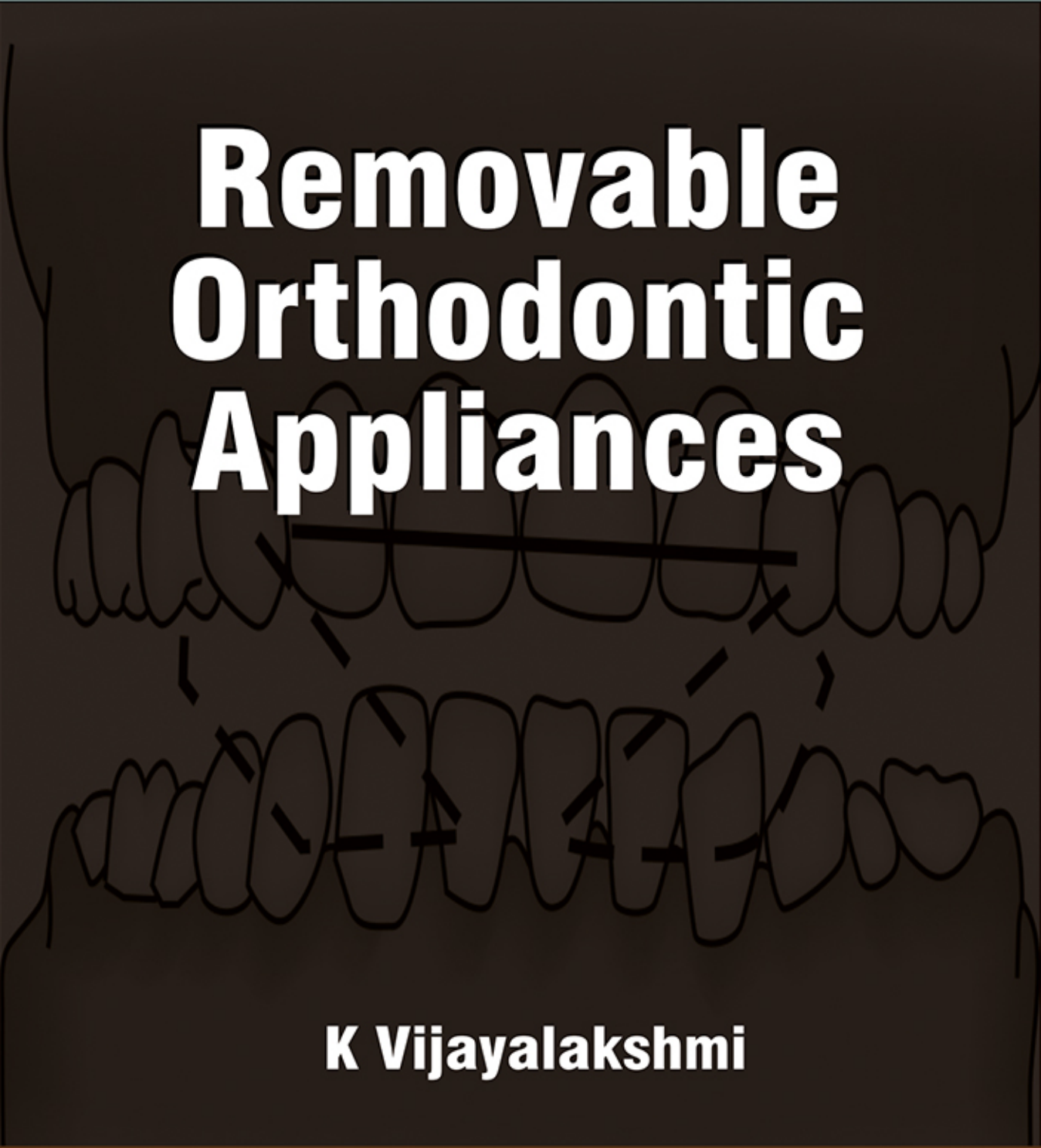
Removable Orthodontic Appliances



K Vijayalakshmi

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4 Springs

In designing springs to move a tooth facially, lingually, or mesiodistally within the arch, two important principles must be kept in mind:

1. The design must ensure adequate springiness and range while retaining acceptable strength. This usually means using recurved or looped wires for additional length and
2. The spring must be guided so that its action is exerted only in the appropriate direction.

In general, it is better to use a larger wire for its greater strength, and then gain springiness and range by increasing the length of the spring, than to use a smaller wire initially. Examples of the springs are:

1. Helical spring for distal tipping of molar
2. Paddle spring for labial movement of an incisor and
3. Buccal loop spring to tip a canine lingually.

The major problem with long flexible springs is that the spring can deflect three-dimensionally even though tooth movement in only one direction is usually desired. For instance, if a spring is placed against a lingually positioned incisor, it will be ineffective is it distorts vertically, sliding down the lingual surface toward the incisal edge. This is a problem with any spring against any tooth surface: unless the spring remains in its planned position, its action will be unpredictable.

This difficulty can be overcome in three ways:

1. Place the spring in an undercut area of the tooth, so that it cannot slip toward the occlusal surface for example, the end of this helical spring to tip the first premolar posteriorly is held in position because it engages the mesial undercut of the premolar.

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2. Use a guide to hold the spring in its proper position. This approach is often necessary with active springs to move the canine and incisors labially, because no undercuts are available on the lingual surfaces. The guide can be called as guided spring or the spring can be boxed with acrylic material.
3. Bond an attachment to the tooth surface to provide a point of positive attachment for the spring.

The most generally useful spring for removable appliance is the cantilever spring. In scientific terms, the connection between the length, thickness and amount of deflection of a cantilever spring of round section is expressed by the formula.

$D \propto PL^3/T^4$ where D is the amount of deflection, P the amount of pressure, L the length of the spring and T the thickness (Figs 4.1A to D).

This means that for a given cantilever spring' deflection will be double when pressure is doubled, deflection will increase by eight times if the length of the spring is doubles and 16 times if the thickness of the wire is halved (Fig. 4.1A). When designing a spring for a particular tooth movement, the requirements are to ensure that the spring will act over the distance and in the direction needed to move the tooth that is being treated, that the spring will exert a suitable pressure to produce tooth movement and that the spring will at the same time be mechanically strong enough to withstand the interferences that occur in the mouth in eating and speaking and during cleaning after meals.

Planning the design and layout of a spring entails selecting a point of attachment so that the free end sweeps along the intended line of movement of the tooth; further details are to ensure an optimum combination of length, number of coils, thickness, shape of the spring and provision for guarding and guiding the spring over its range of activity. If these features are well conceived, the resulting appliance will be comfortable to wear, sure in action, trouble-free and easy for the patient to insert, remove and keep clean. To conclude, longer the wire, thinner the wire will give long range of action (Table 4.1).

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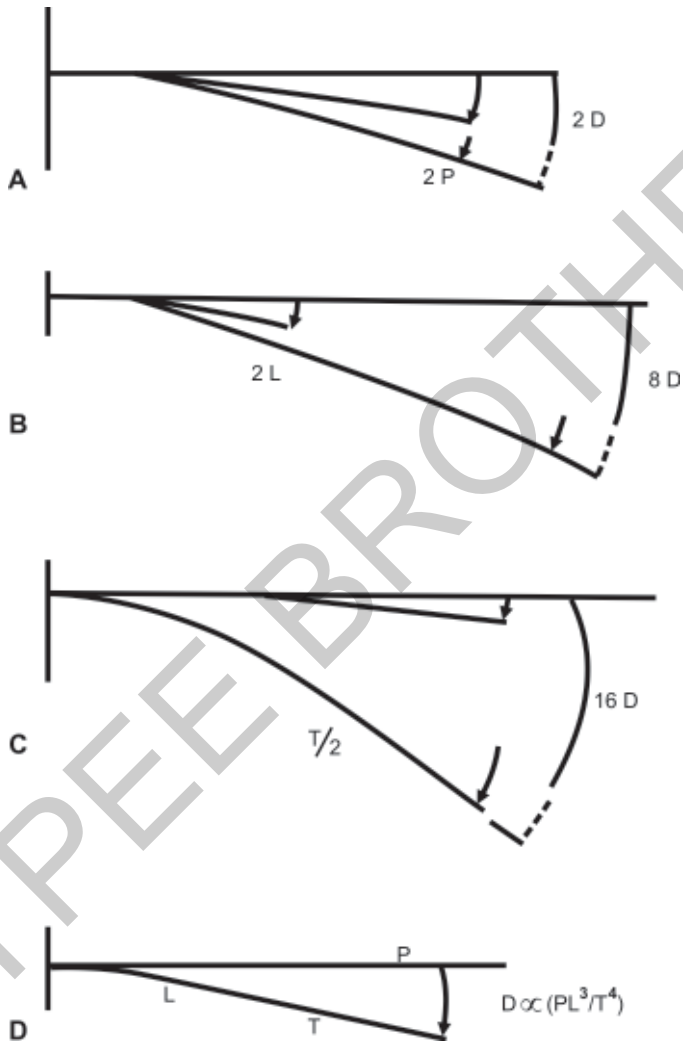

Figures 4.1A to D: A cantilever spring is fixed at one end and free to move at the other which deflects under pressure and delivers a gradually diminishing pressure in returning to its orginal form **A.** The degree of pressure is proportional to the amount of deflection produced; **B.** If the lenght of the spring is doubled, the degree of deflection becomes eight times as great for the same amount of pressure; **C.** If the thickness of the spring is reduced to one-half, the amount of deflection becomes 16 times as great for the same amount of pressure; **D.** Deflection, pressure length and thickness are related by the formula at the right of the illustration

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Table 4.1: Pressures of springs

Spring type	*Length (mm)*	*Thickness (mm)*	*No. of coils*	*Inner diameter of coils (mm)*	*Deflection for 20 g pressure (mm)*
Apron	12	0.3	4	1.0	9.0
Finger	18	0.5	1	2.5	3.0
Self supporting	10 15	0.7 0.7	1	3.5	0.6

In designing springs to move a tooth facially, lingually or mesiodistally within the arch, a few important principles must be kept in mind. Ideal qualities of orthodontic wires to form a spring are (i) flexibility, (ii) spring back action, (iii) formability (The wire should be bent at any configuration).

PHYSICAL PROPERTIES OF WIRE

1. Rigidity
2. Resistance to distortion
3. Susceptibility to fracture. The flexibility of wire depends on the length by wire and its diameter. The effective length is increased by incorporating a coil at least 3 mm in diameter. If a thin wire is used, deflection will be doubled.

CLASSIFICATION OF SPRINGS

I. Based on the direction of tooth movement brought about by the springs, they can be classified as:
   a. Springs used for mesiodistal tooth movement
   b. Springs used for labial movement
   c. Springs used for lingual movement expansion of arches
   d. Springs used for expansion of arches.

II. Based on the nature of support required for its action, orthodontic springs can be broadly classified as:
   a. Self supporting spring
      i. Buccal canine retractor
      ii. Helical canine retractor
      iii. Palatal canine retractor
      iv. Reverse loop buccal retractor
      v. 'U' loop canine retractor.
   b. Guided spring
      i. Finger spring ii. Cantilever spring

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c. *Auxiliary spring:* High labial bow with apron spring for any retractor, there are active arm and passive arm. Self supporting spring.

III. According to placement
   1. Buccal/labial
   2. Palatal/lingual

IV. Number of arms in a spring
   1. *Single cantilever:* The spring has only one arm and one coil.
   2. *Double cantilever:* The spring has two arms and two coils when two teeth are moved in the same direction.

V. According to coil
   1. Spring with coil
   2. Spring without coil.

Buccal Canine Retractor

It is indicated where a buccally placed canine is to be moved distally as well as palatally. It is not popular because liable to cause discomfort for the patient. It is difficult to adjust and unstable in the vertical direction. However, it can be adjusted with the precautions: the free end should be adapted in such a way, so that it encircles the canine at the cervical third. After every activation, the free end is cut and readapted. The activation is by closing the coil by 1 mm. Since the 0.7 mm wire is used, deflection is small and hence frequent adjustments are necessary. The retractor carries a helix which lies at the extraction site and the free end passes through mesial aspect 2nd premolar. Tubing should be done to support the passive arm of retractor (Fig. 4.2).

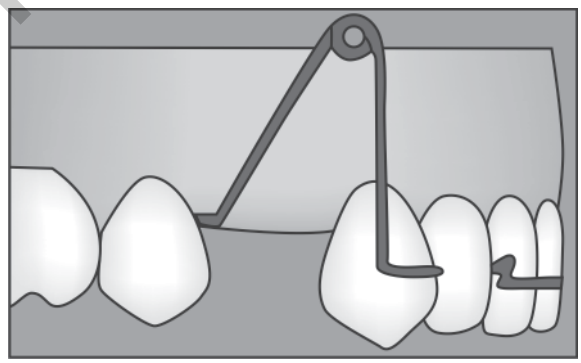

Figure 4.2: Buccal self-supported canine retractor

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Helical Canine Retractor

It is made up of 0.5 mm. The active arm lies below and it carries a 11/2 coil helix and the passive arm lies over the active arm and passes through the mesial aspect of 2nd premolars. The both arms of the helix should be parallel. The activation is by opening the coil and the arms of the loop unparallel after activation. The free end is cut by 1 mm after every activation. The free end should engage the canine at the embrasure and should be readapted every time. It is indicated where the canine lies in the occlusal plane (Fig. 4.3).

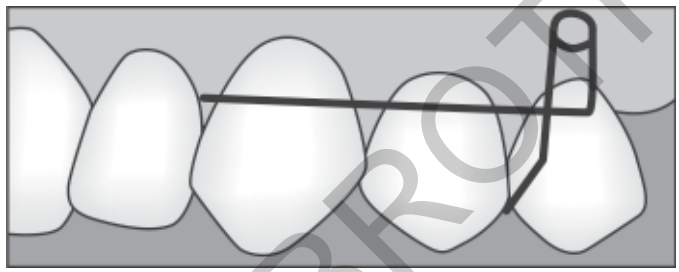

Figure 4.3: Helical canine retractor

Reverse Loop Canine Retractor

It is same as helical canine retractor but it is given for lower teeth.

Palatal Canine Retractor

Helical canine retractor is given on the side but palatal canine retractor is given on the palate (Fig. 4.4).

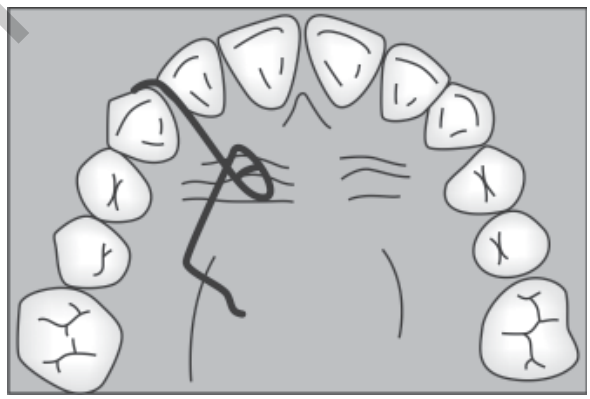

Figure 4.4: Palatal canine retractor

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'U' Loop Canine Retractor

It is made up of 0.7 mm and activation is by compressing the loop. The other features of the retractor remain the same as other retractor. It is given on the buccal side (Fig. 4.5).

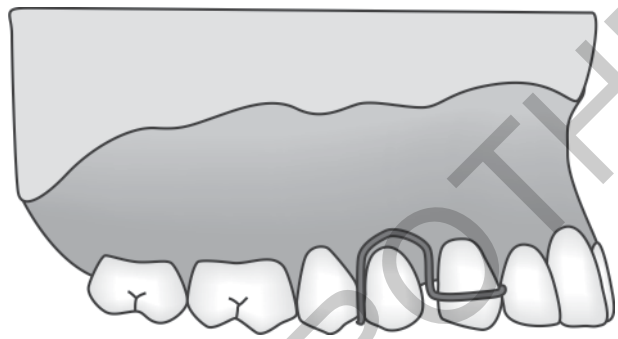

Figure 4.5: 'U' loop canine retractor

Guided Spring

The use of thinner wire gets distorted by the tongue forces. Hence, the spring has to be guided.

Finger Spring

This spring is used to bring about mesial or distal movements of teeth. For example, midline diastema. The active arm of spring lies close to the tissue and carry one and half turn coil. The coil is positioned midway between the initial and final position of the tooth. The coil should be on the opposite side of the direction of tooth movement. The activation is by opening the coil and the free end is readapted (Figs 4.6A to C).

Cantilever Spring

1. Single cantilever spring
2. Double cantilever spring
3. Cranked spring
4. 'Z' spring without coil.

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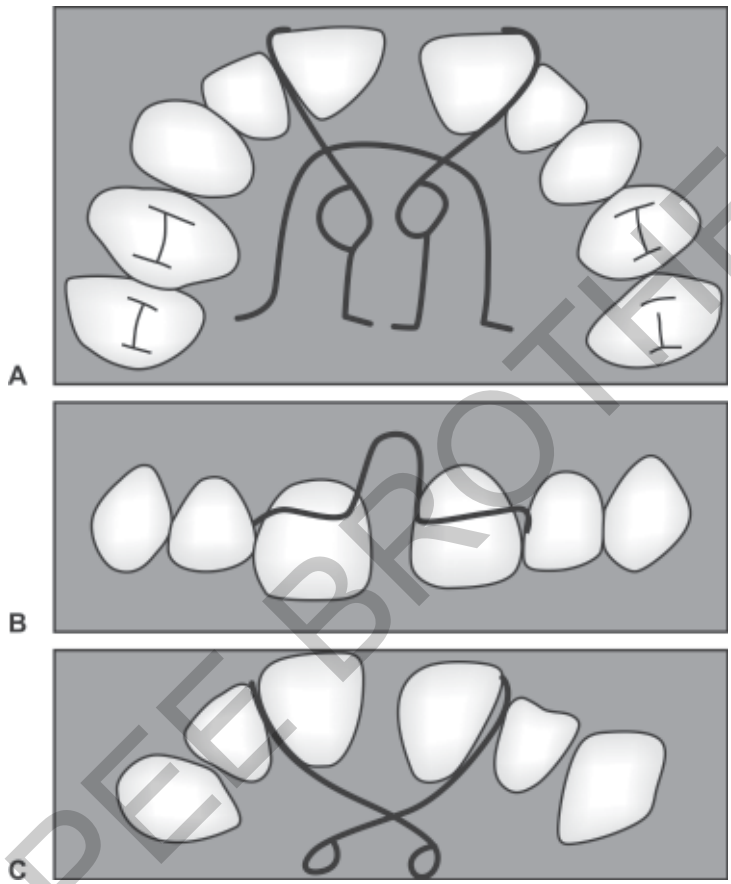

Figures 4.6A to C: Midline diastema correction. **A.** Finger spring; **B.** Closed proximal spring with adjustment loop; **C.** Crossed retention arms of closed proximal spring

Single cantilever spring: It is made out by 0.5 mm and active arm should be parallel to the occlusal plane or at right angle to the long axis of the tooth. The active arm lies below and carry one and half coil. It is indicated for correction of labial movement by single tooth, e.g. anterior cross bite or lingually placed anterior tooth. It is activated by opening the coil. While activating, it is ensured that the active arm lies always at right angle to the tooth which is to be corrected (Fig. 4.7).

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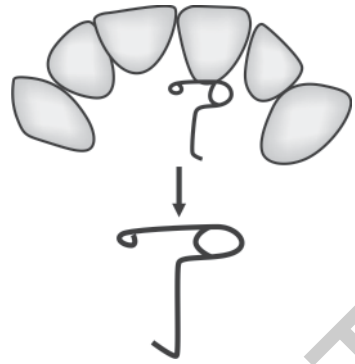

Figure 4.7: Single cantilever spring

Double cantilever spring: It is similar to single cantilever spring except it carries double helices. The passive arm of the first coil, becomes active arm of the 2nd coil. The activation is done on both coils. It is indicated in anterior arms bite, e.g. two teeth involvement (Figs 4.8 and 4.9A to D).

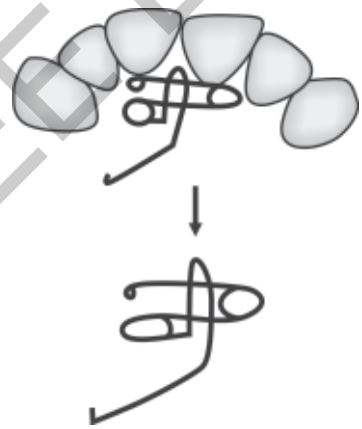

Figure 4.8: Double cantilever spring

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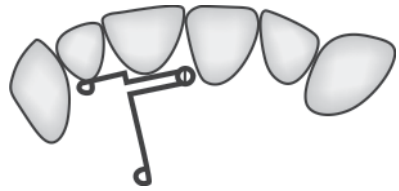

Figure 4.9A: Cranked spring



Figure 4.9B: It is fixed at one end and free at the other end

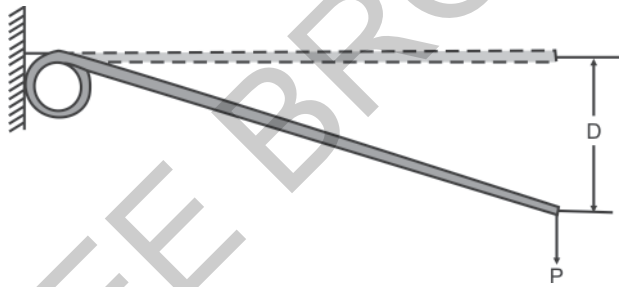

Figure 4.9C: Cantilever spring with coil at the point of attachment to the base plate or support

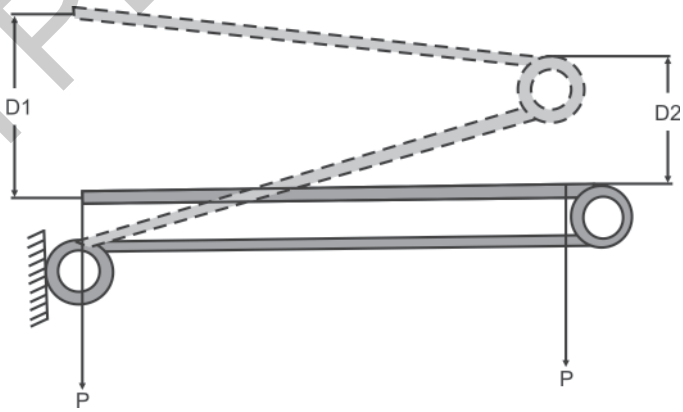

Figure 4.9D: A double cantilever spring which will move two, three or four teeth an equal amount in the same direction. Pressure P-produces deflections D, D1 and D2

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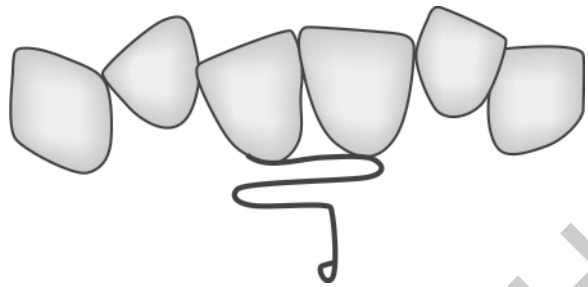


Figure 4.10: 'Z' spring without coil

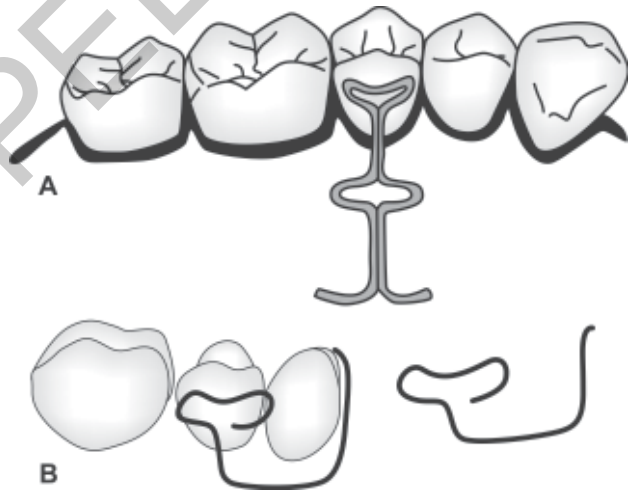
Cranked spring: A longer active arm is made and an offset is placed so that the active arm of the spring can be precisely adapted to the tooth (Figs 4.9A to D).

Z spring: Without coil it can also be designed. The activation is at the loop by opening it (Fig. 4.10).

Auxiliary Spring

It is discussed already in the Chapter 3 – Labial Wire (high labial bow with apron spring).

It is indicated in premolar or molar cross bite. It is made up of 0.5 mm and kept on the palatal side to move palatobuccal direction.



Figures 4.11A and B: A. T spring and **B.** Buccal push spring

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It is adjusted with additional loops incorporated, so, that spring can be elongated as the tooth moves. It is adjusted by straightening the loop. Buccal push spring is used to push buccally placed premolar palatally (Fig. 4.11A and B).

Coffin Spring

Coffin in 1881, introduced the spring and hence it is named after his name. It is fabricated with the wire of 1.25 or 1 mm. It is indicated in bilateral and unilateral cross bite for lateral expansion (Fig. 4.12).



Figure 4.12: Coffin spring

Protrusion Springs

Open spring or closed protrusion springs are employed mainly to move anterior teeth labially. The active part of the spring is bent in one plane and should, if possible, contact the tooth at right angle to its long axis. These springs can also be used to move posterior teeth in a buccal direction. There are two types of springs namely:

1. Open protrusion springs
2. Closed protrusion springs.

Open Protrusion Spring

An open protrusion spring is S-shaped and as wide as the tooth to which it is applied. The wire is bent in two hairpin curves so that a flattened "S" with three parallel arms is formed. The activation of a protrusion spring is illustrated in the Figures 4.13A and B.

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If the first curve is pressed between the beaks of a flat, pointed plier, the free end of the spring will move forward. The same manipulation applied to the second curve will bring the free end parallel to its original position but in a more anterior location. When the plate is inserted into the mouth, the spring will be compressed, that is activated. An easier activation method consists of elongating the spring by stretching more than 1 mm.

When a tooth is to be protruded and rotated simultaneously, the free end of the spring is positioned on the side of the tooth where more force has to be exerted. An open protrusion spring with its free end bent around the mesial or distal sides of a tooth, not only prevents lateral shifting but can, through activation, move the tooth mesially or distally. The appliance in the Figure 4.13A shows two open protrusion springs for the central incisors.

Closed Protrusion Spring

Both ends of the closed protrusion spring wire and anchored in the acrylic, it is therefore, less elastic than an open protrusion spring and it can be formed with one or two loops. When protruding all anterior teeth simultaneously, a closed protrusion spring with auxiliary "U" loops can be employed. This type of loop delivers a uniform force action. It can also be used effectively when combined with a labial wire for support.

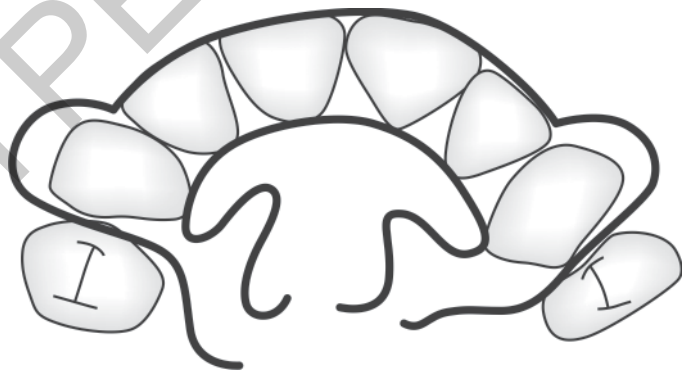

Figure 4.13A: Closed protrusion spring with activating loops

Activation of the closed spring produces a typical alteration in its shape. Figure 4.13B shows changes undergone by a spring

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through the activation of its loops. Activation of a single loop protrusion spring produces a pronounced curvature in the wire, reducing its contact with the teeth and decreasing its effectiveness. This type of spring should therefore be made slightly wider than the teeth upon which it acts so that an adequate contact area remains following activation.

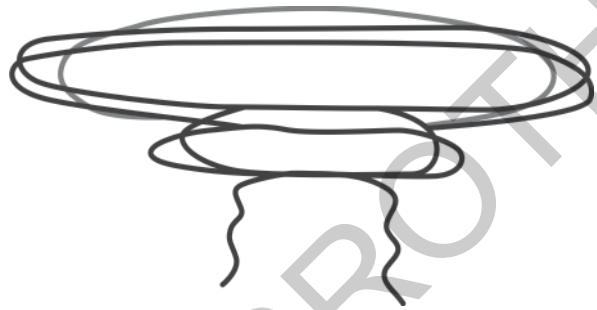

Figure 4.13B: Changes in the activation of a closed protrusion springs in relation to the point of adjustment

Proximal Springs

Proximal springs or interdental springs are used to move anterior or posterior teeth in a mesial or distal direction. Depending on the



Figure 4.14: Proximal springs with 'S' shaped loops for mesial movement of incisors

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individual case, they can also be called mesial or a distal spring, 0.5 mm is used for incisors where as 0.6 mm is used for canines and premolars.

It contains a hairpin like bend that grasps the proximal surface of the tooth extending slightly onto the facial surface. The section of the spring that contacts the tooth lies roughly parallel to the occlusal plane. On anteriors, the spring extends several millimeters onto the labial surface. The palatal part of the spring can be straight, bent into a helix or double looped in an "S" configuration (Fig. 4.14).

Activation of the proximal spring is correctly performed when the place of insertion in the acrylic is ahead of the point of force application on the tooth, that is, during activation the spring arm should be displaced toward the proximal contact area on the tooth. Figure 4.14 shows the activation of a spring with a double loop. When preparing proximal springs, care has to be taken to place the wire approximately 1 mm away from the mucosa. The point of application of a spring on a tooth (toward the incisal or gingival aspect) depends on what type of tooth movement is desired.

A closed type of proximal spring with an adjusting loop on the labial surface is illustrated in Figure 4.14. It should be noted that in an appliance, where an anterior proximal spring is combined with a screw for transverse expansion, the insertion point of the spring wire in the acrylic moves laterally. If such a spring is applied to the distal surface of a central incisor, to move it mesially, for example, its effect will be reduced. This problem can be resolved either by readjusting the spring or by designing "crossed" proximal springs. With the spring for the right central incisor anchored in the left half of the appliance and vice versa, expansion of the plate will automatically activate the springs to move the central incisor anchored in the left half of the appliance and vice versa, expansion of the plate will automatically activate the springs to move the central incisors mesially.

Lingual Springs

The lingual spring is useful for uprighting lingually tipped mandibular molars, where sufficient space is available. For the terminal tooth, the open loop lingual spring is bent out of 0.7 mm. Where the wire exists the acrylic, a vertical loop is formed for the optimal effect, this spring should contact the tooth above the height of contour (Fig. 4.15).

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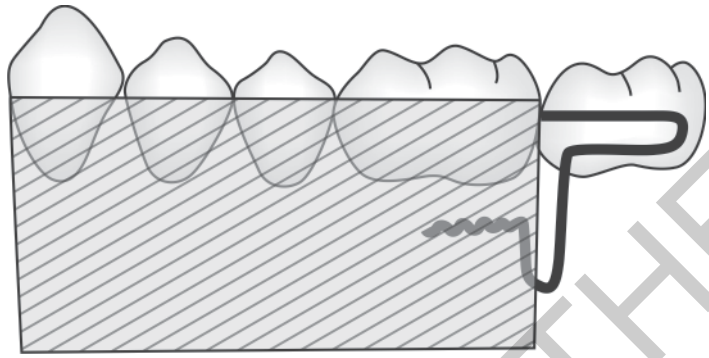

Figure 4.15: Lingual spring on the terminal molar

Paddle Spring

It can also be included in the closed protrusion spring group. They can be applied in the anterior area but are used mainly in the posterior segment mainly on premolars. When the lingual surface of an anteriors is unfavorable for the placement of a regular protrusion spring, a paddle spring can prove useful (Fig. 4.16).

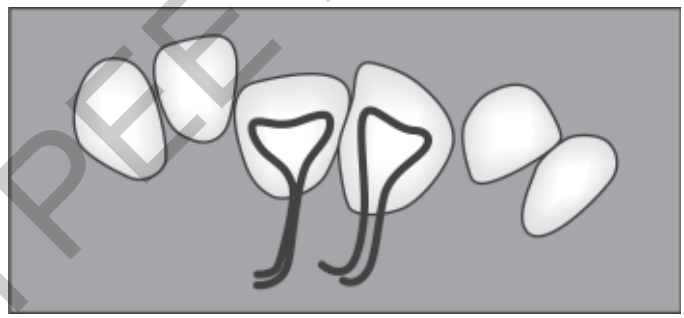

Figure 4.16: Paddle springs for incisors

Springs on the Labial Wire

Various springs can be welded or soldered on a labial wire. These springs approach the teeth from the labial side to move them in a mesial, distal or lingual direction. It is advantageous for such springs to be soldered to the vertical loop of the labial wire (Fig. 4.17).

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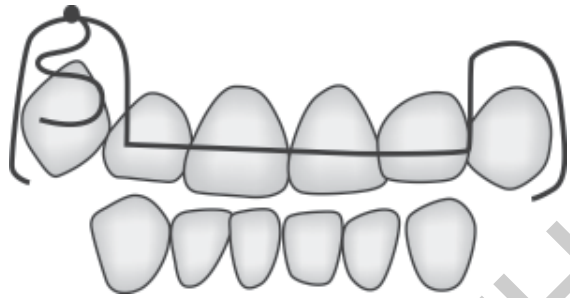

Figure 4.17: Spring soldered to the vertical loops for lingual movement of the canines

Torque Spring

It is a special kind of finger spring where flexibility is given to a rather short and stiff active arm by means of transverse torque limbs which derive flexibility by the twisting of two sections of wire. This spring is particularly useful where a very precise action is required on the lingual aspect of upper anteriors which have to be rotated. Figure 4.18 shows diagrammatically the layout of a torque spring. The spring is symmetrical and the section A-B and A′-B′ are fixed in the baseplate of the appliance. The sections B-C and B′-C′ are torque bars and section C-D and C′-D′, make up an apron spring.

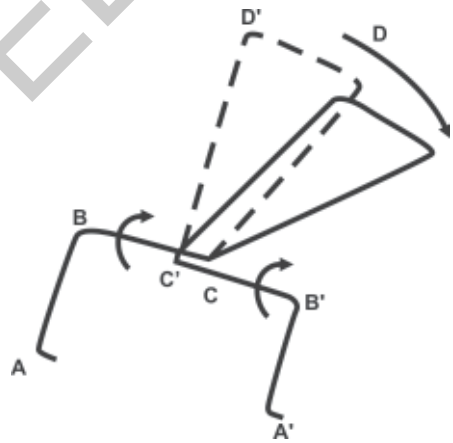

Figure 4.18: Torque-spring: The ends AB and A′ B′ are embedded in the base plate. The lengths BC and B′ C′ twist when the apron CD and C' D' is deflected

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BOXING

The two ways of fixing the flexible springs like cantilever and finger spring to avoid distortion of the wire are (i) to give guide (ii) and to box the springs.

Fabrication of Boxing

1. First the spring is fixed and a layer of wax is placed on the spring to act as spacer.
2. The acrylic can be fruit up over the spacer as flat from which act as bite plane in case of deep bite.
   The main disadvantage of boxing is the accumulating of food particles and difficulty in cleaning. The second disadvantage in the difficulty in activating the coil.
   If the boxing method is adopted there is no need to have a guide.

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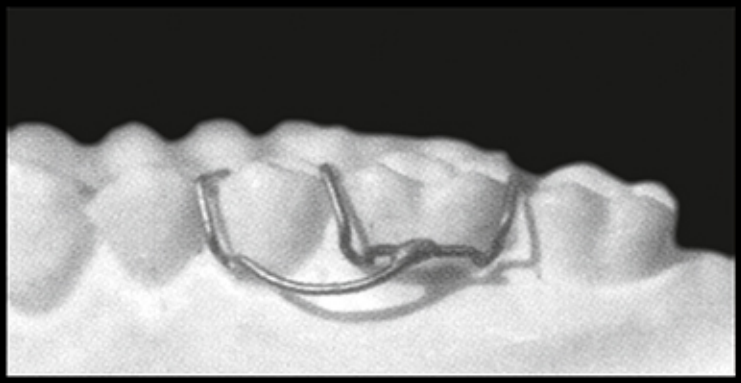

Removable Orthodontic Appliances

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