ISSN 2515-8260 Volume 08, Issue 03, 2021

INTRUSION MECHANICS IN ORTHODONTICS: A REVIEW

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ABSTRACT

Intrusion is a common orthodontic tooth movement which is employed in the cases of deep bite where anteriors are intruded for correction, or in anterior open bite where posteriors are intruded to close the bite for correction. The article includes the biomechanics of Intrusion in Orthodontic treatment and various methods to achieve the Intrusion tooth movement successfully without causing any deleterious effect to the tooth. It also containthe types of Intrusion, their indications and contraindications. Use of various fixed appliances and their modifications to achieve intrusion mechanics is discussed and reviewed in the article.

KEYWORDS: Biomechanics, Intrusion, Deepbite

INTRODUCTION

Intrusion has always been a challenge to the orthodontist, while some authors claim it is possible to achieve intrusion some others claim that it is impossible to achieve true intrusion.

The biomechanical and histological basis of this tooth movement has been a difficult problem for evaluation and understanding.

Intrusion, as defined by **Marcotte**, is the "tooth movement that occurs in an axial (apical) direction and whose center of rotation lies at infinity. It is an axial type of translation". [1]

Burstone defined intrusion as "Apical movement of the geometric center of the root with respect to the occlusal plane or a plane based on the long axis of the tooth".[2]

The correction of deep overbite is one of the major challenges to correct Class II malocclusion. This is done either by extrusion of posteriors or intrusion of anteriors or a combination of both. However, for optimal treatment, more intrusion is required in the upper arch than in the lower.

Intrusion can be a true intrusion or relative intrusion. True intrusion is the movement of the tooth along its long axis in an apical direction. Relative intrusion is the intrusion in which incisors are in its place, posterior teeth erupt while the mandible grows.

TYPES OF INTRUSION[3]

True intrusion: It is achieved by moving the root apices of the anteriors closer to the bony base.

Relative intrusion: It is achieved by keeping the incisors where they are, while the mandible grows and the posterior teeth erupt.

Apparent intrusion: It is achieved by extrusion of the posterior teeth

INDICATION OF INTRUSION IN ORTHODONTICS[3]

- Intrusion of Anterior Teeth In Gummy Smile
- Deep Bite and Reduced Lower Facial Height
- Deep Bite and Increased Lower Facial Height
- Intrusion of Periodontally Involved Teeth
- The intrusion of Posterior Teeth.

BIOMECHANICS OF INTRUSION

True intrusion is obtained when an intrusive force is directed through the center of resistance of the anterior teeth. Unfortunately this is difficult to accomplish; spatial relationship between center of resistance (CR) and point of force application (P.F.A) varies depending on labio-lingual inclination of upper incisors intrusive force is normally applied to the labial surface of the incisors. This produces a moment which tends to flare the crowns forward and move the roots lingually.[4]In cases where incisors are markedly proclined, an intrusive force creates a large moment. In these cases incisors should be retracted first to improve their axial inclination before intrusive mechanics are initiated. Thus the key to successful intrusion is light continuous force, which is directed towards the root apex of incisors.[4]

OPTIMAL FORCE FOR INTRUSION

Loading diagram of intrusive force is concentrated over a small area at the apex. For this reason extremely light forces are needed to produce appropriate pressure within the periodontal ligament during intrusion.

ISSN 2515-8260 Volume 08, Issue 03, 2021

An optimal force is one that produces a rapid rate of tooth movements, without discomfort to the patient or any tissue damage. Optimal force range for intrusion has been a long time controversy. [5]
Burstone(1977) suggested 50 grams of intrusive force for upper central incisors, 100 grams for central and laterals and 200 grams for six upper anteriors. He advocated use of 40 grams for four lower incisors and 160 grams for all six lower anteriors.[6,7]

DESIGNS OF INTRUSION ARCHES
There are two basic designs for an intrusion arch:
1. Continuous arch
2. Segmental intrusion arch
The following Intrusion arches are reviewed in this discussion.

1. Utility arch
2. Connecticut intrusion arch
3. Burstone intrusion arch
4. Tip-back springs (intrusion springs)
5. Three-piece intrusion arch
6. K-SIR

1. UTILITY ARCH [8] : Utility arch was designed by Robert M. Ricketts in the early 1950's and has been popularized as an integral part of bioprogressive therapy.(Figure: 1)
Regardless of the presence or absence of loops, all utility arches have a common design, which consist of,

1. Molar segments
2. Posterior vertical segment
3. Vestibular segment
4. Anterior vertical segment
5. Incisal segment.

As advocated by Ricketts, utility arches are fabricated from chrome – cobalt wires. In contrast to stainless steel wire: chrome – cobalt wire is manipulated easily and loops can be formed in the wire with little difficulty.
With regard to selection of appropriate size of wire for 0.018" slot appliance, recommended wire for mandibular utility arch is either 0.016" x 0.022" or 0.016" x 0.016" wire.
For maxillary arches 0.016" x 0.022" wire is recommended, with 0.022" slot, 0.019" x 0.019" wire can be used in either arch. Generally rectangular wire is preferable to round wire to control torque and prevent unwanted tipping of incisors. Passive, Intrusion, Retraction and Protraction utility arches are the four types of utility arches.

INTRUSION UTILITY ARCH: In Intrusion utility arch, the posterior vertical segments do not lie against auxillary tube on the 1st molar bracket. Arch is activated to intrude the anterior teeth. Utility arch should produce 60–100 grams of force on the mandibular incisors, force level considered ideal for mandibular incisor intrusion.

2.CONNECTICUT INTRUSION ARCH:[9,10]Connecticut intrusion arch (C.I.A) introduced by Ravindra Nanda is fabricated from Nickel – Titanium alloys as it is the material of choice for delivering continuous forces under large activation. (Figure 2)
C.I.A incorporates the characteristics of utility arch as well as those of conventional intrusion arch. C.I.A on preformed wires with appropriate bends are necessary for easy insertion and use.
Two wire sizes are available 0.016" x 0.022" and 0.017" x 0.025" maxillary and mandibular versions have anterior dimensions of 34 mm and 28mm respectively. The bypass, located distal to lateral incisors is available in two different length to accommodate for extraction, non-extraction and mixed dentition.
C.I.A's basic mechanism of force delivery is a V-bend calibrated to deliver approximately 40–60g of force. Upon insertion, the V-bend lies just anterior to the molar brackets.
When the arch is activated, a simple force system results consisting of vertical force in the anterior region and a moment in the posterior region. Headgears may be worn to counteract the side effect on the molars.

3. BURSTONE INTRUSION ARCH:[11]In the 1950's Burstone developed the segmented arch technique, which had different cross-section of the wire within the same arch and wires that did not run continuously from one bracket to the adjacent bracket. Burstone concluded that one of the limitations of the continuous arch therapy is its inability to produce genuine intrusion. Basic mechanism of Burstone intrusion arch consists of posterior anchorage unit, anterior segment, and intrusive arch spring. To increase the stability of the posterior segment, wires that are 0.018" x 0.025" or 0.021" x 0.25" stainless steel can be placed (depending upon whether it is 0.018 or 0.022 slot) after initial alignment. When alignment is completed in the posterior segment, right and left buccal segments are joined together across the arch by means of a transpalatal arch in maxilla and low lingual arch in mandible. Intrusive spring is not tied directly into the incisor bracket. Anterior alignment arch or anterior segment is placed in the central incisor or four incisors and intrusive arch is either tied labially, incisally or gingivally to the wire. (Figure:3)

4. TIP BACK SPRINGS (INTRUSION SPRINGS):[12]Burstone proposed these springs which are made of 0.017" x 0.025" T.M.A wire, upper and lower arches have to be leveled and aligned and rigid stainless steel wire, preferably of 0.017 x 0.025 inch dimension. Anchor molars should be reinforced with a T.P.A in the upper and lingual holding arch in the lower arch. The intrusion springs are made from 0.017" x 0.025" TMA wire without a helix or 0.017" x 0.025" stainless steel wire with a helix for optimal force for intrusion. (Figure:4)
A helix is formed by bending the wire gingivally mesial to the molar tube. The mesial end of the spring is bent into a hook and is engaged distal to lateral incisor, which according to Burstone is the approximate center of resistance of the four incisors. Mesial end of the spring lies passively at the height of vestibular fold and spring is activated by pulling the hook down and engaging it on to the arch wire.

5. THREE PIECE INTRUSION ARCH:[13]The Three piece Intrusion arch consist of the following parts:

1. Posterior Anchorage unit
2. The anterior segment with posterior extension
3. Intrusion Cantilevers

POSTERIOR ANCHORAGE UNIT: After satisfactory alignment of the pre-molars and molars, passive segmented wire (0.017 x0.025" stainless steel) are placed in the right and left posterior teeth for stabilization. A precision stainless steel trans-palatal arch (0.032 x 0.032 inch) placed passively between the first maxillary molars consolidates the posterior unit now consisting of right and left posterior units. Canines may be incorporated into the buccal segment by retracting single.

ANTERIOR SEGMENT: The anterior segment creates a step of 3mm by bending gingivally distal to the laterals and then bent horizontally. The distal part forms a hook posteriorly to the distal end of the canine bracket. The anterior segment should be made of (0.018 x0.025 or larger) to prevent side effects created by bending of wire during force application.

INTRUSION CANTILEVER: The intrusion cantilever wire is fabricated from 0.017 x 0.025 inch T.M.A. bent gingivally mesial to the molar tube and a helix is formed. The mesial end of the cantilever is bent into a hook. The cantilever is then activated by making a bend mesial to the helix at the molar tube, such that the anterior end with the hook lies passively in the vestibule. This is then brought down to engage onto the horizontal portion of the anterior segment so that the resultant forces are made to pass through the center of resistance of anterior teeth. An elastic chain can be attached to the hook for simultaneous intrusion and retraction. However, to achieve true intrusion of anterior teeth it is always necessary to balance the effective force of intrusion. (Figure:5)

6. KALRA SIMULTANEOUS INTRUSION RETRACTION:[14]The K-SIR archwire is a modification of segmented loop mechanics of Nanda and Burstone. It is a continuous 0.019" x 0.025" TMA archwire with closed 7mm x 2mm U-loop at the extraction site. To obtain bodily movement and prevent tipping of teeth into the extraction space a 90° V bend is placed in the arch wire at the level of U-loop. This V-bend, when centered between the 1st molar and the canine during space closure, produces two equal and opposite moments to counter the moments caused by activation force of closing loop. An off centered 60° V-bend located posterior to the inter-bracket distance produces an increased posterior clockwise moment on the 1st molar which augments molar anchorage as well as intrusion of anterior teeth. To prevent the buccal segment from rolling mesio-lingually due to the force produced by loop activation, a 20° anti-rotation bend is placed in the arch wire just distal to each U-loop. (Figure :6)

A trial activation of the arch wire is performed outside the mouth to releases the stress built up in bending the wire. After the trial activation, the neutral position of each loop is determined with the legs extended horizontally. In the neutral position, the U-loop is about

3.5mm wide and the arch wire is inserted into the auxiliary tube of the 1st molar and engaged in the six anterior brackets. It is activated about 3mm aparting the mesial and distal legs of the loop. To increase the inter-bracket distance between the two ends of the attachment, which increases the efficacy of the off centered V bend, 2nd premolars are bypassed. When the loops are first activated, the tipping moments generated by the retracting force will be greater than the opposing moments generated by the V bend in the arch wire. This will initially cause controlled tipping of the teeth into the extraction space. As the loops deactivate and force decreases, the moment to force ratio will increase to first cause bodily and then root movement of teeth. The arch wire should therefore not be reactivated at short intervals, but only every 6-8 weeks until all the space have closed. The anti-centered V-bend will generate an extrusive force on the molars, which is usually undesirable.

One of the keys to preventing unwanted side effects of an appliance is to keep the reactive force at a minimum, while exerting an optimum level of force on the teeth to be moved. K-SIR exerts about 125g of intrusive force on the anterior segment and a similar amount of extrusive force, distributed between the two buccal segments-generally the 1st permanent molar and the 2nd premolars, connected by segments of TMA wire. Reactive extrusive force on the buccal segment is countered by force of occlusion and mastication, adding teeth to anchorage unit, and banding the 2nd molar will increase anchorage in the antero-posterior direction. The main indication of K-SIR is for retraction of anterior teeth in a 1st premolar extraction patient who has a deep overbite and excessive overjet and who require intrusion of anterior teeth and maximum molar anchorage because the intrusion of the six anterior teeth occur at the same time as their retraction, K-SIR shortens the treatment time compared to conventional mechanics.[15]

ONE COUPLE VS TWO-COUPLE SYSTEM:[16,17] A one-couple system applies force to a single point of force system which allows one to devise what type of force is being generated. This system can be statistically determinate. In this system a couple is generated only at one end of the intrusion arch, and thus this type of system is known as one-couple system. For example, in a segmental intrusion arch. In a two-couple system the intrusion arch in engaged in the slots of the anterior brackets and at the tube in the posterior teeth, this creates a two-point contact system thus creating a scenario where the clinician does not have control over the force generated in a clinical setup. This type of system is statistically indeterminate and can be seen with intrusion arches such as Rickett's Utility intrusion arch.

ORTHODONTIC INTRUSION DISADVANTAGE:

The side-effects are observed when intruding teeth by using segmental or continuous arch method.

Incisal flaring: When using intrusion arch which normally has its point of application buccal to center of resistance, a counter-clockwise moment will be observed at the center of resistance which will move the crown labial and root lingual leading to flaring of the incisors. The greater the distance of the bracket from the center of resistance of a tooth, the greater the moment observed to top the incisors buccally.This is called a pseudo-intrusion where the teeth are being tipped and not translated apically through the bone. In extraction cases, retraction of incisors is achieved first to correct its inclination and then upright incisors are intruded or intrusion-retraction simultaneously .[18]

Lingual crown tip on molars : An equal and opposite extrusive force acting at the posterior teeth of the same arch counteracts certain intrusive force acting on the incisors. The extrusive force is seen at buccal of the center of resistance of a molar tooth. Thus, there is a moment that is produced that leads to lingual crown tip and buccal root tip of the that molar tooth. A Lower Lingual Holding arch or a Transpalatal Arch can be used to control the transverse side-effects.[18]

Root Resorption: Intrusion has been suggested as a possible cause of root resorption. The tooth apex and associated periodontium can absorb relatively high compression stresses during intrusion. These high stress levels logically could increase the risk of apical root resorption.[18]

CONCLUSION:

Early studies of treated patients saw little intrusion of incisors because the mechanics used tended to extrusion of posterior teeth with the mechanics used. It has been shown that the use of light constant forces enables the intrusion of teeth with minimal disruption of posterior anchor units. It has also been shown that as the forces for intrusion are increased, more root resorption but not necessarily a greater rate of intrusive movement may result. The upper incisors commonly must be intruded more than lower incisors to maintain the original cant of the plane of occlusion. The typical patient who requires intrusion also requires minimization of extrusion of the posterior teeth. Understanding the basic biomechanical principles involved in effecting controlled tooth movement enables achieving successful orthodontic treatment outcomes which are more predictable and consistent. The choice of appliances and techniques used by practitioners varies radically among individuals but the fundamental forces and moments they produce are universal.

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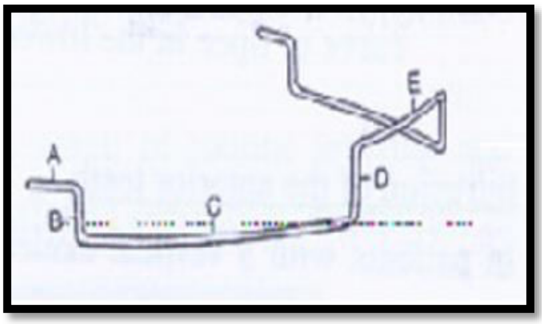

Figure 1: Utility arch

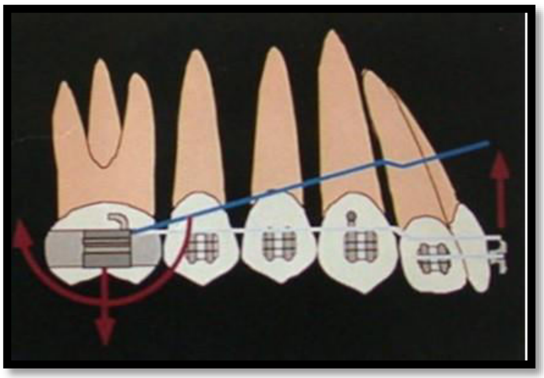

Figure 2: connecticut intrusion arch

ISSN 2515-8260 Volume 08, Issue 03, 2021

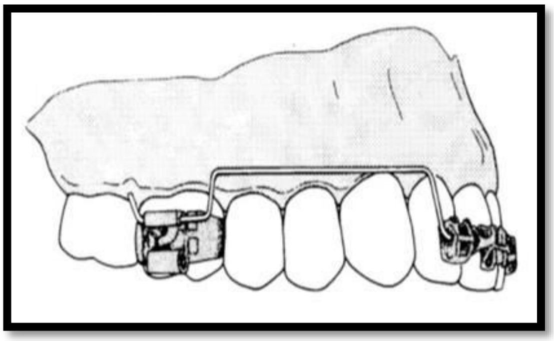

Figure 3:Burstone intrusion arch

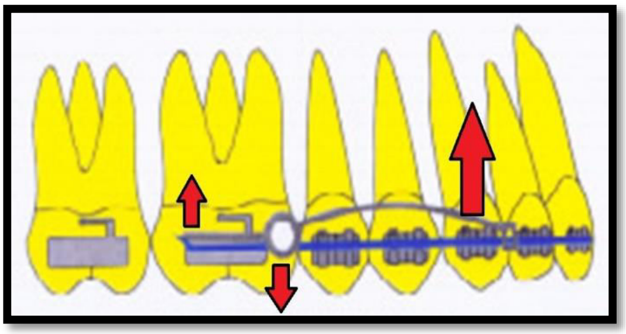

Figure 4:Tip back springs

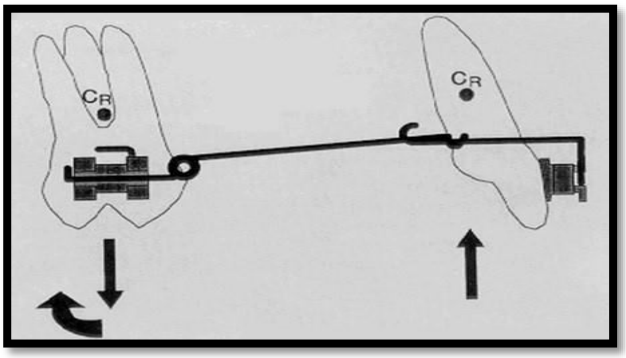

Figure 5: Three piece intrusion arch

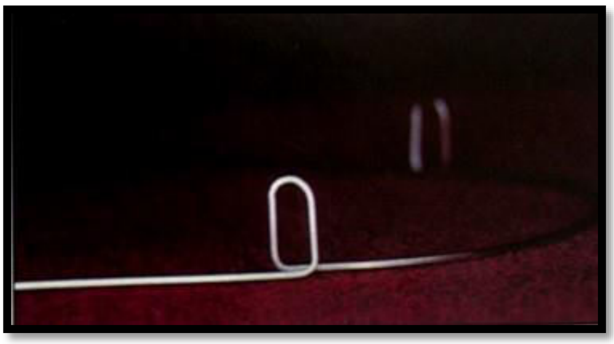

Figure 6:Kalra simultaneous intrusion retraction