ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 3, Issue – 2, March - 2020, Page No. : 210 - 216

Orthodontic Intrusion of Anterior Teeth: Basics and Biomechanics

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Citation of this Article: Dr. Dhinahar S, Dr. D. Praneeth Reddy, Dr. Deenadayalan Purushothaman, Dr. Dhivya Dilipkumar, Dr. Nidhi Angrish, "Orthodontic Intrusion of Anterior Teeth: Basics and Biomechanics ", IJDSIR- March - 2020, Vol. – 3, Issue -2, P. No. 210 – 216.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Introduction

Malocclusion can occur in three planes of space i.e. sagittal, transverse and vertical plane. Frush and fischer studied denture esthetics and proposed that curvature of the incisal edges of upper anterior teeth and curvature of the upper border of the lower lip should be in harmony1. The harmony can be disrupted by having a vertical maxillary excess or in cases of deep bite where the incisor show could be more than the normal.

Generally, intrusion as an orthodontic therapeutic manipulation may mean:

a) Orthopedic intrusion referring to superior displacement or, even better, to inhibition of inferior movement of the maxillary complex, and it is achieved with the use of functional appliances or high pull headgear with or without functional appliances

b) Surgical superior maxillary displacement in cases of vertical maxillary excess (VME) and

c) Intrusion of a single tooth or groups of teeth2

The first two categories concern growing and adult patients and include complex skeletal and dento-alveolar changes. However, pure dental intrusion in growing individuals or adults constitutes a basic therapeutic strategy of many orthodontic techniques (bioprogressive)3 or certain schools of treatment (Begg) for managing deep bite. Even more often, intrusion occurs, to a certain extent, almost always spontaneously during orthodontic treatment, given that, irrespective of the therapeutic technique, wire activation at the time of ligation on two teeth with height difference leads to intrusion of one tooth and extrusion of the other. Thus, orthodontic intrusion is encountered in almost all treatment types and is often not the clinician's choice[2].

One of the major challenges of Class II treatment is the correction of deep overbite. In most instances this correction is produced by the extrusion of posterior teeth.

Differential treatment planning for the class II patient requires that the relative amount of anterior intrusion and posterior extrusion be determined before treatment and that differential mechanics be utilized to produce the desired correction. Lip length may be relatively short in relation to the vertical dimension, it is not desirable to increase the vertical dimension since it would tend to make the A-B relationship more class II and increase an abnormally large lower face4. Correction of deep over bite can involve any of the combination of these tooth movement depending on the individual cases/growth pattern.

1) Extrusion of posteriors
2) Up righting of posteriors
3) Increasing the inclination of anteriors
4) Intrusion of anteriors2

Extrusion of the posterior teeth will result in increased lower facial height, steepening of the occlusal plane, downward and backward rotation of the mandible, Deep overbite correction by intrusion of anterior teeth offers a number of advantages including, simplifying control of vertical dimension and allowing forward rotation of the mandible. Intrusion of anterior teeth to correct deep overbite may be indicated in patients with unaesthetic excessive maxillary incisor showing at rest position of the lip (5-8mm), and deep mandibular curve associated with long lower facial height or a gummy smile. The amount of incisors exposed at rest is a crucial aesthetic parameter, which depends on a number of hard tissue and soft tissue factors like

a) Short upper lip philtrum height- which results in children due to incomplete lip growth, in adults, short lip is simply an anatomic variable.
b) Vertical maxillary excess
c) Excessive clinical crown height

Numerous methods have been described for incisor intrusion, and all of them employ the same principle, a tip-back bend at the molars, or a V bend in the posterior region of the arch to provide an intrusive force at the incisors. Wire material used for the intrusion is diverse, but all recognize the need for light continuous force3,5

Definition: Marcotte defines intrusion as 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"6.

Nicolai as "Translational form of tooth movement directed apically and parallel to the long axis"7

Burstone as "Apical movement of the geometric center of the root in respect to the occlusal plane or a plane based on the long axis of the tooth"4

Terminology

Relative intrusion: is achieved by the extrusion of the posterior teeth rather than the true intrusion of the anterior teeth. Pseudointrusion refers to the labial tipping of the incisor around the centroid. Absolute intrusion is pure intrusion of the incisors without extrusion of the posterior teeth8 For many years dental intrusion was considered improbable because of the side effects from the periodontium and cementum (root resorption), however in recent years successful orthodontic intrusion is clinically documented and is a safe procedure, provided that the magnitude and direction of forces are carefully monitored.

Absolute intrusion can also be classified into: anterior or incisor intrusion and molar intrusion.

Bio-Mechanics of Intrusion4, 6, 9, 10

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 application (P.F.P) varies depending on labiolingual 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.

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, key to successful intrusion is light continuous force, which is directed towards the root apex of incisors.

one couple and Two couple systems

Determinate systems in orthodontics are those in which a couple is created at one end of an attachment with only a force (no couple) at the others. This constitute the one – couple system; which means that the wire that will serve as a spring can be inserted into a tube or bracket at one end, but must be tied so that there is only one point of contact on the other.

When wire is tied into the bracket on both ends a statistically indeterminate two couple system has been created.

One couple systems: In orthodontic applications, one couple systems are found, when two conditions are met.

1) Cantilevers spring or auxillary arch wire is placed into a bracket or tube. It typically attaches to a tooth or teeth that are part of the stabilized segment.
2) Other end of cantilever spring or Auxillary arch wire is tied to teeth that are to be moved with a single point of force application like an intrusion arch.

Two Couple Systems

The effect of tying an intrusion arch into the brackets changes the bio-mechanical aspect of the appliance from a one couple system to an indeterminate two couple system. Utility arch popularized by Ricketts used frequently for incisor intrusion, makes this charge like a one – couple intrusion arch, it is formed from rectangular wire; so that it will not roll in the molar tube, and it bypasses the canine and premolar teeth. The resulting long span provides excellent load deflection properties so that light force necessary for intrusion can be created. Difference comes when utility arch is tied into the incisor brackets.

Utility arch often is an intrusion arch in a two couple configuration, created by tying the intrusion arch into the slots of the brackets. When this is done, the precise magnitude of the force and couples cannot be known.

Appliance Requirement for Uniform Intrusion4

Appliances, which are used, for intrusion should fulfil two important criteria

1) It should deliver a constant moment to force ratio to maintain the center of rotation of incisors
2) Appliances should have low load deflection rate with long range of activation so that greater force constancy over the activation range can be achieved.

One or more of the following ways can reduce load deflection, in the appliance, they are:

1) Reducing the cross section of the wire

Reducing the diameter of the wire is commonly use to improve the force constancy and reduce the load deflection rate, however as the cross section of the wire gets smaller, less control is expressed on the tooth in all three planes of space.

2) Increasing the inter bracket distance

Large inter bracket distance reduces the load deflection rate and helps deliver a constant force magnitude, providing a better directional control of tooth movement.

3) Wire material

Materials are available which have lower modulus of elasticity than stainless steel and reduction in the modulus of elasticity translates into almost 1:1 reduction in the load deflection rate of the arch wire.

Optimal Force For Intrusion3,6,11,12,13

A movement of intrusion must be performed carefully in adults, lamina dura of adult teeth in the apical region is frequently denser and periodontal ligament is somewhat narrower than in children's teeth. A careful examination of radiograph is always important for intrusion.

Loading diagram, of intrusive force shows that force is concentrated over a small area at the apex8. For this reason extremely light forces are needed to produce appropriate pressure within the periodontal ligament during intrusion.

An optimal force is one that produces a rapid rate of tooth movements, without discomfort to the patient or ensuing tissue damage. Optimal force range for intrusion has been a long time controversy.

Optimal Force

Dellinger (1967), demonstrated intrusion histological & cephalometrically for the first time on monkey premolars when applied 50 grams of force and found very little resorption with good intrusion14

Stenvik and Mjor (1970), investigated the effect of intrusion on pulp and dentine on human premolars and found that force above 150 to 200 grams caused stasis in pulp vessels15

Reitan (1974), did studies on the intrusion of human premolars and concluded that force around 80 to 90 grams range caused apical root resorption while any force not exceeding 30 grams did not result in any damage16.

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 anteriors4.

Bench, Gugino and Hilgers (1978), advocated intrusive force of 15 to 20 grams per lower incisor and 60 to 80 grams for all four lower incisors17

Ricketts (1980) advocated use of 125 to 160 grams of force for upper incisor intrusion and 60 to 75 grams for lower incisors3

Nicolai (1985), suggested that intrusive force should be 60 grams / cm2 of occlusoapical projection of root surface area7

Proffit (1993), suggested 15 grams of force needed for incisor intrusion10

Siatkowski (1997), based on the work of Dermaut suggested 10-15 grams of force for upper central incisor where a 5-10 grams for lower lateral and 15-25 grams for canines18

factors affecting intrusion 4,6,10:

1. Force Magnitude and Constancy:It is important to use the lowest magnitude of force that is capable of intruding incisors. If the magnitude of force is too great; rate of intrusion will not increase and rate of resorption will increase as demonstrated by Dellingers research on monkeys4.

Too great a force will have reciprocal effect on posterior anchorage, posterior teeth will feel a vertical force which will tend to extrude the buccal segment and a moment which in upper arch will steepen the plane of occlusion and in the lower arch flatten it.

Anterior single point contacts: Anterior single point contact is needed in the anterior segment, so that a constant force is produced and genuine intrusion is produced in the anterior segment.

By having a single point of force application on the incisors, the clinician knows more positively the full force system acting at the incisors segment and buccal tube

thereby producing a statically determinant system. By placing the intrusive arch into the brackets, produces a statically indeterminant system, which prevents the orthodontist from knowing exactly what type of force he is delivering.

3. Point of force application: An intrusive force placed through the center of resistance of the incisors will intrude the teeth and not produced any labial or lingual rotation of teeth. Center of resistance of an anterior segment can be estimated to be at the geometric center of roots of the incisors to be intruded.

4. Control of reactive units: Best control over the posterior teeth, is the minimization of force magnitude used for intrusion. Since the moment arm is so large from anterior to posterior segments it is necessary to give a thought to control the posterior teeth. Posterior teeth are joined together to from the posterior anchorage unit.

5. Selective Intrusion: Taking advantage of geometry of anterior segment is one of the key concepts in producing genuine intrusion. In class II division 2 cases, it is desirable to intrude just the two central incisors to the level of lateral incisors before joining all four incisors together for further intrusion. In a similar way class II division I patients may require intrusion of four incisors, both maxillary and mandibular, to the level of canines.

6. Avoiding extrusive mechanics: Extrusive mechanics should be avoided if one is to accomplish genuine intrusion. Examples of extrusive mechanics include use of class II and class III intermaxillary elastics, cervical headgear with outerbows placed high applied to the maxillary arch and placement of reverse curve of spee in lower arch to extrude premolars.

Types of Intrusion Appliances In Preadjusted Edgewise Appliance:

Anterior Intrusion Appliance

a) Burstone intrusion arch4
b) Utility arches5
c) 3-Piece base arch19
d) Mulligan's arch20
e) Connecticut intrusion arch21
f) K-sir arch22

Histological Changes Of Teeth Undergoing Orthodontic Intrusion2, 23

Relevant studies have shown that vertical (intrusive, eruptive) orthodontic forces are those with the highest load on the apical area. Due to stress concentration over a limited area, orthodontic intrusion is considered to present risks for root resorption of involved teeth. However, response to orthodontic loading varies and is affected by many factors, such as force type, magnitude and duration, gender characteristics and individual host characteristics. Several studies have shown apparent histological changes on the surface and surrounding tissues of teeth undergoing orthodontic intrusion.

Orthodontic Intrusion Side Effects23-26

Intrusion side effects include excessive intrusion resulting in esthetic compromise of smiling and resorption of the apical root third.

Root Resorption: Apical root resorption is a commonly observed side effect of orthodontic tooth movement. Early investigators of this phenomenon found maxillary incisors to be the teeth most susceptible to root resorption. At this time, evidence indicates that a typical course of orthodontic treatment will lead to an average apical resorption of 1 to 2 mm for upper incisors with only 2% to 3% of patients showing a loss of 4 mm or more of root length. Intrusion is one of the specific types of tooth movement that has been suggested as a possible cause of root resorption. The tooth apex and associated periodontium can experience relatively high compression

stresses when an intrusive force is applied to the crown. Because of the potential for these high stress levels, intrusion is a technique that logically could increase the risk of apical root resorption.

Conclusion

Intrusion mechanics is very efficient for correction of deep bite or open bite. But it requires proper diagnosis and treatment planning. Various methods of appliances are available and can be used depending on clinical situation. For many years dental intrusion was considered impossible or problematic and was associated with numerous side effects from the periodontium and cementum (root resorption).

However, in recent years successful orthodontic intrusion is clinically documented and is considered a safe procedure, provided that the magnitude and direction of forces are carefully monitored (Proffit and Fields, 2000).

Intrusion at the initial stages of treatment with or without auxiliary means is proposed independently of the therapeutic technique followed, such as Begg (Lew, 1990), tip-edge (Bolender, 2001) or bioprogressive 3(Ricketts et al., 1979).

But over the years – advancements in orthodontic technique and appliances have proved that diagnosis, treatment planning and application of precise appliance system can bring about the true intrusion of anterior and posterior units – with an application of optimum force.

Though this tooth movement has been the topic of discussion regarding the possibility, a thorough study of the clinical situation, diagnosis and treatment planning can definitely help in achieving intrusion of the anterior or posterior segment.

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