation starts by carefully separating the legs of both M-Ioops by approximately 3 mm. Additional gable bends may be placed, as needed, mesially to increase the anterior moment (torque) and distal to the M-Ioop to increase anchorage moment. Next, the torque on the distal legs is eliminated to make the wire passive in the third order in the buccal segments.[13]

The archwire is ready to be activated approximately 4 mm (3 mm of preactivation plus I mm of additional activation). The loop should not be reactivated until there is at least 3 mm of space closure

Once the space is closed the wire should be left in the mouth for one or two additional visits so that the residual moments can be utilized for correction of the root axial inclination of anterior and posterior teeth. This completely eliminates the need for root uprighting and torquing springs and significantly reduces the treatment time.[13]

**Opus Loop**

**Raymond Siatkowski (AJO 1997)** presented a systematic approach to closing loop design (Fig 23) for use in continuous arch wires by using Castigliano's theorem, which was then refined, using FEM simulations, and verified experimentally.[61]

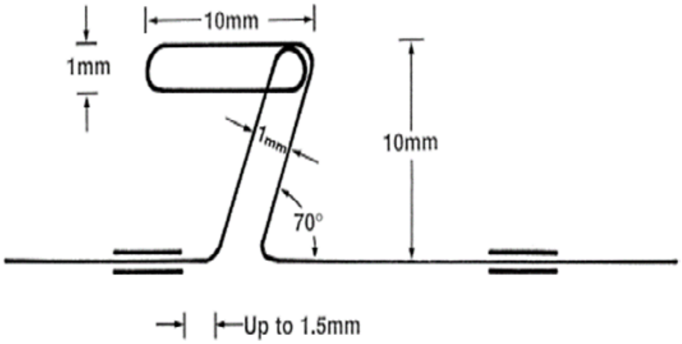


**Fig 5**

The result of this process was a new design, the Opus loop, which is capable of delivering a target M/F within the range of 8.0 - 9.1 mm inherently, without adding residual moments, so that more precise force systems with non varying M/F can be delivered by these closing loops formed in a continuous arch wire.[61]

Being free of residual moments, the design can produce a true rest period when deactivated and therefore could be used with future to produce intermittent force systems during space closure.

The opus loop achieves a M/F ratio of 8-9.l mm without addition of activation bends in the loop or arch wire itself. Therefore its neutral position is the same as the inactivated position before it was tied into the brackets. Having the loops neutral position accurately allows known forces systems to be applied to the teeth via simple cinch back activations. [61]

The apical horizontal leg is 10mm long, the ascending legs at an angle of 70 to the plane of the brackets, the apical helix is on the leg ascending from the anterior teeth, that ascent must begin within 1.5mm posterior to the most distal bracket of the anterior teeth being retracted and the spacing between the ascending legs especially the apical loops legs must be l mm or less. All these dimensions are critical to the performance of the loop. Clinically comfort bends are not necessary.[61]

It is important that sufficient lingual twist exists in the arch wire engaging the incisors so that bracket wire play is reduced for axial control of the incisors.

For the Opus loop, the posterior and anterior moments are in the same direction and so the total moment is the difference between the moments at the two ends, they being in opposite directions, decreasing the tendency to change the occlusal plane.[61]

**Tear drop shaped loops**

**R. G. Alexander (JCO 1983)** used the tear drop loop (Fig 24) in his vari – simplex disciplne. The loops are placed distal to the maxillary lateral incisor bracket. The closing loop arch wire extends through the first molar tube[66]. The portion of the arch wire distal to the closing loops is reduced approximately 0.001” in the anodic polisher, so that part of the wire can slide through the brackets easily during activation. The loop is activated by opening the loop 1-2 mm by pushing distally and bending gingivally.[66]

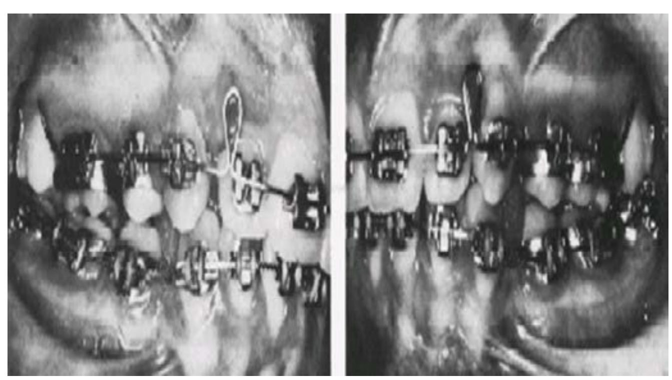

**Fig 6**

**P.G. Universal Retraction Spring**

**Poul Gjessing (AJO 1985)** designed a canine retraction spring constructed from 0.016 x 0.022" stainless steel wire (Fig 25). The principal element is the double ovoid loop 10 mm in height to reduce the load/deflection of the spring and is placed gingivally so that activation will cause a tipping of the short horizontal arm (attached to the canine) in a direction that will increase the couple acting on the tooth. A double loop is necessary to incorporate sufficient wire. The gently rounded form avoids the effect of sharp bends on load/deflection and, through the use of the greatest amount of wire in the vertical direction, reduction of horizontal load/deflection is maximized. At the same time, minimizing horizontal wire increases rigidity in the vertical plane.[68]

The smaller loop occlusally is incorporated to lower levels of activation on insertion in the brackets in the short arm (couple) and is formed so that activation further closes the loops.[68]

**Fig 7**

The mesial and distal extensions of the looped wire segment are angulated both in the vertical and in the horizontal plane. When the spring is in place, but prior to activation of the driving force , static antitip and antirotation couples will be exerted to the canine.

The distal driving force is generated by pulling the distal, horizontal leg through the molar tube. A desirable force level of approximately 160 gm is obtained when the two sections of the double helix are separated 1 mm. During the activation the force is matched by an additional couple (activation couple) arising from the double-helix loop which, in theory, acts as four lever arms.[68]

Incorporation of a segment of a circle ("sweep") in the distal leg of the spring is an adjustment with the purpose of eliminating undesirable ß moments acting at the second premolar bracket and tending to move the root apex too far mesially.

The PG Universal Retraction Spring is designed for controlled retraction of either canines or upper incisors. No clinical alteration of the spring is needed, and the force system produced is independent of interbracket distance.

Adjustment of the spring for incisor retraction: Before engagement, the spring is modified by making a 90° twist in the anterior extension, 3mm in front of the small circular loop. The twisted extension should be angulated 105° to allow for a 15° play between the wire and the vertical slot.[68]

The anterior and posterior points of force application are the centers of the lateral incisor bracket and the triple molar tube,the posterior extension of the spring is always inserted in the gingival auxiliary molar tube and the anterior extension is placed in the vertical slot of the lateral incisor bracket, pulled as far occlusally as possible, and locked with a mesial bend.

Activation: The spring is activated by pulling the posterior extension distally until the double helix is distorted producing an initial horizontal force of about 100g. The posterior extension is secured with a gingival bend distal to the molar tube. The spring is reactivated every four to six weeks by returning the double helix to its initial configuration.[68]

**Bull Loop**

**Dr. Harry Bull's** procedure for cuspid retraction was to bring these teeth back bodily by means of his sectional arch, which contained the Bull (closed vertical) loop and was formed with 0.021 x 0.025" steel wire (Fig 26). All sectionals are fabricated so that cuspid retraction activations are made from the mesial.[33]

In retracting a canine into a first bicuspid extraction space, the vertical loop is usually placed at the mesial of the second bicuspid bracket. This roughly doubles the length of the horizontal arm, as compared with placing the vertical loop at the distal end of the cuspid bracket, and gives a more gentle, continuous force.

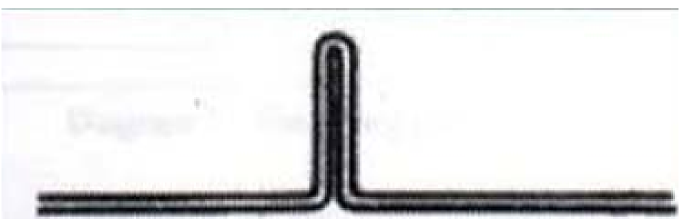

**Fig 8**

In an upper cuspid retraction sectional arch, the Bull loop is approximately 7mm

In a lower sectional, the Bull loop is 5mm in height

The vertical loops are activated by threading a ligature through the activation eyelet loop, then gingival to the cuspid bracket and tying the ligature around the mesial of the cuspid bracket, and tightening it to bring the mesial leg of the vertical loop forward 1mm. An alternate tie is to double a ligature around the activation eyelet loop and then tie forward to activate the vertical loop.[33]

**Tandem Yoke Retractor**

The Tandem Yoke with retractor **(William Wilson, Modular Orthodontic System JCO 1978)** consists of an 0.045" round tube which slides with freedom on the 0.040" end section of the Bimetric Round Arch. It employs a standard 0.018" retractor which is adjusted for variable needs or simply removed. Attached to the 0.045" tube is an edgewise section with an intermaxillary hook and an offset extension for control of rotation. The edgewise section may be 0.018" or 0.022".[72]

When used with a retractor, the Tandem Yoke operates as a free-sliding mechanism, activated by intermaxillary elastics, with the 0.018" loop adapted to engage the mesial of the cuspid at the gingival border. This is extremely effective for engaging newly erupted high buccal cuspids of key importance is the high positioning of the retracting loop. The Tandem Yoke edgewise section controls the horizontal nonrotating distal action. There is no molar rotation with cuspid retraction by this method.[72]

In extraction cases, the Tandem Yoke is used both as a non-reactive suspension system for cuspid retraction and a reactive suspension system for space closure. The 0.018" loop is adjusted to engage the mesial of the cuspid at the gingival border increasingly as the tooth moves distally and continues to erupt. The yoke is activated through intermaxillary traction and the edgewise extension assures a horizontal nonrotational pull. The free sliding 0.045" tube assures a friction-free force system.

If reciprocal mesial molar movement is desired in space closure, the edgewise section is pulled distally through the tube and cinched, which further activates the cuspid movement while reciprocally inducing a mesial vector on the molar.

The double buccal tube permits retracting the incisors using an 0.016" closing loop arch in the molar edgewise tube.

The Bimetric Arch with intermaxillary elastics is an alternative, nearly friction-free method of retracting anterior teeth.[72]

**Drum Spring Canine retractor (Darendeliler et al, EJO 1997)**

The Drum Spring retractor is designed for intraoral use to produce a force which remains constant without the need for reactivation and consists of four parts:

(1) a constant force spring with a hook especially designed and fabricated to apply 50 g of constant and continuous force

(2) a drum

(3) a spring box

(4) a central pin soldered to the molar band (Fig 27)

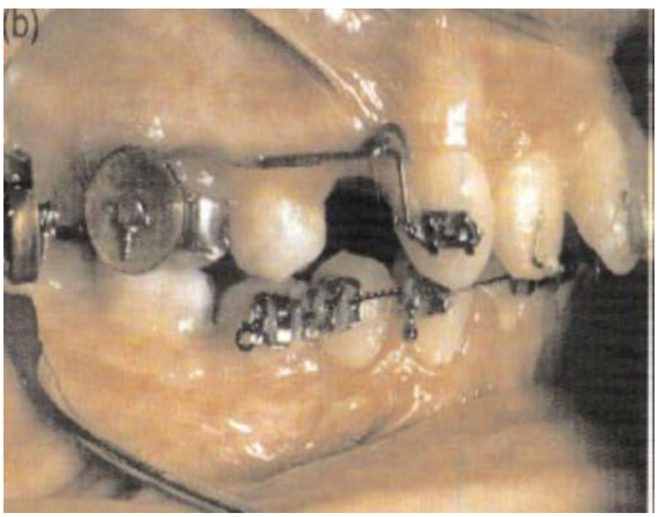


**Fig 9**

When assembled and mounted on the molar band, the DS retractor is activated by pulling the end of the spring. The amount of activation does not influence the amount of force applied.[38]

The Drum Spring retractor is successful for space closure without any reactivation, and the continuous and constant force provided a more rapid canine movement than the continuous but diminishing force. Canine retraction occurs faster in adolescents than in adults.[38]

**Three piece intrusion – retraction arch (Bhavna Shroff, Burstone et al AJO 1997)**

It is a segmental approach to achieve simultaneous intrusion and space closure. Passive segmented wires (0.017 x 0.025" stainless steel) are placed in the right and the left posterior teeth for stabilization. A precision stainless steel transpalatal arch (0.032 x 0.032") placed passively between the first maxillary molars. A three-piece base arch is used to intrude the anterior segment (Fig 28).[67]

A heavy stainless steel segment (0.018 x 0.025" or larger) with distal extensions below the center of resistance of the anterior teeth is placed passively in the anterior brackets. The distal extensions end 2 to 3 mm distal to the center of resistance of the anterior segment. The intrusive force is applied with a 0.017 ´ 0.025 TMA tip-back spring. The application of a light, distal force delivered by a Class I elastic to the anterior segment is used to alter the direction of the intrusive force on the anterior segment.

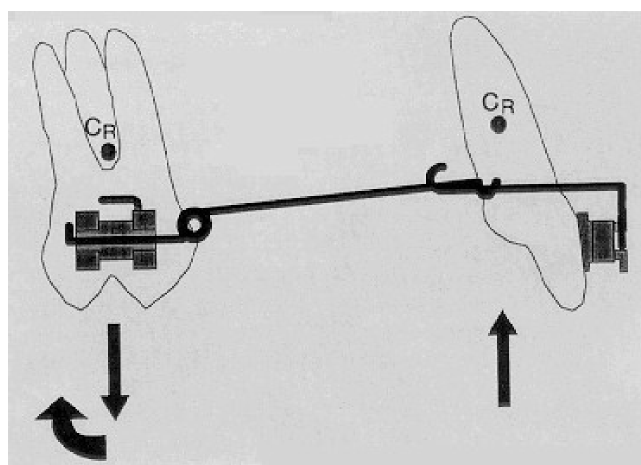


**Fig 10**

This appliance design allows the application of the intrusive force to get true intrusion of the incisors along their long axes & enables low-friction sliding to occur along the distal extension of the anterior segment during space closure[67]

The line of action of the resultant force will be lingual to the center of resistance and a combination of intrusion and tip back of the anterior teeth will occur.

The distal force used in this intrusion retraction system is of very low magnitude and is used to redirect the line of action of the intrusive force. One advantage of this system is the low magnitude of force applied on the reactive or anchorage unit.[67]

**Retraction Utility arch**

It is used in the mixed or permanent dentition to achieve simultaneous intrusion and retraction of the incisors by incorporating loops in the arch wire anterior to the anterior vestibular segment. Activation is by grasping the molar segment with a Weingart plier distal to the molar tube, pulling the wire posteriorly and then turning it gingivally. The utility arch engaged only the first molars and the four incisors. It originally was developed to provide a method of leveling the curve of Spee in the mandible, but it has been adapted to perform many more functions than just lower incisor intrusion. With an 0.018" appliance, the recommended wire for the mandibular arch is 0.016 × 0.016" or 0.016 × 0.022" Blue Elgiloy (not heat-treated). For most maxillary arches, 0.016 × 0.022" Blue Elgiloy is recommended. With an 0.022" appliance, 0.019 × 0.019" Blue Elgiloy can be used in either arch.[65]

Utility arches can be designed differently for extraction and nonextraction cases. In extraction cases, the forces generated on the molars are often directed mesially and occlusally. A distolingual bend in the molar segment of the utility arch can prevent this mesial rotation of the first molars. Such a bend may not be necessary in nonextraction cases.[65]

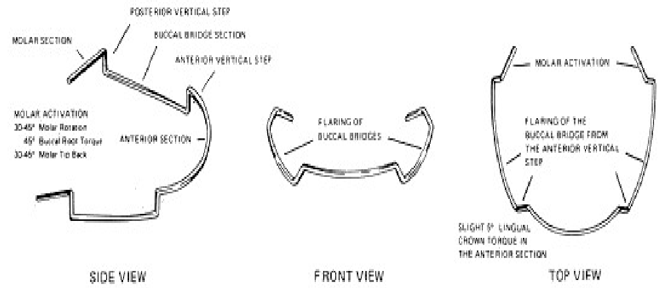


**Fig 11**

**K – Sir Appliance (Kalra, JCO 1998)**

The K-SIR (Kalra Simultaneous Intrusion and Retraction) archwire is a modification of the segmented loop mechanics of Burstone and Nanda. It is a continuous 0.019 x 0.025” TMA archwire with closed 7mm x 2mm U-loops at the extraction sites (Fig 30).[63]

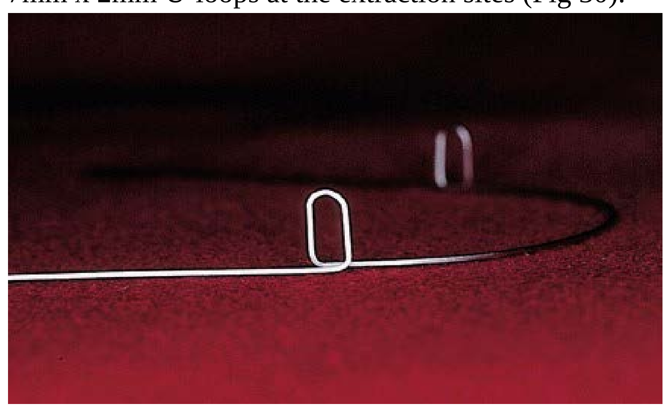

**Fig 12**

To obtain bodily movement and prevent tipping of the teeth into the extraction spaces, a 90° V-bend is placed in the archwire at the level of each U-loop (Fig 31). This V-bend, when centered between the first molar and canine during space closure, creates two equal and opposite moments to counter the moments caused by the activation forces of the closing loops

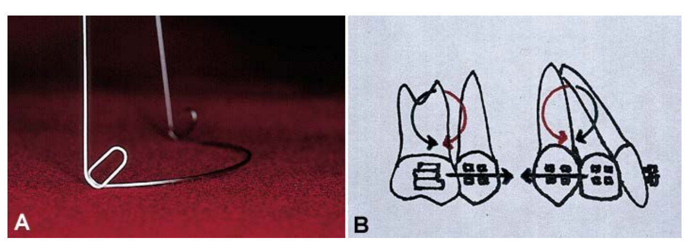


**Fig 13**

A 60° V-bend located posterior to the center of the interbracket distance (Fig 32) produces an increased clockwise moment on the first molar, which augments molar anchorage as well as the intrusion of the anterior teeth .[63]

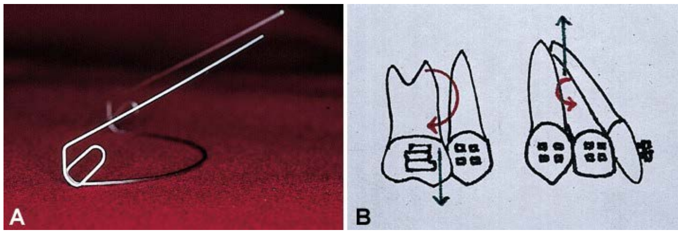


**Fig 14**

To prevent the buccal segments from rolling mesiolingually due to the force produced by the loop activation, a 20° antirotation bend is placed in the archwire just distal to each U-loop (Fig 33).

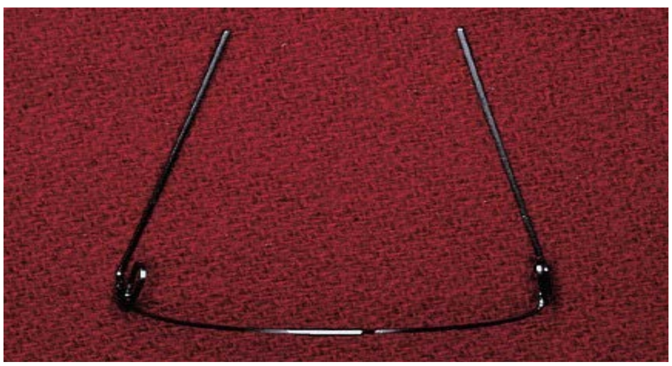

**Fig 15**

The archwire is inserted into the auxiliary tubes of the first molars and engaged in the six anterior brackets (Fig 34) . It is activated about 3mm, so that the mesial and distal legs of the loops are barely apart. The second premolars are bypassed to increase the interbracket distance between the two ends of attachment.

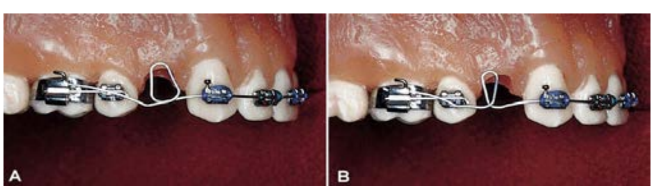


**Fig 16**

When the loops are first activated, the tipping moments generated by the retraction force will be greater than the opposing moments produced by the V-bends in the archwire. This will initially cause controlled tipping of the teeth into the extraction sites. As the loops deactivate and the force decreases, the moment-to-force ratio will increase to cause first bodily and then root movement of the teeth. The archwire should therefore not be reactivated at short intervals, but only every six to eight weeks until all space has been closed.[63]

**Conclusion**

A good understanding of mechanics is required when using retraction loops or springs, because minor errors in mechanics can result in major errors in tooth movement. Today's orthodontist requires a working knowledge of both friction and frictionless mechanics. There are indications for both and hence a practitioner should always have an open mind when it comes to choosing the right mechanics.

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