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Orthodontic intrusion: A contemporary review

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ABSTRACT

Orthodontic intrusion is a common treatment approach in managing orthodontic esthetic and functional problems, including gummy smile and deep bite. This review presents contemporary reports related to the intrusion, types of dental intrusion, clinical observations, and the tissue reactions after the application of intrusive force, as well as indications and contraindications for intrusion. This paper concisely describes the fixed and removable appliances used for intrusion accomplishment.

Key words: Biomechanics, intrusion arch, orthodontic intrusion

Contemporary Reports Related to the Intrusion



Intrusion is defined by Nikolai^[1] as “a translational form of the tooth movement directed apically and parallel to the long axis”, whereas Burstone^[2] defined it 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.” Labial tipping of an incisor mound its center of resistance produces pseudointrusion, which can also correct the deep bite.

Dental intrusion often constitutes an integral part of orthodontic treatment in order to improve sagittal and vertical incisor relationships, to correct interincisal angle and consequently, the gingival line and restore the esthetics of smiling.^[3]

In general, intrusion as an orthodontic therapeutic manipulation may mean: Orthopedic intrusion, surgical superior maxillary displacement, and intrusion of a single tooth or groups of teeth [Box 1].^[4]

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.^[5] Intrusion at the initial stages of treatment with or without auxiliary means is proposed independently of the therapeutic technique followed, such as Begg, tip-edge, or bioprogressive.^[6-8]

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Box 1: Intrusion may mean

- 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 a functional appliance
- Surgical superior maxillary displacement in cases of vertical maxillary excess and
- Intrusion of a single tooth or groups of teeth.

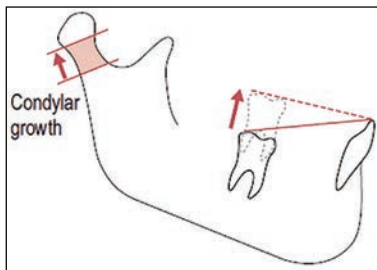
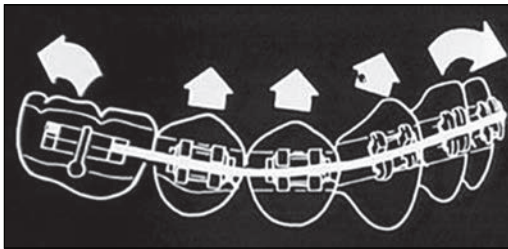
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Types of Intrusion^[9]

Relative intrusion

It is achieved by preventing eruption of the incisors while growth provides vertical space into which the posterior teeth erupt
 Can be achieved with continuous archwires by placing a reverse curve of Spee in the mandibular arch wire, and an exaggerated curve of Spee in the maxillary arch wire

Relative intrusion of the incisors is accomplished by labial tipping of the incisors and extrusion of other teeth in the arch, without any actual intrusion, as the diagram shows. Therefore, in the leveling phase any wire can relatively intrude teeth. However, an intrusion wire, is used when there is a necessity for absolute intrusion of teeth, where tipping and extrusion of other teeth is not in demand



Methods of relative intrusion include:

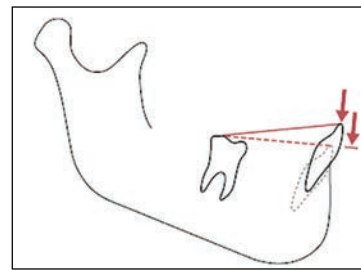
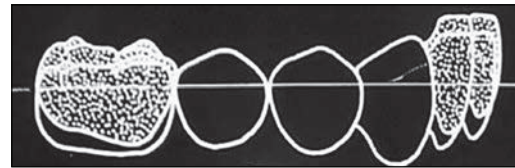
- Anterior bite plates contacting the anterior dentition while allowing posterior eruption
- Twin-blocks, where differential molar eruption can occur by trimming the posterior blocks
- Anterior bite turbos
- Reverse curve of Spee

Absolute intrusion

There is pure intrusion of the incisors without extrusion of the posterior teeth

Requests the teeth being apically pushed into supporting bone, it requires a mechanical arrangement other than a continuous archwire attached to each tooth. Light continuous force directed toward the tooth apex is the key to successful intrusion

Incisors being intruded, using the molars as anchorage as the diagram shows. There is an equal and opposite extruding force occurring on the molars, as with every force in orthodontics. Pure absolute intrusion is preferable accomplished with the use of mini-implants



Methods of absolute intrusion include:

- J-Hook headgear
- Bypass and segmental mechanics
- Temporary skeletal anchorage (micro-implants)

Clinical Observations and the Tissue Reactions after the Application of Different Orthodontic Forces

Intrusion of the tooth involves resorption of the bone, particularly around the apex of the tooth [Figure 1]. In this movement, the whole of supporting structures are under pressure with virtually no areas of tension.

Unlike extruded teeth, intruded teeth in young patients undergo only minor positional changes after treatment. Relapse usually does not occur, partly because the free gingival fiber bundles become slightly relaxed. Stretch is exerted primarily on the principal fibers. An intruding movement may therefore cause the formation of new bone spicules in the marginal region. These new bone layers

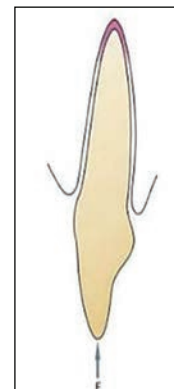


Figure 1: Intrusion of the tooth involves resorption of the bone, particularly around the apex of the tooth

occasionally become slightly curved as a result of the tension exerted by stretched fiber bundles. Such tension also occurs in

the middle third of the roots. Rearrangement of the principal fibers occurs after a retention period of a few months.^[10]

Intrusion requires careful control of force magnitude. Light force is required because the force is concentrated in a small area at the tooth apex. A light contentious force, such as that obtained in the light wire technique, has proved favorable for intrusion in young patients. In other cases, the alveolar bone may be closer to the apex, increasing the risk for apical root resorption. If the bone of the apical region is fairly compact as it is in some adults, a light interrupted force may be preferable to provide time for cell proliferation to start, and direct bone resorption may prevail when the arch is reactivated after the rest period. Intrusion may also cause changes in the pulp tissue such vascularization of the odontoblast and pulpal edema.^[11]

Biomechanical Methods of Orthodontic Intrusion

In the literature, intrusive force values vary among authors from 15 to 200 g.^[12] This variation may be explained by the difficulty in measuring the force applied by complex biomechanical systems using continuous straight archwires,^[12,13] as well as by differences among various techniques.

Begg technique ^[6]	Bioprogressive technique ^[8]
Accomplished more rapidly due to the cervically located bracket-wire point contact in combination with the use of special pins for wire ligation in the Begg bracket, leading to lower friction when compared to the edgewise technique	Using the segmented rectangular utility arch, made of cobalt-chromium alloy, which is not as hard as stainless steel, incorporates intrusion with low forces in the initial treatment stages, taking advantage of the force systems developed by the activated wire
With the Begg technique, there is less relaxation of the stress applied by the ligating means, that is, the pin, on the bracket compared with the elastomeric modules that present 50% force reduction during the first 24 hours	Correction includes incisor intrusion in combination with tipping or extrusion of the molars; therefore, the force system is not predictable
Intrusion in the Begg technique is relative, because deep bite correction is accomplished through eruption of posterior teeth. Thus, the applied stress is maintained for a longer time period	

However, continuous light forces of 15-30 g per tooth seem to be ideal. In general, heavier forces should be avoided given the fact that in this type of movement, the force is distributed over a small area around the apex.^[14] Related studies have determined that forces exceeding 50 g lead to apical displacement of about 40 μ m resulting in vessel torsion or distortion.^[15] Other studies have shown that force increase from 0.5 to 2 N results in reversible 20% reduction of blood circulation in the pulp.^[16]

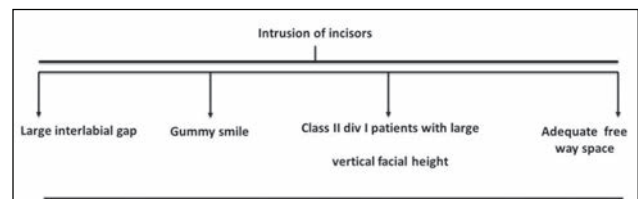
Higher loading at the apical area is related to intrusion, extrusion and rotation forces, whereas tooth translation and movement with tipping, apply the load along the whole length of the root or toward the cervical area.^[17]

An important factor for successful incisor intrusion is the anatomical position of tooth roots in relation to the cortical plate. Maintaining roots in a proper position within spongy bone and avoiding their displacement in cortical bone are considered to increase treatment effectiveness and limit the risk for root resorption.^[18] However, it is generally accepted that certain techniques, such as the bioprogressive one, use root positioning of posterior teeth within cortical bone to increase anchorage and limit mesial molar movement. This hypothesis is not supported by research data.

Intrusion Arch

Two major orthodontic intrusion techniques for the anterior dentition have been developed: The segmented arch and the bioprogressive techniques.^[2,8,19-21] Both use intrusion arches with anchorage on posterior teeth, but have fundamental biomechanical differences in their construction/use and consequently in their mode of action.^[22]

Indications and Contraindications



Intrusion of Anterior Teeth in Gummy Smile

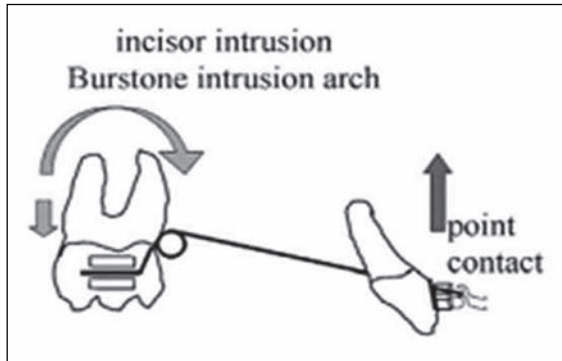
One of the major challenges of orthodontic treatment is the correction of deep overbite. In most instances, this correction is produced by the extrusion of posterior teeth, or a combination of anterior intrusion along with posterior extrusion, which is undesirable in vertical growers.^[2] In such cases, absolute intrusion or true intrusion of the anteriors is desired, especially when there is excessive incisal display with extruded incisors.

More specifically, in cases where bite opening with orthodontic eruption of posterior teeth using biteplates or cervical headgear is contraindicated or unsuccessful, deep bite correction may only be achieved with intrusion of the anterior teeth. In order to improve esthetics, Class II, division 1 malocclusion patients with increased overjet and lower facial height, showing at the same time a gummy smile and incisor exposure at lip rest [Figure 2], considered

Burstone intrusion arch^[19,20]

The arch is not inserted into the anterior brackets

A large tip back moment is felt at molar, with a small extrusive force
The single anterior point contact allows for precise calculation of the force delivery and it can be applied at the desired level relative to the position of the center of resistance of the anterior segment

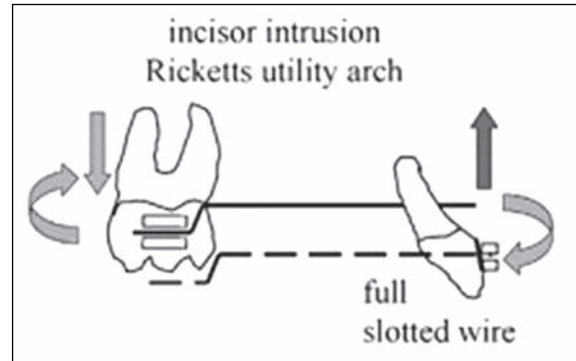


Side-effects: Molar tip back

Ricketts utility arch^[8,21]

The rectangular arch is inserted into the posterior tubes and the anterior brackets

A large tip back moment is felt at molar, but also a large extrusive force
A large buccal root torque moment is felt at the incisors, and depends on the wire/bracket relationship (careful for root resorption)



Side-effects: Molar extrusion and tip back, anterior palatal crown torque



Figure 2: Gummy smile at lip rest

as perfect candidates for such intrusion.^[23] Since, it has been suggested that attractive smiles have zero gingival exposure, whereas gingival exposure of more than 2 mm results in significant esthetic,^[24] deep bite correction with orthodontic eruption of posterior teeth does not contribute towards esthetic improvement.

Deep Bite and Reduced Lower Facial Height

The outcome of orthodontic eruption is not stable, especially in adult patients with a small mandibular plane angle and strong masticatory system as shown clinically by the presence of strong masseter muscles and a rectangular face, due to the increased vertical component of the biting force that affects the stability of posterior eruption.^[5] On the other hand, in patients with severe deep bite and minimal exposure of incisors at smiling, correction should include careful intrusion of lower incisors in order to avoid further concealment of upper anterior teeth at smiling. Alternatively, and depending on the degree of deep bite,

posterior orthodontic eruption with the use of an anterior biteplate is recommended and hence that part of the correction is achieved without intrusion.

Deep Bite and Increased Lower Facial Height

In the rare cases, where the dental deep bite is combined with a skeletal background of increased vertical growth and clinical "open bite tendency", posterior orthodontic eruption should be avoided due to an increase of the mandibular plane angle.^[25]

Incisor intrusion is also necessary in cases of extrusion of maxillary but, especially, mandibular incisors often observed in Class II, division 2 malocclusion. In these cases, esthetic improvement is important mainly due to restoration of the gingival line. During intrusion of lower incisors with lingual tipping, using a utility arch without tie back, the incisor crown follows an arch and moves labially, while being vertically displaced. This horizontal crown displacement contributes towards correcting part of the over jet.^[6] Similar movement with the same biomechanical principles takes place in the Begg technique, where once again the tie back is not recommended so as to avoid side-effects, such as root resorption.^[6]

Intrusion of Periodontally Involved Teeth

The most common pathologic cause of extrusion is periodontal disease, which in advanced stages results in clinical crown lengthening and spacing of the teeth, thus, further compromising the esthetics of smiling.^[26]

In general, orthodontic treatment in periodontal patients is a contradictory issue. Many authors dispute the benefits of

such an approach and claim that it has negative effects on the periodontium,^[27] whereas others support the view that orthodontic treatment inhibits the progression of osseous loss.^[28] More recent studies conclude that a combination of periodontal treatment and orthodontic intrusion may improve periodontal status, given that the mechanics used and oral hygiene are carefully controlled.^[29,30] More specifically, use of light orthodontic forces is recommended because, as bone loss progresses, periodontal support is reduced and the same force now induces greater stress on the periodontal ligament when compared to a tooth with normal tissue support.^[31] Further documentation is necessary before these results and the hypothesis of re-attachment are applied in the clinical situation.

Intrusion of periodontally involved teeth still controversial, however, some authors pointed out that if the inflammation would be well monitored, the loss of the marginal bone level would not result.^[32-37]

Intrusion of Posterior Teeth

Overeruption of maxillary molars because of the loss of opposite teeth creates occlusal interferences and functional disturbances [Figure 3]. To restore proper occlusion, intrusion of the overerupted molars becomes essential before multidisciplinary reconstructive dental approaches can be initiated.^[35]

In general, the extent of intrusion depends on anchorage and may include absolute or relative intrusion, depending on the severity of the occlusal and esthetic problem.

Posterior intrusion is one of the most difficult tooth movements in orthodontics, because of the multiple molar roots. Intrusion requires more alveolar bone reaction as well as a longer treatment time.^[38] Therefore, using conventional orthodontic treatment for this movement is a big challenge. Three-dimensional movement control

is essential in this therapy. Vertical position, the arch form, the tooth axes, the inclination of the occlusal plane and the posterior torque should be the treatment objectives.^[39] The use of orthodontic mini-implants simplified the treatment plan and allowed maximum conservation of tooth structures.

The Fixed and Removable Appliances Used for Intrusion Accomplishment

In general, intrusion may be divided into two wide categories on the basis of the group of teeth on which it is applied:

- a. Incisor intrusion and
- b. Intrusion of posterior teeth.

The scope of orthodontics is expanding. Temporary anchorage devices have allowed the orthodontist to overcome anchorage limitations and perform difficult tooth movements predictably and with minimal patient compliance.^[40]

Acrylic intrusion splint with occlusal and incisal coverage in combination with very high, almost vertical pull headgear [Figure 4] has been also proposed for the intrusion of anterior teeth.^[23] This method corrects the position of anterior teeth sagittally and vertically and is indicated in Class II, division 1 cases where both incisor intrusion and reduction of increased overjet are required.

The use of magnets, as an alternative to conventional methods, has become popular after the introduction of new small, powerful and permanent rare earth magnets. Studies have shown that, when magnets are placed in the oral environment, saliva acts as an electrolyte creating small currents that stimulate tissues.^[41] It has also been



Figure 3: Intrusion of posterior teeth



Figure 4: Intrusion splint combined with high pull headgear

Table 1: Orthodontic intrusion means

Therapeutic biomechanical means or systems	Site of application
Straight wire with second order bends	Isolated teeth and incisors
Intrusion arch and segmented arches at posterior teeth (Burstone) ^[2]	Incisors
Arch with reverse curve of Spee	Incisors
Utility arch	Incisors
Auxiliary arch connected to main arch	Incisors
Repelling magnets	Posterior teeth
Transpalatal arch anchorage system connected to the extruded tooth through an elastic chain	Posterior teeth
Implant anchorage system with traction elements for extruded teeth	Posterior teeth
Posterior bite plate	Molars
Intrusion splint combined with high pull headgear	Maxillary incisors

supported that the electromagnetic field created in the mouth with magnet movement increases vascularity and stimulates bone metabolism.^[42] Orthodontic applications include samarium-cobalt (SmCo_5 , $\text{Sm}_2\text{Co}_{17}$) and neodymium-iron-boron ($\text{Nd}_2\text{Fe}_{14}\text{B}$) magnets.^[43] The latter deliver higher forces, but are more susceptible to demagnetization and corrosion.^[44] Table 1 concisely presents the basic means used for orthodontic dental intrusion.

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