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## Loops in Orthodontics

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**Abstract**---Present article reviews about application of loops in orthodontics. Loops are used mainly during alignment phase but may be used later for closing spaces. The alignment phase in any technique has a very important place both from the patient point of view, who gets fascinated by the alignment of crowded teeth and also from the operator point of view who gets a chance to use rectangular and square wires in leveled up teeth. Basically the purpose of an orthodontic appliance is the production of controlled forces to move teeth. A controlled force is one that is properly directed and which has the correct amount of force to stimulate the histological process that must accompany tooth movements.

**Keywords**---orthodontics, loop, teeth, rectangular, leveled up teeth.

**Introduction**

Optimum control of tooth movement requires the application of specific orthodontic force system. Therefore knowledge of the mechanics of orthodontic appliances is essential to achieve desirable and predictable treatment results. Loops are used mainly during alignment phase but may be used later for closing spaces. The alignment phase in any technique has a very important place both from the patient point of view, who gets fascinated by the alignment of crowded teeth and also from the operator point of view who gets a chance to use rectangular and square wires in leveled up teeth. All this can be accomplished successfully only by the precise application of different size, shape and types of loops having a control on the distribution, direction, degree and duration, the 4 D's of forces applied.

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### Brief review of history

- Incorporation of loops in the archwire was revolutionized in 1915 by RAY ROBINSON who was an early advocated of light wires and light continuous forces by means of loops.
- Dr. R.H.W. STRANG was first to introduce loops in the edgewise technique.
- In 1956, the interest in incorporation of loops became more prominent by the publication of an article by P.R. BEGG of Australia.
- In 1960, STONER, in an extensive article on “FORCE CONTROL IN CLINICAL PRACTICE” gave a broad outlook to the various types of loop springs and described new methods of contouring loops to obtain effective control in all the three planes of space.
- Then came STEINER, TWEED, STRANG, JARABAK, STORY & SMITH and SCHWARG who come out with different configurations of loops, but the basic mechanism remained the same.

The best way to understand the activity of any quick loop is first to understand what broad rules apply to any deflection in wire. Therefore before considering the various designs and their clinical applications let us test the various functional factor which they have in common and clinical considerations in wires and forces control.

### Wire- clinical considerations

In orthodontics, the intent is to apply known forces and have these forces active over a given distance. To design an archwire properly to develop maximum mechanical efficiency, the properties of wire, which are of major interest.

- Range of deflection
- Magnitude of force

These properties depend upon the following factors:

- Diameter of wire :
  - The magnitude of force that can be developed through deflection of a wire is proportional to the 4<sup>th</sup> power of the number of times by which the diameter of wire is changed.

$$\text{Force} \propto (\text{Diameter})^4$$

- The maximum load before permanent deformation takes place vary directly with the 3<sup>rd</sup> power of the increase in diameter.
- The range, the elastic limit, will vary inversely with the increase in diameter.

$$\text{Load} \propto (\text{Diameter})^3 \qquad \text{Range} \propto \frac{1}{(\text{Diameter})}$$

- **Length of wire**

- An increase in length of a given diameter of wire will yield force that will be decreased in proportion to the cube of difference in length.

$$\text{Load} \propto (\text{Diameter})^3 \qquad \text{Range} \propto \frac{1}{(\text{Diameter})}$$

- An increase in length will proportionally decrease the maximum load on a one for one ratio.

$$\text{Load} \propto \frac{1}{\text{Length}} \qquad \text{Range} \propto (\text{Length})^2$$

- Range, within the elastic limit increase proportionally according to the square of the difference in length of wire.

### Elasticity

Within elastic limits, a wire follows Hooke's law. For each unit of deflection of wire within its elastic limits, there is an equal increase in force potential.

### Clinical implications

The range can be increased by decreasing the diameter or by increasing the length. Now the question arise – which one is the better choice ?

It we apply the formula when diameter (D) is halved, the range double s (2R), and the force reduces 16 times (F/16).

$$F \propto \frac{D^4}{L^3} \qquad R \propto \frac{L^2}{D}$$

On the other hand, if the length is doubled, the range available is 4 times greater (4R), and the reduction in force is just the half (F/2). So for somewhat comparable variation in range, more of the original force potential is maintained in the given piece of wire, when the length is varied. So it is much better to increase the length of the wire than to reduce the diameter, whenever a choice is present. Also if the diameter of wire is reduced, its resistance to the forces of occlusion is reduced and the possibility of distortion and breakage in the mouth is increased. But the amount of space available for placement of appliance limits the length of wire that can be used. The logical solution to this problem is the use of various loops, which can be simple or helical.

### **Loop activity for force control**

Through the contouring of loops, control can be exercised over the action of the four D's in the inter-bracket span. In deciding when and how to employ loops, the following factors should be considered.

- Increasing wire in the interbracket span :  
The presence of a loop increases the length of the wire and this in turn affects the degree and duration in proportion to the difference in length between the interbracket span without the loop and that with the loop added.
- Activating loops by compression :  
When a loop is contoured into the wire, and the loop is activated by compressing the legs, the range of action, the duration, will be considerably greater than the range of action developed when the loop is activated by extending the legs, as in the later case elastic limit of the wire will be reduced considerably. A loop may be contoured as a "Closed Loop" or "Open Loop".
  - Closed loop : In this loop, the horizontal extensions of the archwire at the base of the loop are crossed. When the loop is activated by compression it will tend to draw the attached extensions of the wire toward each other.
  - Open loop : It is so contoured, that when activated by compression of legs, it will tend to thrust the attached horizontal extensions of the archwire away from each other.
- Including a helix for force reduction :  
A helix is usually added when further force reduction is desired, but legs of loops cannot be made longer due to anatomical limitations.

### **Loop design**

One important consideration in loop design is that the legs of a loop should always be contoured at right angles to the desired direction of activity. The performance of a loop, from the perspective of engineering theory, is determined by 3 major characteristics:

- Spring properties  
The spring properties are determined almost totally by:
  - Wire material
  - Size of the wire
  - Distance between the points of attachment  
The distance in turn is largely determined by the amount of wire incorporated into loop. Wires of greater inherent springiness or smaller cross sectional area allow the use of simpler loop designs.
- Root – Paralleling moments  
Design of loop should permit full control of root position. For example, to close an extraction site while producing bodily tooth movement, a closing loop must generate not only a closing force but also appropriate moments to bring the root apices together at the extraction site.

This requirement to generate a moment limits the amount of wire that can be incorporated to make a closing loop springier, because if the loop becomes too flexible, it will be unable to generate the necessary moments even through the retraction force characteristics are satisfactory. Placing some of the wire within the closing loop in a horizontal rather than vertical direction improves the ability to deliver the moment needed to prevent tipping. If the legs of a closing loop were parallel before activation, opening the loop would place them at an angle that in itself would generate a moment in the desired direction. But this moment may not be sufficient enough with the acceptable length of loop. So additional moments must be generated by “Gable-bends”. This bend is given between the legs of the loop and lateral extensions. The gable angulations should be adjusted according to both the springiness of the loop and the width of the bracket.

### **Location of loop**

Because of its gable bend, the closing loop functions as a V-bend in the archwire, and the effects of a V-bend is quite sensitive to its position. Only if it is in the centre of the span does a V-bend or loop produces equal forces and couples on the adjacent teeth. For routine use with fail safe closing loop, the preferred location is at the spot that will be the centre of the embrasure when the space is closed. For example, in a first premolar extraction situation, the closing loop should be placed about 5mm distal to the centre of the canine.

### **Additional design considerations**

- The loop should be “fail safe”. This means that, although a reasonable range of action is desired from each activation, tooth movement should stop after a prescribed range of movement even if the patient does not return for a scheduled adjustment. Too long a range of action with too much flexibility could produce disastrous effects if a distorted spring were combined with a series of broken appointments.
- Design should be as simple as possible.
- A loop is more effective when it is closed rather than opened during activation.

### **Loop designs**

Various loop designs considered are as follows :

- Vertical loop
- Double vertical loop
- Omega loop
- Helical loop
- Twin helical loop
- Horizontal loop
- Double horizontal loop
- T loop
- Box loop
- Squashed vertical loop (Bull loop)
- Bent in stop loop (Tweed)
- Combined vertical and horizontal loops

- Delta loop
- Transverse loop
- Torquing loop

### **Classification of loop**

JARABAK (1963) classified helical loop springs according to the function they perform as:

- Vertical helical loop springs
- Horizontal helical springs.
- Transverse loop springs.

The vertical loop releases its stored energy most efficiently by moving teeth in an antero-posterior direction. The horizontal loop moves teeth in a vertical direction. The transverse loop moves teeth most efficiently in a mediolateral direction.

### **The vertical loop**

- Introduced by Robinson in light wire technique employed in edgewise technique by Strang.
- Has two vertical components and may be activated in any plane perpendicular to these components.
- Best suited for labiolingual or mesiodistal deflection, not for occlusogingival deflection.
- May be contoured as an OPEN or CLOSED loop.

### **Open vertical loop**

- Most efficient when used to open space. The archwire is fixed to brackets, the loop is activated by compressing the legs, and as the loop returns to its original position, the teeth move apart.
- It can be used somewhat less efficiently to close space, where a short range of activity will accomplish the movement. Then it is activated by opening the legs as in the loop design suggested by Dr. Harry Bull.
- This loop may also be used for added labiolingual deflection when rotation of a tooth is desired. By contouring a vertical loop adjacent to the displaced contact of the rotated tooth, immediate bracket engagement is possible. The increased resiliency permits deflection of the loop and allows a greater duration of activity that will tend to rotate the tooth toward its desired position.

### **Closed vertical loop**

- Used primarily to close space.
- Activated by compressing the legs. As the loop expends its force it draws the horizontal extensions of the archwire together and moves the attached teeth with them.

- Because of the complexity of design and the overlapping of the archwire, this loop may bind to the brackets or against itself. As a result, the closed loop is not usually selected unless space closure is desired.
- The height of a vertical loop is limited by anatomical restrictions. It must not impinge on gingival or alveolar tissues. For practical, clinical considerations, it is rarely possible to use vertical loops longer than 6 or 8mm.

### **Mechanism of working of a simple vertical loop**

When the loop is used to push two teeth apart, it is formed with its diameter and side arms appropriately shaped to fit into approximately the final position that the teeth are expected to attain. It is then deformed and activated within the elastic limit of the wire to fit into the brackets on teeth as they exist before treatment. If this amount of activation exceeds the elastic limit of the wire and causes a permanent deformation of the loop, it means the distance through which the teeth must be moved is too great for this simple loop. This simple loop is symmetrical. It pushes equally hard against the two brackets. When the two legs are equal, the tipping couples that the loop ends apply to the brackets are equal. Either side may be called as the working side or the opposite side may be called the reciprocal side. If one tooth is to remain unmoved, it must be stabilized by additional system of forces.

### **The horizontal loop**

Introduced by STONER in 1960. Designed such that its active legs were parallel to the archwire, to effect force reduction in the occlusogingival direction. Can be activated in an occlusogingival plane and in labiolingual plane. Principal value lies in force reduction in vertical plane permitting immediate bracket engagement in severely displaced teeth, which must be elevated or depressed. When horizontal loop is seated, loop should overlies shorter (less erupted) tooth to permit activation by compression. The elastic forces act reciprocally, intruding teeth on one side of the loop while extruding them on the other. Horizontal loops can be used effectively to compound reciprocal forces in a vertical plane for the intrusion or depression on mandibular anterior teeth that are in supraversion and for the extrusion of posterior teeth that are in infraversion. The posterior extension of the horizontal loop which extends to become buccal portion of the archwire, is fashioned occlusally, whereas, the anterior extension is fashioned gingivally. Ligating the two levels of archwire, first to the posterior teeth and then to anterior teeth, activate the loops in vertical direction.

### **Helical loop**

The helical loop is a force storing unit designed in the shape of a coil with a cantilever arm-extending tangentially from each end of the coil. The helical spring is in reality three separate springs made up into a single unit of force. Each of the cantilever arms, by virtue of their bracket attachments are a part of this force system. The coil is the third part. The force from the cantilever arms give direction to this whole force system while the cross section geometry of the wire, its modulus of elasticity, diameter, number of turns in helix and the length of the

arms control the force magnitude of this highly elastic system. Incorporating a helix increases the range of motion of a simple loop. Helix at reflexes point of the loop could have  $1\frac{1}{2}$  or  $2\frac{1}{2}$  turns. It is possible to gain a significant increase in flexibility in helical loop by coiling more wire into two helical loops or **lateral extension coils** located at each of the right angle bends. These lateral extension coils not only increase flexibility but also reduce the tendency to tip adjacent teeth as they are being moved. Helical loop spring can be classified as vertical, horizontal and transverse.

### **Combined vertical and horizontal loop springs**

If vertical and horizontal components are combined into a single loop, it is possible to obtain tooth movements in all the three planes of space.

### **Squashed vertical loop (Bull loop)**

It was advocated by Dr. Harry Bull, Made in 0.0215" x 0.025" edgewise wire, usually used for space closure and it is activated by opening the loop.

### **Bent in stop loop (Tweed)**

Tweed recommends the use of a bent in stop loop, mesial to molar tube, whenever required. It has a slight mesial cant for tying the ligature wire.

### **The double vertical loop**

It is contoured on either side of a tooth and has two effective uses.

- One is to move a labially or lingually displaced tooth into line through the labiolingual spring quality inherent in the horizontal section between the two loops.
- The other is to rotate a tooth. When tied into the bracket of a rotated tooth, the loop on one side of the tooth will be displaced labially and loop another side lingually, causing a reciprocal rotational activity on the brackets.
- The double vertical loop has also been used to move a tooth bodily in a mesial or distal direction. This is accomplished by fixing the connecting horizontal section to the brackets so that archwire cannot slide and then opening one loop and compressing the other.

### **Twin helical loop**

Modification of vertical loop.

- Consist of a vertical loop with two adjacent helices at the top. Design of loop permits legs to touch each other, using minimal space in the interbracket span.
- Because of position of helices, this loop is activated by extension on drawing legs apart.
- It is used to shorten arch length where great range of activity is desired.



**Omega loop**

Modification of vertical loop.

- It tends to distribute stresses more evenly through the curvature of loop instead of concentrating them at apex.
- Selected to apply moment to last tooth in arch, causing a bodily root thrust.
- Can be used effectively as an anchorage device if counterbalanced by a crown force to create an even distribution of stresses to the root of tooth.

**Double horizontal loop**

It is most efficient when working on an individual tooth above or below the line of occlusion.

- Most efficient when working on an individual tooth and can be used to elevate or depress this tooth.
- It also can be activated in such a manner that one loop will tend to elevate and the other depress, thereby creating a tipping moment on the bracket.

**The box loop**

- It is composed of a series of vertical and horizontal levers contoured in such a manner to provide a short section of archwire that is freely movable in all planes.
- It is of width of a single tooth.
- Box loop can be moved freely in all three planes and force values will depend on plane in which it is activated.
- In occlusogingival plane, the deflection is related to amount of wire in horizontal planes and bending at corners of the box.
- Deflection in labiolingual plane is related to total amount of wire contained in box loop.
- Box loop increases the total amount of wire between the brackets to such an extent that there is greater force reduction capacity and greater range of action than any other loop.
- Used for severely displaced teeth such as palatally positioned canine and tooth out of line of the arch.
- Because of relative rigidity of continuous wire between adjacent brackets-sufficient anchorage is provided by bulk of loop.

**T- loop**

Variation of horizontal loop.

- It adds more wire to horizontal plane, again increasing the resiliency and reducing the forces.
- It deflects archwire in parallel plane, thereby avoiding any tipping moments on the brackets.
- When T-loop is contoured on either side of a group of teeth causes elevation or depression of a contained section. This is effective for bite opening.

### **Torquing loop (Begg)**

- It is compressed vertical loop, which may be seated between twin brackets or adjacent to single brackets.
- It is contoured to press against the gingival surface of the crown and is activated by ligating the brackets.
- When buccal segments are established it tends to exert lingual root thrust.
- Begg recommends the application of torquing auxiliaries in 3<sup>rd</sup> stage of his treatment.

### **Clinical application of loops**

Different loop designs have specific applications and when properly employed produce effective responses. The following list reviews the clinical activity of several different types of loops selected for specific movement of a single tooth

Required movement	Type of loop
Labial	Double vertical – Open
Lingual	Double vertical – Open
Elevation	Double horizontal or box
Depression	Double horizontal or box
Rotation	Double vertical open or box
Root tipping	Box or double horizontal (Rectangular wire only)

These types of movements of a single tooth can be produced effectively by the loop suggested. Loops are usually included in the initial alignment archwire to attain bracket alignment, however loops also may be used in other stages of treatment, such as space opening and closing and bite opening. A few of the common types of treatment procedures are as follows:

- Mesial or distal movement– Double vertical loop or a combination of open and closed vertical loops.
- Space closure – closed vertical loop, tied back.
- Space opening – open vertical loop, with stops.
- Bite opening – T loops mesial to canine can be used.

### **Anchorage considerations in the employment of loops**

In the employment of loops, consideration must be given not only to optimal forces applied in degree, duration, distribution and direction but also to the type of response expected from these forces. Applied forces produce readily responsive tooth movements in certain directions, but encounter great resistance in other direction. Equal and opposite forces will produce equal and opposite responses, provided the type of tooth movement produced by each force is the same, the teeth are the same, and the bone structure is the same. But in case of different type of movements involved, the highly resistant tooth movement serves as anchorage and the reciprocal action causes the adjacent tooth to respond more readily.

If a desired tooth movement is readily responsive and the reactionary forces of loop to be used are directed against teeth in a direction that is highly resistant, the operator can expect the loop to accomplish its objective without complications. But the operator must be concerned with the reciprocal forces produced by a loop employed for a highly resistant movement such as root tipping. These forces can cause readily responsive tooth movements to occur in an undesired direction. For example, a moment directed to the bracket of a canine, tending to tip the root distally, would also tend to move the crown mesially because crown tipping in mesial direction is much more readily responsive than root tipping. Thus to cope with this situation, an effort must be made to prevent the undesirable mesial crown tipping.

- Anchorage in the area adjacent to a loop is developed through the rigidity of the comparatively short sections of wire in the interbracket span. This rigidity is lost when several adjacent loops are employed. But loops working in different directions will not appreciably reduce the anchorage value of the wire, e.g. adjacent vertical and horizontal loops.
- When two loops are employed on either side of a tooth and activated in the same plane, the activity of the combination of loops is confined essentially to the tooth between the loops and anchorage is developed in the adjacent teeth through the rigid section of wire.
- When the three adjacent loops are used and activated in the same plane, two teeth are involved. Here anchorage will depend almost entirely on their differences in resistance to tooth movement and the loops may cause undesirable reactions if either of the teeth fails to move as planned.
- When loops are employed for highly resistant tooth movements and relatively light gauge wire is used, the rigidity of wire may not be sufficient to dissipate the reciprocal forces among several teeth. Heavier gauge archwires are better able to resist displacement when highly resistant tooth movements are required. But for readily responsive movements, loops can be employed to great advantage in light or heavy wire.

## **Conclusion**

Basically the purpose of an orthodontic appliance is the production of controlled forces to move teeth. A controlled force is one that is properly directed and which has the correct amount of force to stimulate the histological process that must accompany tooth movements. As BURSTONE remarks, that "Rectangular loops and other loop designs offer the potentials of delivering the desired force systems with minimum side effects, a capability not usually possible with the continuous arch". As a general rule, loops are used with the initial alignment archwire only, when a straight arch wire will take a permanent set if fully engaged in the bracket.

Although loop systems can be included in any region of the archwire, their incorrect location, excessive activation or use for prolonged periods will have unfavorable results. As the teeth gradually align, however, these loops tend to roll and if not carefully controlled, they impinge upon the gingival tissue. Therefore, in the majority of patients, it is essential that the loop should be discarded after 10 weeks at the maximum. When loop systems are used with a full understanding of

their reciprocal effects in other sections of the arch wires they offer positive advantages in correcting selected cases of malocclusion.

The modification of arch wire shape with the inclusion of loops has been advocated for a number of reasons. These included the improved resiliency of an appliance between adjacent teeth as well as the significant reduction in the customary number of clinical adjustments. Furthermore, diminished force values could be applied to provide improved control over individual tooth movements. The various loop combinations because of their ability to produce rapid tooth movement, appeal to offer significant advantages to the patient as well as to the operator.

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