INTRUSION IN ORTHODONTICS

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Abstract: Orthodontic intrusion is a common treatment approach in managing orthodontic esthetics and functional problems, including gummy smile and deep bite.Deep bite can be corrected in a number of ways, depending on the individual needs of the patient and the nature of the problem. There are two major mechanisms in biomechanics of intrusion: continuous and segmental. Various methods of incisor intrusion include utility arches, Connecticut intrusion arch, burstone intrusion arch, K sir Arch and tip back spring. Various methods of molar intrusion includes TADs, Headgears, biteplane, magnets, maxillary intrusion splint, Invisalign and active vertical corrector. In this review, the various intrusion methods and its mechanics are discussed in detail.

INTRODUCTION:

Orthodontic intrusion is a common treatment approach in managing orthodontic esthetics and functional problems, including gummy smile and deep bite. It refers to the apical movement of the geometric center of the root (centroid) in respect to the occlusal plane or a plane based on the long axis of the tooth[1]. Labial tipping of an incisor around its centroid produces pseudo-intrusion. Although this pseudo-intrusion would help correct a deep overbite in a Class II, division 2 patient, it should not be confused with the genuine intrusion. Incisal edges should therefore not be used to

evaluate intrusion, since they are easily affected by tipping movements of the incisors[2]. Ideally, a point should be selected in the center of the root (centroid) and comparison should be based upon the movement of this point[2].

DEFINITION

Intrusion, as defined by Marcotte[3], 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".

Burstone[1] defined intrusion as “Apical movement of the geometric center of the root (centroid) with respect to the occlusal plane or a plane based on the long axis of the tooth”.

TYPES OF INTRUSION

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

BIOMECHANICS OF INTRUSION

Deep bite can be corrected in a number of ways, depending on the individual needs of the patient and the nature of the problem. Precise diagnosis and careful treatment planning are extremely important for a proper outcome[4]. There are two major mechanisms in biomechanics of intrusion: continuous and segmental.

Continuous Arch mechanism:

A continuous intrusion arch is bent from a 0.018 × 0.025—inch stainless steel (SS) wire with a 2.5 mm helix or a plain 0.017 × 0.025—inch titanium-molybdenum alloy (TMA) wire. Continuous intrusion arch mechanics are similar to those of 2 × 4s. A sweep (V) bend is placed in the wire at the level of the first premolars (or first primary molars). If incisor protrusion is indicated, the arch is ligated on the central incisor brackets or at the midline. For incisor protrusion, the arch should slide easily through the molar tubes. With these mechanics, the deep bite will be corrected with both incisor protrusion and intrusion. This is especially useful in correcting Class II, division 2 deep bite cases with mandibular retrusion in growing patients. As the maxillary incisors protrude, the mandible will have more room to grow forward to reduce the overjet and reach a Class I relationship[3].

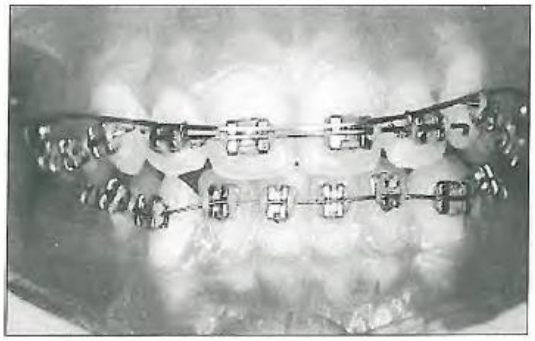

Fig.1- Frontal view of a continuous intrusion arch ligated to the anterior teeth between the central and lateral incisors.

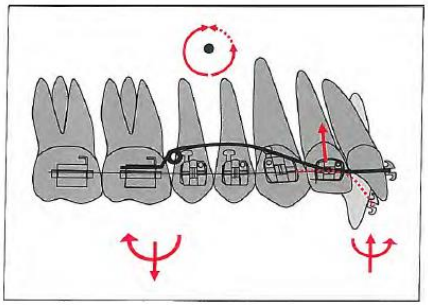

Fig.7- A continuous intrusion arch can be used in combination with a straight leveling wire. This arch can be ligated to the lateral incisor brackets so that the line of action of the force passes close to the center of resistance of the incisors. The central incisors intrude and protrude with the straight wire as the lateral incisors keep their positions with the effect of the intrusion arch

Segmental arch mechanics:

In the 1950's Burstone developed an approach to orthodontic therapy which did not use continuous arches. The technique, known as the segmented arch, used different cross sections of wire within the same arch and wires that did not run continuously from one bracket to the adjacent bracket. Segmented arch procedures have a number of advantages in space closure in extraction cases and in producing tooth alignment with minimum side effects. Segmentation allows for the genuine intrusive movement of the anterior teeth. One of the limitations of traditional continuous arch therapy has been its inability to produce genuine intrusion.

The basic mechanism for intrusion consists of three parts:

(1) A posterior anchorage unit.

(2) An anterior segment.

(3) An intrusive arch spring[1].

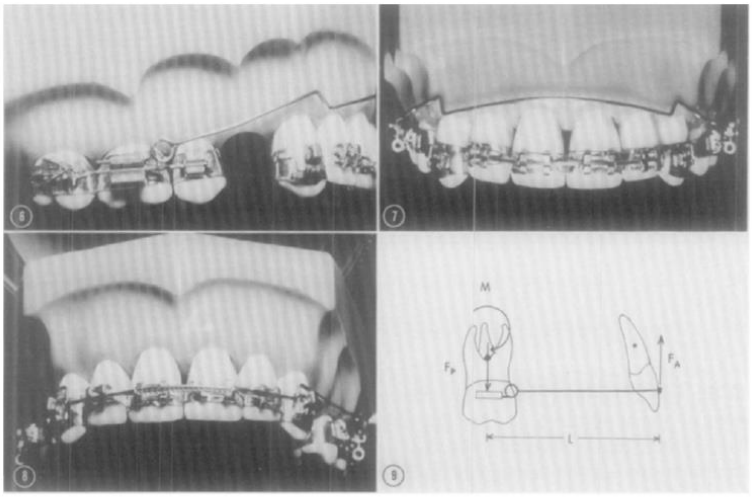

Fig 2. Basic mechanism for intrusion; posterior anchorage unit, anterior segment in the four incisors, and an intrusive arch. The intrusion arch is placed in the auxiliary tube on the first molar attachment.

OPTIMAL FORCE FOR INTRUSION

An optimal force is one that produces a rapid rate of tooth movements, without discomfort to the patient or any tissue damage.

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[1].

In the literature, intrusive force values vary among authors from 15 to 200 grams[5,6]. This variation may be explained by the difficulty in measuring the force applied by complex biomechanical systems using continuous straight archwires, as well as by differences among various techniques. continuous light forces of 15-30 grams per tooth seem to be ideal.

INDICATION OF INTRUSION IN ORTHODONTICS

- 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.

ORTHODONTIC INTRUSION DISADVANTAGES

- Incisal flaring
- Lingual crown tip on molars
- Root resorption

DESIGN OF INTRUSION ARCHES:

The various intrusion arches are:

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

Sl.No	**Intrusion Arches**	**Year**	**Given by**	**Wire**	**Site of application**
1.	Utility arches	**1950s**	Robert M Ricketts	0.016x 0.016 Blue elgiloy wire	Incisors
2.	Connecticut intrusion Arch	**1998**	Ravindra Nanda	0.016X0.022NiTi,0.017X 0.025 NiTi alloy Ni free βIII CAN	Incisors
3.	Burstone Intrusion Arch	**1950s**	Burstone	0.017x0.025 inch TMA wire	Incisors
4.	Tip Back Springs (Intrusion Springs)		Burstone	0.017x0.025 inch TMA wire	Molars
5.	Three Piece intrusion Arch	**1995**	Shroff, lindauer, Burstone, Leiss	Anterior segment 0.019x0.025 SS Posterior segment 0.017x 0.025 TMA	Intrusion and retraction of flared

				Tip back spring	anterior teeth
6.	K- Sir		kalra	0.019x0.025 TMA Wire	Intrusion and retraction of flared anterior teeth

UTILITY ARCH

Utility arch was designed by Robert M. Ricketts in the early 1950's and has been popularized as an integral part of bioprogressive therapy. It originally was developed to provide a method of leveling the curve of Spee in the mandible, but it has been adapted to perform many more functions than just lower incisor intrusion.Regardless of the presence or absence of loops, all utility arches have a common design[5],

which consist of

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

The four types of utility arches are:

1. Passive Utility Arch
2. Intrusion Utility Arch
3. Retraction Utility Arch
4. Protraction utility Arch[5]

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. Generally rectangular wire is preferable to round wire to control torque and prevent unwanted tipping of incisor[7].

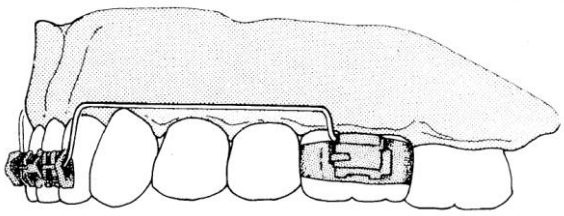

Fig.3. Utility arch

CONNECTICUT INTRUSION ARCH

The CTA is fabricated from a nickel titanium alloy to provide the advantages of shape memory, springback, and light, continuous force distribution. It incorporates the characteristics of the utility arch as well as those of the conventional intrusion arch. The CTA is preformed with the appropriate bends necessary for easy insertion and use.

Fig 4. Connecticut intrusion arch

Two wire sizes are available: .016" X .022" and .017" X .025". The maxillary and mandibular versions have anterior dimensions of 34mm and 28mm, respectively. Although in most cases the wire is not directly ligated into the bracket slots, the anterior wire dimension is adequate to allow for it. The bypass, located distal to the lateral incisors, is available in two different lengths to accommodate for extraction, nonextraction, and mixed dentition cases[8].

Mechanics

The CTA's basic mechanism for 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[9]. When the arch is activated, a simple force system results, consisting of a vertical force in the anterior region and a moment in the posterior region (Fig. 5).

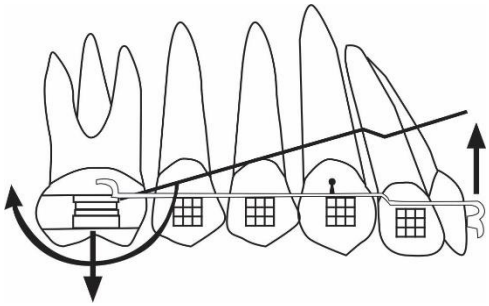

Fig. 5. Intrusion force system consists of anterior intrusive force, posterior extrusive force, and posterior tipback moment.

BURSTONE INTRUSION ARCH

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.[4]

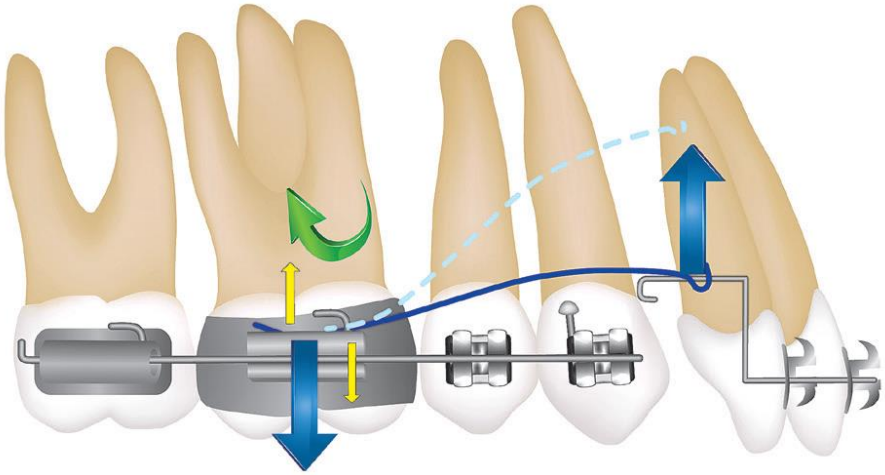

Fig.6. Mechanics of three piece intrusion arch.

KALRA SIMULTANEOUS INTRUSION RETRACTION

(Simultaneous Intrusion and Retraction of the Anterior Teeth)

Retraction of the six anterior teeth under the edgewise system is usually carried out in two distinct steps: canine retraction followed by incisor retraction. In the Begg and Tip-Edge techniques, on the other hand, the canines and incisors are retracted en masse.

Separate canine retraction has the disadvantages of increased treatment time and the creation of an unesthetic space distal to the incisors. The rationale for separate retraction in the edgewise technique is that molar anchorage is conserved. However, Burstone[1] and Nanda[2] have demonstrated molar anchorage control, using non-frictional loop mechanics for en masse retraction of the anterior teeth,that compares favorably with that of conventional edgewise sliding mechanics[10].

An appliance for simultaneous intrusion and retraction of the six anterior teeth should ideally control:

- Magnitude of forces and moments
- Moment-to-force ratio
- Constancy of forces and moments
- Friction

Appliance Design

The K-SIR (Kalra Simultaneous Intrusion and Retraction) archwire is a modification of the segmented loop mechanics of Burstone and Nanda. It is a continuous .019" X .025" TMA archwire with closed 7mm X 2mm U-loops at the extraction sites[10].

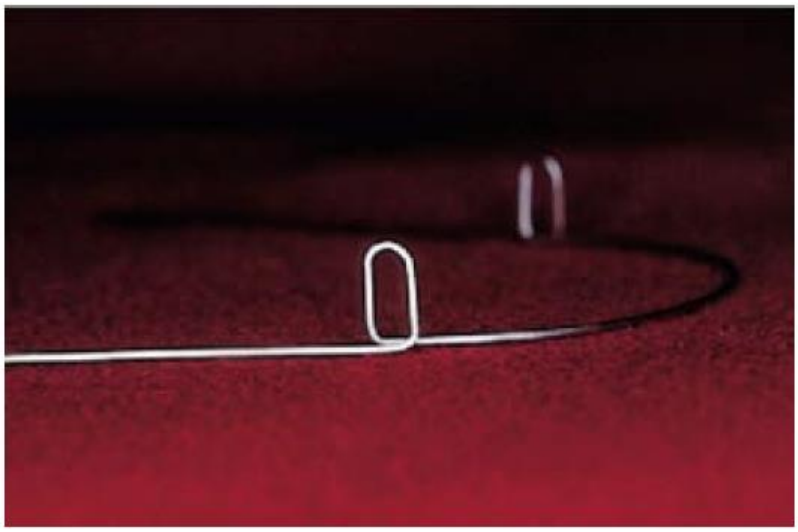

Fig.7. K-SIR archwire: .019" × .025" TMA archwire with closed U-loops 7mm long and 2mm wide

To obtain bodily movement and prevent tipping of the teeth into the extraction spaces, a 90° V-bend is placed in the archwire at the level of each U-loop. This V-bend, when centered between the first molar and canine during space closure, creates two equal and opposite moments to counter the moments caused by the activation forces of the closing loops.[1]

Activation

A trial activation of the archwire is performed outside the mouth. This trial activation releases the stress built up from bending the wire and thus reduces the severity of the V-bends. However, the shape of the archwire should be maintained in subsequent activations of the loops[10].

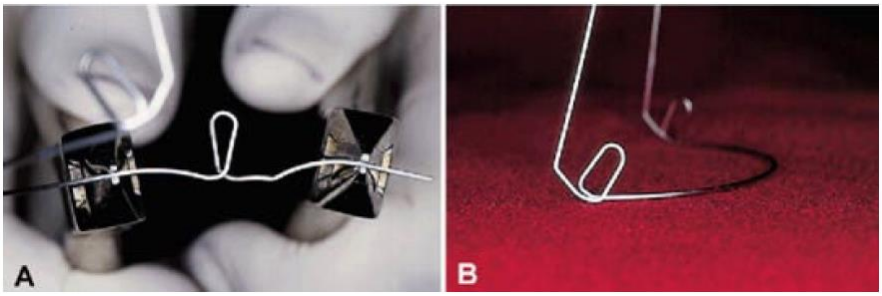

Fig.8. Trial activation performed on each loop. B. Archwire after trial activation. Note reduction in severity of bends

TIP BACK SPRINGS (INTRUSION SPRINGS)

Burstone proposed these springs which are made of 0.017" x 0.025" T.M.A wire, upper and lower arches have to be levelled 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[9].

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.[2]

TECHNIQUES OF MOLAR INTRUSION

Molar Intrusion Techniques- Non-Surgical Approach

Compliance appliances	**Non-Compliance Appliances**
High pull Headgear	Temporary Anchorage Device
High pull Headgear to a splint	Rapid Molar Intrusion Device
Vertical Pull chin cup	Vertical Holding Appliance
Posterior bite Block	
Magnetic Bite-Block	
Spring-loaded bite-Block	

Molar Intrusion Techniques- Surgical Approach

Corticotomy –Enhanced Molar Intrusion
Osteotomy - Assisted Molar Intrusion

High Pull Headgear

It has been published that high pull headgear has been used primarily for the purpose of producing an orthopedic force to the maxilla for correction of class II as well as open bite malocclusions.It has been suggested to apply a force of 500 g to the upper first molar for a 6-month period. Moreover, it has been claimed to produce dental changes of intrusion (0.96 ± 0.54 mm) in addition to the distal movement (2.6 ± 0.6 mm)[10]. More intrusion has been shown with higher force levels and headgear treatment over a longer time period[7].To create these effects, the force has to be directed carefully through the center of resistance of the upper first molar which is located at the

level of buccal trifurcation area. The direction of the force above or below the center of resistance causes undesirable extrusion by tipping the crown mesially or distally, depending on the direction of the force which could result in downward rotation of the mandible. The use of a transpalatal arch (TPA) is necessary to maintain the arch width and to prevent molar rotation[11].

High pull Headgear to a Splint

This type of headgear is used for intrusion a group of teeth. It works with similar principles of high pull headgear; however, the force is applied to a splint covering the intended teeth. A slight intrusion of maxillary dentition has been reported in a study using headgear that attached to a full-coverage maxillary occlusal splint in patients with the maxillary dentoalveolar protrusion.However, there have been limited papers published specifically regarding this area.

Vertical Pull Chincap

The vertical chincap or high pull chincap has been used as a functional orthopedic appliance for the treatment of skeletal open bite. A force of 400 g is applied per side, and the force vector passes through the anterior and inferior region of the mandibular corpus approximately 3 cm from the outer canthus of the eye.A study using vertical chincap for 6-12 months in a growing group of subjects with open bites had observed some intrusion of mandibular molars compared to the control group.

Posterior Bite-block

The use of passive acrylic posterior bite-blocks has also been used for the molar intrusion. These functional appliances hinge the mandible open by approximately 3-4 mm beyond its resting position, thereby maintaining pressure on the neuromuscular system supporting the mandible.It has been found to be effective in controlling vertical dimension which is of benefit for patients with skeletal open bite.When intrusion of the posterior teeth is needed in adults with excess vertical face height, bite-blocks have been unsuccessful in accomplishing molar intrusion[12].

Magnetic Bite-block

This appliance was first introduced by Dellinger, in 1986, under the name active vertical corrector. The components of this appliance consist of two posterior occlusal splints, one for the upper, and one for the lower jaw. Samarium cobalt magnets are incorporated into the acrylic splints, over the occlusal region of the teeth that planned to be intruded. These magnetic modules are expected to generate forces between 600 and 650 g per module.It has been reported as an effective therapeutic tool in reducing the open bite in growing patients by the intrusion of molar teeth.Moreover, the

magnetic repelling bite-block has been reported to significantly intrude the molars in adult patients.Although magnetic posterior bite-blocks also have shown to produce a quick response in the dental and skeletal vertical relation, in can also help change posterior cross bite relations compared to a passive bite block. Maintaining arch width is sometimes difficult with magnetic bite-blocks. Therefore, TPA is necessary[13].

Spring-loaded Bite-block

The design of spring-loaded bite-blocks was first described, in 1986, by Woodside and Linder-Aronson. Upper and lower bite block are connected with two helical springs that are activated progressively to maintain the forces between 250 and 300 g.Few authors have reported that it has an orthopedic influence in treating open bite by intruding molars in growing patients. However, to this date, there is limited data regarding intrusion in adults[12].

TEMPORARY ANCHORAGE DEVICE

TAD is a device that is temporarily fixed to the bone for enhancing orthodontic anchorage either by supporting the teeth of the reactive unit (indirect anchorage) or by obviating the need for the reactive unit altogether (direct anchorage), which is subsequently removed afteruse[13].

MAGNETS

Intrusion of posterior teeth can be done using magnets. The use of occlusal bite blocks containing repelling magnets has been proposed as the treatment procedure for patients who have anterior open bites. The repelling force of the opposing magnets is reported to cause intrusion of the posterior teeth, allowing the mandible to rotate upward and forward in much the same way that it would if the maxilla were surgically impacted.

The MAD IV Appliance:

The Magnetic Activator Device IV (MAD IV) uses anterior attracting magnets as well as posterior repelling magnets. The anterior magnets guide the mandible in to a centered-midline position, add an anterior closing effect, and enhance the anterior rotation of the mandible.

The MAD IV consists of removable upper and lower plates, each of which contains three cylindrical neodymiuim magnets coated with stainless steel.[14]

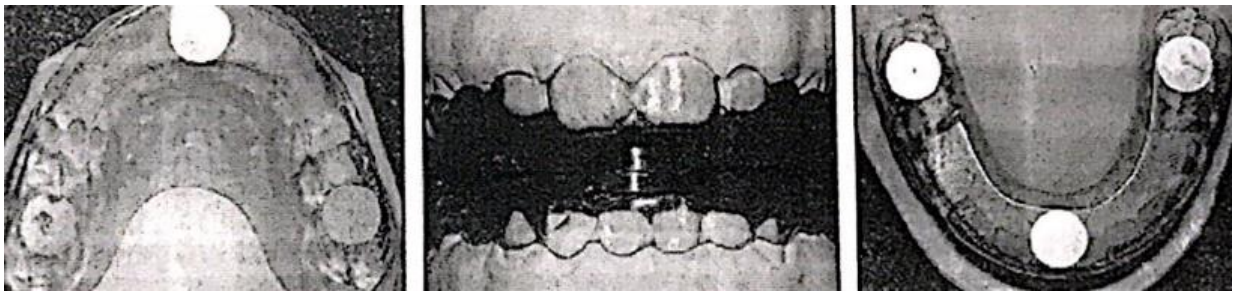

Figure 9. MAD IV appliance

MAXILLARY INTRUSION SPLINT

Maxillary intrusion splint (M.I.S) system with vertical pull headgear is used in the management of severe 'gummy' Class II division 1 malocclusion. The appliance was designed to reduce the visibility and vulnerability of the maxillary incisors in this difficult clinical situation by achieving the intrusion of maxillary teeth, restraining maxillary growth, and encouraging an element of subsequent forward mandibular rotation. The principle effects of the M.I.S were on the maxillary teeth giving decisive overjet control and incisor retraction with actual maxillary incisor intrusion. There was a similar effect on the maxillary molar and the M.LS. provided effective en masse vertical control of the maxillary dentition. There was some degree of maxillary restraint in the M.I.S. group, but no noticeable difference in the change of mandibular position between the groups at the end of treatment[15].

INVISALIGN

The Invisalign appliance designed by 'Align Technology, SantaClara, Calif',is a series of computer designed clear plastic which fit closely over the labial, lingual (palatal), and occlusal surface of the teeth . Incrementally moving to their respective correct position. Patients need to wear each aligner for at least 20 hours daily with a routine two-week change. Each aligner is designed to move a tooth or small group of teeth about 0.25-0.3mm [45,46]. Orthodontic treatment with the Invisalign appliance is more esthetically appealing to some patients when compared with conventional fixed appliances, because of that the demand for this treatment method is increasing. The Invisalign technique has long been used to treat mild to moderate orthodontic cases. Recently, it has been used successfully in more complex cases. Clear Aligner Technology (Invisalign) .[16]

Align Technology recently developed new treatment options including special designing of attachments and virtual bite ramps. Attachments are composite buttons attached to the buccal surfaces of the teeth, and they come in different shapes to assist the tooth movement. Specifically, these attachments increase retention, transmit desirable force to the teeth and support auxiliary

functions such as placement of elastics . Feasible bite ramps function similar to bite plates or bite turbos. These bite ramps incorporated into the maxillary aligner, contact with the mandibular incisors to dis-contact the posterior teeth. For anterior intrusion cases, the G5 pressure areas are placed on any incisor requiring intrusion incisors automatically.[16]

ACTIVE VERTICAL CORRECTOR

Active Vertical Corrector (AVC), is a simple removable or fixed orthodontic appliance that intrudes the posterior teeth in both the maxilla and mandible by reciprocal forces. By the use of effective posterior intrusion of teeth, the mandible is allowed to rotate in upward and forward directions. The uniqueness of this appliance is that it allows the clinician to correct anterior open bite problems by actually reducing anterior facial height. This treatment approaches the problem at its cause (overeruption of posterior teeth) and provides better facial balance and esthetics than most conventional orthodontic treatment procedures. Problems formerly thought to require orthognathic surgery can now be treated successfully with the AVC.[17]

CONCLUSION

The correction of deep overbite requires careful differential diagnosis and the determination of which teeth must be intruded or extruded for proper correction. Therefore, the mechanics for treatment can differ radically from one patient to another. The key to successful correction is not only the proper treatment plan, but precise mechanics to achieve the predetermined treatment plan goals.Not all patients with deep overbite should be treated with the same mechanics.

Some patients require intrusion of the anterior teeth, while others require primarily extrusion. Six principles must be considered in incisor or canine intrusion:

(1) the use of optimal magnitude of force and the delivery of this force constantly with low load deflection springs;

(2) the use of a single point contact in the anterior region;

(3) the careful selection of the point of force application with respect to the center of resistance of the teeth to be intruded;

(4) selective intrusion based on anterior tooth geometry;

(5) control over the reactive units by formation of a posterior anchorage unit; and

(6) inhibition of eruption of the posterior teeth and avoidance of undesirable eruptive mechanics.

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