Review Article

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Newer Temporary Skeletal Anchorage Devices In Orthodontics: An Overview

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ABSTRACT

Background: A fundamental requirement of successful treatment of various malocclusions in the field of orthodontics is the presence of secure anchorage. Anchorage has been defined as the source of resistance to the forces generated in reaction to active components of an appliance. In simple words, it means resistance to displacement. All of those anchorage arrangements like headgears, elastics, transpalatal arches, lingual arches, and nance palatal arch produce acceptable to good anchorage but not provide completely secure anchorage in all three dimensions. Anchorage loss is a reciprocal reaction that could obstruct the success of orthodontic treatment by complicating the anteroposterior correction of malocclusion possibly detracting from facial esthetics. So, interest in appliances that use implant-based anchorage has been great, but they had some disadvantages such as space limitations and cause impingement on roots during placement. Therefore, Skeletal anchorage system that utilizes miniplates and miniscrews have been introduced into orthodontics for obtaining more secure anchorage.

Keywords: Anchorage, Bollard, Miniplate, C tube.

INTRODUCTION

Anchorage is a challenging aspect of orthodontic treatment.[1] Anchorage, resistance to unwanted tooth movement, is a prerequisite for the orthodontic treatment of dental and skeletal malocclusion.[2] Anchorage can be related to Newton's third law: "To every action there is equal and opposite reaction". This means that the forces act not only on the teeth to be moved, but also elsewhere to the same extent, often reciprocally, upon other teeth which are referred to as the anchor units. Anchorage is primarily considered in anteroposterior plane but, also need to be planned in vertical and transverse spatial planes. [3]

Conventional anchorage methods like headgears, elastics, transpalatal arches, lingual arches, and nance palatal arches rely on patient compliance and result in unwanted reciprocal tooth movements. So treatments based on absolute anchorage have gained much importance and can be used to avoid

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such unwanted tooth movements. Absolute anchorage or infinite anchorage is defined as no movement of the anchorage unit (zero anchorage loss) as a consequences of reaction forces applied to move teeth. Such an anchorage can only be obtained by two means, using ankylosed teeth or using implants, both relying on bone for their anchorage.[2]

To widen orthodontic treatment possibilities or reduce the need for compliance dependent devices, implants were incorporated into orthodontic treatment. These devices are relatively expensive, require a healing period before orthodontic loading, and cause impingement on roots during placement. To overcome these limitations, recently, Skeletal Anchorage System(SAS) was introduced. This system comprises of miniplates and miniscrews which are smaller and cheaper and require shorter healing periods, and also have other added, advantages like they do not interfere with tooth movements and do not cause root impingement during placement. Thus, miniplates provide more secure anchorage in all three planes when huge forces, such as orthopedic forces are needed.[4]

The goals of orthodontic therapy include structural balance, functional efficiency and esthetic harmony. Traditional orthodontic mechanics are efficient at accomplishing these goals for clinical scenarios that require mild to moderate compensation. Those patients who have more significant discrepancies, however, require additional techniques such as miniscrews and miniplates which works on the principle of skeletal anchorage system(SAS).[5]

Patients with discrepancies beyond what can be managed with standard orthodontic therapy are usually treated with techniques that include growth modification or orthognathic surgery in combination with comprehensive orthodontic therapy. Presently, patients with mild to moderate discrepancies may benefit from skeletal anchorage devices to compensate further for malocclusions that were not previously correctable using conventional orthodontic mechanics.[5] The skeletal anchorage system provides Type A anchorage which is usually difficult to obtain with traditional devices.[6]

There is no doubt that skeletal anchorage system can revolutionize the treatment mechanics in orthodontics. They will not create any counteracting moments to cancel these in the anchor unit, which, the anchorage teeth (reactive units) would create with conventional biomechanics. The aim of this comprehensive review is to discuss the development, clinical applications, advantages and comparison of two types of miniplates, namely Bollard and C tube which are used to obtain temporary, but absolute skeletal anchorage for orthodontic applications.

DEFINITIONS OF ANCHORAGE PUT FORTH BY VARIOUS AUTHORS

Louis Ottofy[7] defined it as the base against which orthodontic force or reaction of orthodontic force is applied.

Moyers[8] defined anchorage as resistance to displacement.

T.M. Graber[9] defined anchorage as the nature and degree of resistance to displacement offered by an anatomic unit when used for the purpose of effecting tooth movement.

Proffit[10] defined anchorage as resistance to unwanted tooth movement. Resistance to reaction forces that is provided (usually) by other teeth, or (something) by the palate, head or neck (via extra oral forces), or implants in bone.

Nanda[11] defined anchorage as the amount of movement of posterior teeth (molars, premolars) to close the extraction space in order to achieve selected treatment goals.

Pullen[12] defined anchorage as selected of adequate and properly distributed resistance units for control and direction of force applied to the teeth for dental arch development or for lesser tooth moment.

Stoner[13] defines anchorage as source which can resist the reaction of orthodontics forces.

Lewis[14] defined anchorage simply as "the resistance to unwanted tooth movement".

Gardiner et al.[15] defined it as "the site of delivery from which the forces are exerted".

Webster's[16] dictionary defines anchorage as "a secure hold for a heavy pull".

CLASSIFICATION OF ANCHORAGE

I.E.H.ANGLE CLASSIFICATION

Historically, the concept of anchorage was introduced by Angle. [17]

- Simple anchorage
- Stationary anchorage
- Reciprocal anchorage
- Intermaxillary anchorage
- Occipital anchorage

II.MOYERS CLASSIFICATION[8]

II a. ACCORDING TO THE MANNER OF FORCE APPLICATION

- **SIMPLE ANCHORAGE**

In this type, the manner and application of force is such that it tends to change the axial inclination of the anchor tooth in the plane of space in which the force is being applied. In other words, the resistance of the anchorage unit to tipping is utilized to move another tooth or teeth.

- **STATIONARY ANCHORAGE**

It is defined as dental anchorage in which the manner of application of force tends to displace the anchorage unit bodily in the plane of space in which this force is being applied. In this type of anchorage, the resistance of anchor teeth to bodily movement is utilized to move other teeth. Stationary anchorage provides greater resistance than simple anchorage to unwanted tooth movement.

- **RECIPROCAL ANCHORAGE**

The reciprocal anchorage refers to the resistance offered by two malposed units, when the dissipation of equal and opposite forces tends to move each unit towards a more normal occlusion.

II b. ACCORDING TO THE JAWS INVOLVED

- **INTRAMAXILLARY**

Intra-maxillary anchorage is the anchorage in which the resistance units are situated within the same jaw. Class I elastic stretched from first molar to canine teeth in either of the dental arches is an example.

- **INTERMAXILLARY BAKER'S ANCHORAGE (1904)**

Inter-maxillary anchorage is the anchorage in which the units situated in one jaw are used to affect tooth movement in the other jaw. Class II elastics stretched from upper canine to lower molar to affect correction of class II malocclusion and class III elastics stretched from upper molar to lower canine to correct class III malocclusion are good examples.

II c. ACCORDING TO THE SITE OF ANCHORAGE

- **INTRA ORAL:** when intra-oral structures such as teeth and other anatomic areas used as units it is called intra-oral anchorage. Mini screws can be considered as an absolute intra-oral anchorage.

- **EXTRA ORAL:** Extra-oral anchorage is the anchorage established from extra-oral structures. It includes

1) Cervical region: Use of cervical pull headgear.

2) Occipital region: Use of occipital pull headgear.

3) Forehead and Chin: Use of reverse pull headgear.

- **MUSCULAR**: Peri-oral musculature may be used as anchorage units in certain cases. For examples, the lip bumper utilizes the forces exerted by lower lip musculature to bring about distalization of mandibular first molar.

II d. ACCORDING TO THE NUMBER OF ANCHORAGE UNITS

- **SINGLE OR PRIMARY ANCHORAGE:** It is defined as the resistance provided by single tooth with greater alveolar support to move another tooth with lesser alveolar support, e.g. retraction of a premolar using a molar tooth.

- **COMPOUND ANCHORAGE:** It is the type of anchorage where more than one tooth with greater anchorage potential are used to move a tooth/group of teeth with lesser support.

- **REINFORCED ANCHORAGE:** Anchorage is said to reinforced when more than one type of resistance units are utilized.

III.NANDA CLASSIFICATION[11]

- **A ANCHORAGE: CRITICAL / SEVERE** 75% or more of the extraction space is needed for anterior retraction.
- **B ANCHORAGE: MODERATE** Relatively symmetric space closure (50%).
- **C ANCHORAGE:MILD / NON CRITICAL** 75% or more of space closure by mesial movement of posterior teeth.

IV.BURSTONE CLASSIFICATION [18]

- **GROUP A ANCHORAGE:** Also refers to maximum posterior anchorage. 75% or more space required for anterior retraction.
- **GROUP B ANCHORAGE:** Simplest form of space closure. The requirement includes equal translation of the anterior and opposite segments into the extraction space.
- **GROUP C ANCHORAGE:** Also refers to maximum anterior anchorage. 75% space closure achieved through mesial movement of posterior teeth.

V.GIANELLY AND GOLDMAN [19]

- **MAXIMUM ANCHORAGE (TYPE A ANCHORAGE):** A situation in which the anchorage demand is very high. Not more than ¼ th of the extraction space should be lost by forward movement of the anchor teeth.
- **MODERATE ANCHORAGE (TYPE B ANCHORAGE):** A situation in which anchorage is not critical and space closure should be performed by reciprocal movement of both the active and the anchorage segment.
- **MINIMUM ANCHORAGE (TYPE C ANCHORAGE):** A situation in which, for an optimal result, a considerable movement of the anchorage segment (anchorage loss) is desirable, during closure of space.
- **ABSOLUTE ANCHORAGE:** In this type of anchorage, mesial migration of the anchor unit is avoided conserving 100% of the extraction site space. Temporary Anchorage Devices (TAD) like mini-implants have been used in orthodontic treatment in order to provide absolute anchorage without patient compliance. These mini-screws are small enough to be placed in different areas of alveolar bone.

VI.PULLEN CLASSIFICATION[12]

BASED ON FORM OF ATTACHMENT	BASED ON SOURCE OF RESISTANCE
Pivotal Reinforced Stationary	Intermaxillary Occipital Cervical

VII.GARDINER ET. AL. CLASSIFIED AS[15]

1. Simple
2. Stationary
3. Reciprocal
4. Reinforced
5. Intermaxillary
6. Extra oral.

VIII.CLASSIFICATION BASED ON IMPLANT[20]

- **DIRECT ANCHORAGE:** When the Temporary Anchorage Device is used directly to move a tooth. In this type of setup, orthodontic force is applied directly from the implant to one or multiple teeth. The location of the implant plays a very important role due to different force vectors being affected.
- **INDIRECT ANCHORAGE:** When a tooth or group of teeth are connected to Temporary Anchorage Device that act as periodontal-skeletal anchorage unit allowing for anchor tooth or group of teeth to be moved against this stabilized unit. In this setup, an implant is used to stabilize one or multiple teeth into a unit. An orthodontic force is then used against this unit to move single or multiple teeth. In this setup, the location of the implant is not as important, as long as the implant is stable.

SKELETAL ANCHORAGE

Skeletal anchorage is applied to orthodontic tooth movement when 'Absolute anchorage' is necessary. With various skeletal fixtures, forces might be applied to produce tooth movement in any direction without detrimental reciprocal forces.[13] Skeletal anchorage devices are indicated when stationary

anchorage is required involving diverse anchorage tasks.[20]

METHODS OF OBTAINING SKELETAL ANCHORAGE

1. Conventional Dental Implants [13]
2. Palatal Endosseous Implants
3. Onplant
4. Mini implant
5. Spider Screw
6. Micro implant
7. C-orthodontic Micro implant
8. Impacted Titanium Post
9. Transitional Implants
10. Mini Plate
11. Zygoma Anchorage System
12. Zygomatic Ligatures

IMPLANTS IN ORTHODONTICS

Implants solve one of the orthodontists' dilemmas, anchorage control. The innate ability of an Osseo integrated implant can provide this advantage. Patient co-operation would be minimized because the use of head gear and elastics would be eliminated.[13]

SITES FOR IMPLANT PLACEMENT[13]

Maxillary zone	Mandibular zone	Extra orally
Infrazygomatic crest area Maxillary tuberosity area Anterior nasal spine Midpalatal area Alveolar ridge Extraction site	Retro molar area Symphysis area Lingual plate Interdental region	Temporal buttress Zygomatic buttress

SKELETAL ANCHORAGE SYSTEM(SAS) - MINIPLATES

Conventional anchorage methods generally rely on patient compliance, result in unwanted reciprocal tooth movements, and can be limited in patients with compromised dentitions. In an effort to overcome some of these problems, skeletal anchorage has been increasingly incorporated into orthodontic treatment for over 25 years.[21] The quest for absolute anchorage began with conventional dental implants, retromolar implants, and palatal implants. However, space limitations, cost of the implants, and difficulties with connecting to the orthodontic appliances encouraged the rapid development of smaller devices that could be placed in various locations in the dental arch.

Miniscrews[22] and miniplates,[23] specifically designed for orthodontic anchorage, satisfy some of these requirements and are being progressively adopted into clinical practice. Recently, the literature has tended to focus on miniscrews, perhaps because of their small size and apparent ease of placement.[24,25] However, miniscrews have been associated with a fairly high failure rate,[26] including fracture during placement,[27] loosening under loading,[28] and impingement on roots either during placement or tooth movement.[29] Miniscrews might also need to be repositioned during treatment to allow all intended tooth movements to be accomplished. To address some of these issues, surgical miniplates with intraoral attachments have been modified to serve as **temporary skeletal anchorage devices (TSAD)**.[30]

Skeletal anchorage system (SAS) as devised by Sugawara is an orthodontic anchorage system that utilize miniplates and monocortical screws made up of titanium that are temporarily fixed in the maxilla and/or mandible to provide absolute orthodontic anchorage.[31,32]

Plate systems were originally used by **Sugawara** and others to provide additional three-dimensional stability and increase the success rates over the long-term. Originally these were modified fixation plates used for Le Fort osteotomies and facial trauma repair. Eventually, custom-designed plating systems specifically indicated for skeletal orthodontic anchorage were developed. Skeletal anchorage plates have the advantage of increased stability, allowing the use of greater forces. They do not require osseointegration and can be loaded immediately. The plates typically allow for placement of multiple small screws away from the tooth roots, avoiding injury. Skeletal anchorage plates are also easy to remove, but require an additional incision and dissection.[5]

Miniplates, which are placed at a safe distance from the roots, offer the advantages of reduced risk of root impingement, allow the free movement of roots

past the TSAD, and are associated with a lower failure rate than miniscrews. Claims have been made that miniplate anchorage simplifies previously complex treatments[33] and permits correction of malocclusions previously thought beyond the scope of orthodontic therapy alone.[34-37]

HISTORY [1,5]

In 1940s, Gainsforth and Higley - experimented with vitallium screws and wires in the dog ramus used for skeletal anchorage. Linkow - used blade-type implants in the posterior mandible to apply class II elastics for retraction of maxillary incisors. Sherman also used dental implants in dogs for anchorage with limited success. In 1979, Smith noted that dental implants could act like ankylosed teeth during orthodontic movement. In 1983, Creekmore and Eklund suggested the use of a vitallium screw for intrusion of maxillary central incisors. In 1985, Jenner reported the use of a bone plate as an additional orthodontic anchor to retract lower molars. In 1988, Shapiro and Kokich discussed how dental implants could be used for orthodontic anchorage. In 1995, Block and Hoffman used a hydroxyapatite-coated onplant placed in the midline palatal tissues for use with an orthodontic anchor device. Costa and coworkers used titanium miniscrews borrowed from plating fixation systems for orthodontic anchorage with some success. In 1999, Umemori and colleagues described techniques for using a modified rigid fixation plate for use as orthodontic anchorage. This was a particularly important leap, because the plating system could be easily placed and significant force could be used without loosening of the device that was seen rather frequently with individual screws. Loosening of the screw mechanic had been a major drawback of screw systems. Sugawara was first to use titanium miniplates and miniscrews and other authors subsequently described a number of interesting compensation techniques for a variety of problems that traditionally would have required orthognathic surgery to treat, such as the anterior open bite and significant class III deformity.

While comparing TAD'S with mini-plates, mini-plate system is advantageous as they do not interfere with tooth movement and more secure anchorage is provided by multiple screws, which is especially beneficial in patients with extremely thin cortical bone, most often seen in those with excessive vertical facial height.[32]

The most useful application of the SAS is to permit the predictable and anticipated intrusion and distalization of maxillary and mandibular molars. SAS offers a non-extraction treatment approach for some severe malocclusions characterized by maxillary or mandibular protrusion, as well as a non-surgical orthodontic treatment option to correct skeletal malocclusions(surgical), anterior crowding in adult patients, retreatment cases, patients with complex orthodontic problems, reduce total treatment time, correct minor surgical inaccuracies and relapse tendencies after orthognathic surgery.[32]

SITES FOR MINIPLATE PLACEMENT[32]

TYPE OF MINIPLATE	AREA OF INSERTION	TYPE OF TOOTH MOVEMENT
Y-Plate	Zygomatic buttress	Intrusion or distalization of upper molars.
I-plate	Anterior ridge of the piriform opening	Intrusion of upper anterior teeth. Protraction of upper molars.
L or T-plate	Anterior border of the ascending ramus. Mandibular body	Extrusion of impacted molars. Intrusion, protraction, or distalization of lower molars.

BIOMECHANICS OF SAS USING MINIPLATES[32]

Miniplates have greater stability and are away from dental component of arch, allowing for three dimensional movement of molar (intrusion, extrusion, mesial or distal movement). With the adjuvant of SAS mechanics envelop of tooth movement has enhanced dramatically and also patients with dental and skeletal malocclusions are offered with more treatment options.

MOLAR DISTALIZATION

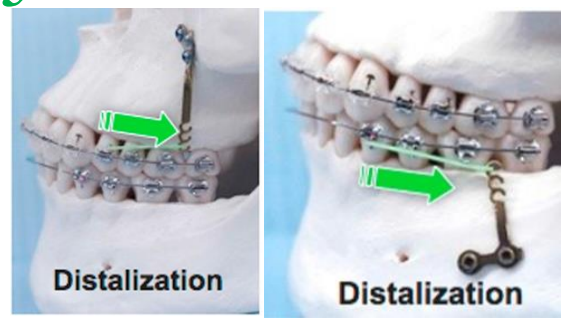

FIG. 1 DISTALIZATION WITH MINIPLATES

With the development of SAS mechanics, en-mass movement of the posterior molars can be achieved, considerably reducing treatment time. Third molars if present are usually extracted to build space for molar distalization. For molar distalization the amplitude of orthodontic force up to 400-500 gram can be implicated on each side. Distalization of upper molar is indicated for relieving anterior crowding in maxillary arch, Class II cases, a symmetrical maxillary dentition, and in skeletal Class III cases for dental decompensation of upper incisors before orthognathic surgery. Distalization of lower molar is indicated for relieving anterior crowding in mandibular arch, a symmetrical mandibular dentition, anterior crossbite, and in skeletal Class II cases for dental decompensation of the lower incisors before orthognathic surgery.

MOLAR INTRUSION

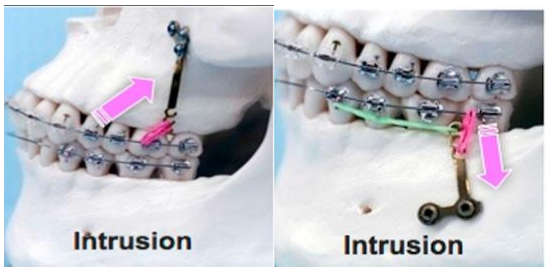

FIG.2 INTRUSION WITH MINIPLATES

With traditional mechanics, intrusion of molars is difficult but using miniplates anchorage placed at zygomatic buttress for maxillary molar, or at the posterior mandibular body for mandibular molar intrusion is now achievable. Intrusion of maxillary molar is indicated for cases with anterior open bite cases, posterior vertical maxillary excess and moderate Class II relation. Intrusion for mandibular molar is indicated for cases with anterior open bite, lower molar height excess and mild Class III relation. Intrusion of molar result in counterclockwise movement of mandible following correction of open bite.

MOLAR PROTRACTION

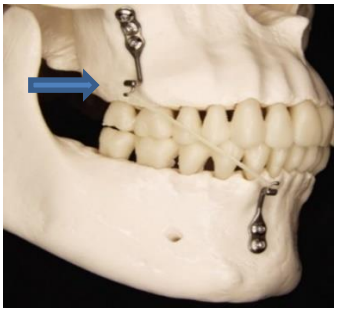

FIG.3 MOLAR PROTRACTION

With miniplate placed at the anterior mandibular body or at the piriform rim, orthodontic protraction of molar is effortless. Protractive force of about 200-400 gram can be applied unilaterally. Protraction of maxillary molar is indicated for cases with Class III molar relationship, asymmetrical maxillary dentition, anterior crossbite caused by maxillary deficiency, congenitally missing lateral incisor or second premolar. Protraction of mandibular molar is indicated in cases with Class II molar relationship, asymmetrical mandibular dentition, congenitally missing second premolar, diastemas of mandibular dentition.

BUCCOLINGUAL MOVEMENT

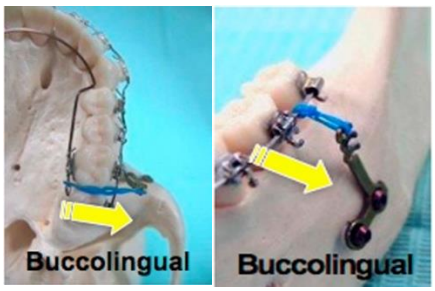

FIG.4. BUCCOLINGUAL MOMENT OF MOLAR

In traditional mechanics, Buccolingual movement of molars is difficult hence using miniplates enables a better movement of molars bucco-lingually.

NEWER TSAD's IN ORTHODONTICS

BOLLARD MINIPLATE

FIG 5. BOLLARD ANCHORAGE SYSTEM

Bollard miniplates was first introduced by **Dr. Hugo De Clerk** in Belgium. Skeletal anchorage can be used to modify the growth of the jaws. In Class III children with a prominent chin, Bollard miniplates can be inserted in the posterior part of the upper and in the anterior part of the lower jaw. A continuous traction is applied through elastics fixed between the upper and lower miniplates. This results in a restriction of the growth of the lower jaw and a stimulation of the growth of the upper jaw. These growth changes reduce the prominence of chin. The use of the Bollard miniplates as orthodontic bone anchors allows an easy treatment for distalization mesialization and intrusion of teeth.[38]

PRINCIPLE

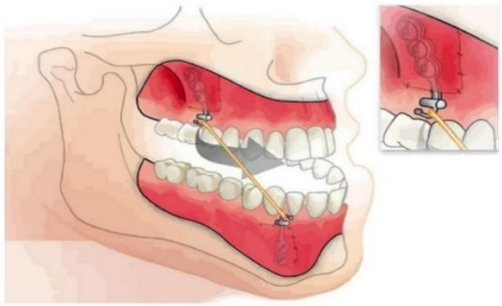

FIG.6 BONE ANCHORED MAXILLARY PROTRACTION WITH MINIPLATES

Bollard anchorage is based upon bone anchored maxillary protraction principle, in this system miniplates are incorporated in zygomatic buttress in maxilla and between lateral incisor and canine region in mandible. The application of a continuous forward traction on the maxilla results in a stretching of the fibres in the sutures and stimulation of bone apposition. Because of the complex interdigitation in the zygomatico-maxillary suture the resistance against the opening of this suture is greater than when separating the zygomatico-frontal and zygomatico- temporal sutures. So both halves of the maxilla and the left and right zygoma move forward as one unit.[38]

PARTS OF BOLLARD MINIPLATE

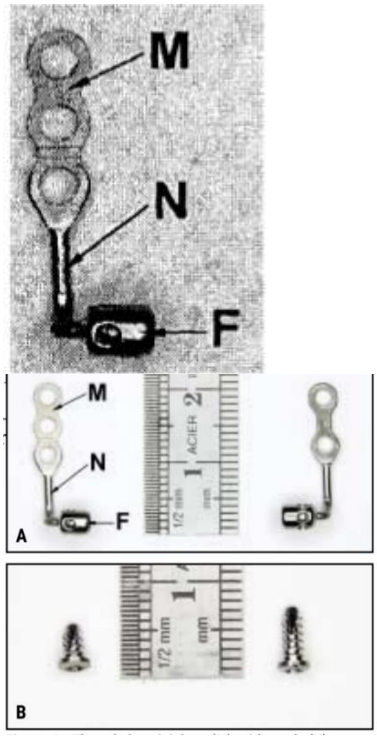

FIG7. PARTS OF BOLLARD MINIPLATE

- A 2 or 3 holes titanium mini plate is fixed by monocortical mini screws.
- A neck (round bar with a diameter of 1.5 mm) is penetrating the soft tissues at the muco-gingival boarder.
- A cylindrical fixation unit with a blocking screw makes it possible to fix an auxiliary wire that connects the bone anchor with the fixed orthodontic appliance. [37]

DESIGNS OF BOLLARD MINIPLATES [39]

Bollard miniplates are available in three designs.

1. **BOLLARD WITH HOOK(BH SRIES)**

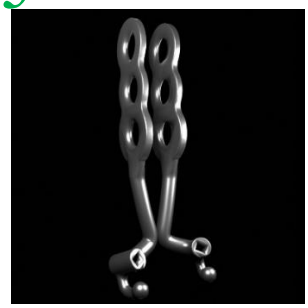

FIG.8 BOLLARD WITH HOOK

The straight plate is the preferred design for patients with normal anatomy and bone quality at the maxillary buttress. Two lengths are available: normal(21mm long with 3 holes) and pediatric(18mm long with 3 holes). For the mandible the miniplate is 16mm long and contains 2 holes. The intraoral part contains a hook to fix orthodontic elastics, springs, or ligatures. An 0.018x0.025" tube allows the fixation of orthodontic auxiliaries.

2. **BOLLARD WITH BLOCKING SCREW (B SERIES)**

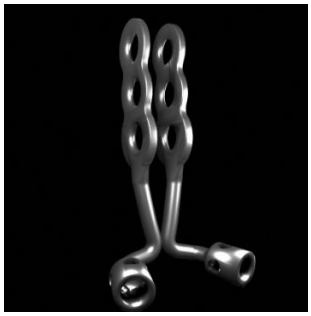

FIG.9 BOLLARD WITH BLOCKING SCREW

For maxilla – 21mm long with 3 holes, mandible – 16mm with 2 holes. Through two perpendicular canals in the intraoral cylinder, the orthodontist can fix a wide variety of auxiliaries by means of blocking screw.

3. **Y SHAPED BOLLARD (Y SERIES)**

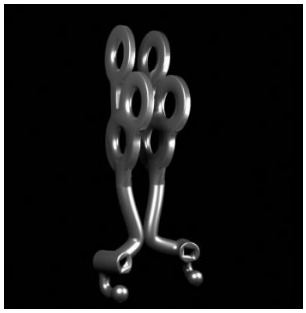

FIG.10 Y SHAPED BOLLARD

Bollard with hook combined with a Y-shaped plate. This form made of soft grade of titanium allows a close fit to the maxillary buttress when bone quality or quantity is limited. It is 19mm long with 3 holes.

LOCATION OF INSERTION

- In the upper or lower jaw at a safe distance from the root apices of the teeth.
- Most commonly: infra-zygomatic crest of the maxillary buttress or in the lower canine region between lateral incisor and canine.
- Can also be inserted in the paranasal crest or the molar region of the mandible.[38]

LOADING AND FORCE LEVELS

- Start with loading of about 100g each side (Light continuous forces).
- 5/16-in elastic used (the choice of elastics depends on the distance between the upper and lower plate, which is related to the severity of the skeletal Class III and the A-P position of the upper Bollard miniplates, depending on the inclination of the infrazygomatic crest.
- Next three months: ¼-in elastics and 3/16-in elastics can be used to increase the force levels.
- Patient is instructed to replace elastics atleast twice a day.
- Loading is started no later than 2 to 3 weeks after surgery.
- Forces above 200g not used as this may exceed the maximal resistance of the external cortical plate of infrazygomatic crest and can lead to bone loss and loosening of screws.[38]

IDEAL AGE

Face mask therapy is usually recommended before the age of 9 years. However at this age the thickness of the bone in the maxilla is not sufficient to obtain a solid mechanical retention of the screws. So the best age seems to be around 11 years for girls and 12 years for boys.[38]

SURGICAL PROCEDURE AND PRECAUTIONS

- The surgical procedure is important factor in determining the failure rate.
- A small mucoperiosteal flap has to be made. In the upper jaw miniplate is positioned just in front of and parallel to the infrazygomatic crest. In the lower jaw the miniplate is fixed between the lateral incisor and the canine.
- The device is positioned so that the round connecting bar of the neck penetrates the soft tissues in attached gingiva, close to the mucogingival border. The lower part of the neck should be in tight contact with the alveolar bone surface.
- Patient asked to apply ice after surgery to reduce swelling, and to rinse with chlorhexidine twice a day for 12 days.
- To reduce the mechanical irritation of lip the patient covers the intraoral extension with wax.
- Patient instructed not to touch the miniplate repeatedly by pressing the tongue or fingers.
- Loading by elastics should be started no later than 2 to 3 weeks after surgery.[38]

PRECAUTIONS DURING RETENTION STAGE

After the active orthopedic treatment the expression of Class III growth will further continue and will lead to relapse. An interindividual variability is seen in the amount of remaining Class III growth during retention period until adulthood. For this reason miniplates are not removed after active treatment. They are used for night time traction when a relapse tendency is observed.

Although treatment is started two to three years later than conventional facemask therapy, the follow up takes a long time.[38]

COMPLICATIONS OF BOLLARD MINIPLATE

The most common complication faced is loosening of the miniplate, mainly in the maxilla, in case of poor quality of bone. Exceptionally a fracture of a miniplate can occur. This mainly happens after excessive bending of the round connecting bar during the surgical procedure. If a miniplate is lost, it can be replaced under LA and treatment can be completed.[38]

CLINICAL APPLICATIONS OF BOLLARD MINIPLATES

- Maxillary protraction[40] - Most commonly used in growing children for Class III orthopedic correction. In that case, 4 miniplates are inserted: 2 in maxilla close to the upper left and right infrazygomatic crest and 2 in the mandible at both sides between lateral incisor and canine.
- Molar distalization – miniplate inserted only on both infrazygomatic crest.
- Molar mesialization – inserted between lower canines and lateral incisors.
- Molar intrusion[41]
- Incisor retraction.
- Class II extraction and non-extraction treatment.[42]

De Clerk et al 2011[43] evaluated the success rate of Bollard miniplate anchorage for bone anchored maxillary protraction (BAMP). The overall success rate of miniplate anchorage in terms of stability was 97% and therefore Skeletal anchorage by means of Bollard modified miniplates is effective for BAMP.

C-TUBE MINIPLATE:

The C-tube was developed exclusively for orthodontic purpose with the concept of simple design and small size for easy placement. **Kyu-rhim Chung 2002,[44]** made attachment of an orthodontic tube to a miniplate that would improve the versality of the rigid anchorage system. A round 0.036" tube was selected and it was soldered to one end of a miniplate.

An Orthodontic miniplate tube device, the C tube was designed for use in patients whom a conventional miniscrew is not suitable, such as those with narrow interradicular spaces, extended maxillary sinuses, dilacerated roots, or severe bone loss.

TYPES OF C-TUBE MINIPLATE

FIG.11 A. I TYPE C TUBE. B. CROSS TYPE C TUBE.

C-tubes are made of titanium miniplates with a 0.036-in diameter hole in the tube. They have 2 to 4 holes (diameter, 1.5 mm) and lengths of 4 to 7 mm; they are self-drilling miniscrews (KLS Martin, Tuttlingen, Germany, Jin Biomed Co., Bucheon, Korea).

1. **I TYPE C TUBE MINIPLATE**: It is fixed with 2 drill-free miniscrews and applied in the posterior maxillary area if there are narrow interradicular spaces or dilacerated roots, or in the anterior maxilla with a prominent labial frenum.

2. **CROSS TYPE C TUBE MINIPLATE**: Cross-type C-tubes are used when there is severe pneumatization of the maxillary sinus or when distalization of the dentition is planned. The cross-type C-tube is fixed with 2 to 4 drill-free 4-mm miniscrews according to the quality of bone and the direction of the orthodontic force vector.

The C-tube can be placed in various region of the oral cavity and is valuable where absolute anchorage is needed. C-tube is placed in alveolar bone between dental roots or in cortical bone above the alveolar bone. These areas are much lower and more accessible than the zygomatic buttress where a conventional miniplate is usually placed. [45]

LOCATION OF INSERTION

The C-tube is anchored to the cortical bone near the posterior teeth, instead of the zygomatic buttress. C-tube placement requires a minimum of dissection compared with the buttress site.[45]

VIRTUALLY FABRICATED GUIDE FOR THE PLACEMENT OF C-TUBE MINIPLTE

Paek et al. 2014,[51] introduced a virtually planned and stereolithographically fabricated guiding system that allows the clinician to plan carefully for the best location of C-tube miniplate and achieve accurate position without complications. To confidently and safely place a miniplate with screw fixation, a simple customized placement guide for the orthodontic miniplate was introduced.

CLINICAL APPLICATIONS

- Intrusion and distalization of posterior teeth.
- Intrusion of anterior teeth.
- It is applicable for lingual orthodontics and can be placed on the retromolar pad with rolled tube exposed in oral cavity.
- It can be used for en masse retraction without appliances attached on posterior dentition in maximum anchorage cases.
- It can be used for vertical correction (I type C tubes can be used for intrusion of maxillary incisors).
- Distalization of full mandibular dentition can be achieved with an I type C tube placed on the retromolar pad.[45]
- It can be used to replace the failed mini-implant without interrupting the treatment mechanics.[46]
- Correction of dental Class III with posterior open bite[47]. C-tube was fixed to the lower symphysis and connected with NiTi reverse curve archwire for uprighting molars without appliance on mandibular anteriors.
- It can be used for traction of impacted teeth.[48]
- Bendable C-tube head as practical temporary anchorage device to treat open bite patients with maxillary sinus pneumatization. Simple bending of C-tube miniplates ensured great alternate over miniscrews or regular miniplates with reduced risk of perforation and ability to bend the head portion to control the orthodontic vectors and forces.[49]
- C tube miniplates used in mandibular arch which is smaller than other surgical anchorage plates to correct midline deviation.[50]

ADVANTAGES

- Maximum reliability and stability for orthodontic procedures resulting from multiple miniplate anchoring screw applications.

- Minimal mucosal irritation around the miniplate after placement since tube-shaped head of the miniplate is most of the time exposed to the oral cavity through the attached gingiva.

- Location of the miniplate anchoring screws rarely interferes with orthodontic tooth movement or frenum attachment, since they are placed above the apices of the teeth.[46]

Miniplates despite yielding good treatment results, are not yet widely used, possibly due to the requirement of surgical procedures with certain degree of complexity, as well as the need for subsequent orthodontic treatment.[52]

AN OVERVIEW OF BOLLARD AND C-TUBE MINIPLATES[4]

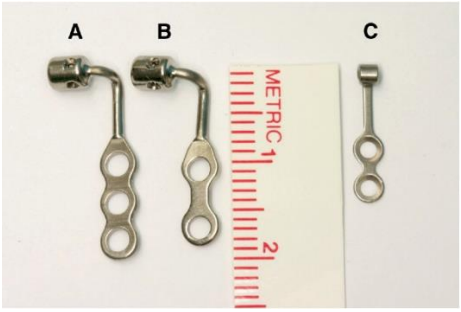

FIG.12 A. MAXILLARY BOLLARD MINIPLATE

B. MANIBULAR BOLLARD MINIPLATE

C. C-TUBE MINIPLATE

FEATURES OF BOLLARD AND C-TUBE MINIPLATES[37-39, 44,45]

Parts **Length**	Bollard miniplates has miniplate with 2 or 3 holes, neck, round connecting bar, cylindrical fixation unit with locking screw. Bollard miniplate available in lengths of 21mm(normal) and 18mm(pediatric).	C tube miniplate has miniplate with 2 or 3 holes with flat connection bar and tube soldered to one end. C-tube miniplate available in length of 4 to 7mm.
Material	Made of titanium	Made of titanium
Types	Bollard with hook Bollard with blocking screw Y shaped bollard.	I type C tube miniplate Cross type C tube miniplate.
Age	Bollard miniplate given for growing patients (11 years for girls and 12 years for boys).	C tube miniplate given for adults.
Location	Zygomatic buttress in maxilla and lower canine region in mandible.	Alveolar bone between dental roots or in cortical bone near posterior teeth. It is usually anchored to the cortical bone of the posterior teeth instead of zygomatic buttress.
Uses	They are most commonly used for treating Class III malocclusion in young patients.	They are used in patients with narrow interradicular spaces, dilacerated roots, and severe pneumatization of maxillary sinus.

CONCLUSION

Skeletal anchorage devices allow orthodontic movements that were previously thought to be difficult if not impossible. The devices do not accelerate tooth movement, but do provide the greatest amount of anchorage in a manner that is bone-borne, creating more efficient mechanics for moving teeth while avoiding unwanted (reciprocal) tooth movement in a number of challenging clinical situations. Additionally, unwanted reciprocal tooth movements are minimized or avoided altogether. An additional advantage is the use of mechanics for which the success is not based on compliance factors, such as with headgear or elastic band therapy that requires patient placement and removal. In addition to that it has advantages of continuous force application, don't interfere with tooth movement as located away from the dentition, surgical procedures are necessary but simple in most instances, and devices are easy to remove.

Miniplates are well accepted by patients and providers, and offer safe and effective anchorage possibilities with a high success rate (92.5%), with few side effects or problems during treatment. Even novice users found miniplates to both simplify orthodontic treatment and enhance the possibility of treatments that might have been considered unfeasible without skeletal anchorage. Although the surgery to place miniplates is more invasive than for miniscrews, the patients experienced few undesirable sequelae, were enthusiastic about their use, and appeared to regard their placement as a relatively trivial dental event.

Thus, Skeletal Anchorage System has mainly changed the possibilities in orthodontic treatment. The use of the miniplate for absolute anchorage has proved to have many advantages. First, the capacities to provide alternative treatment possibilities that were not previously feasible. Second, absolute anchorage leads to reduction in

the treatment time and a more reliable treatment plan. Third, this anchorage system eliminates the dependency on patient compliance. Extra-oral anchoring devices such as headgear could be replaced by this system unless patient cooperation could be obtained. This also allows an overall decrease in the number of non-extraction and orthognathic surgery cases. The Skeletal orthodontic anchorage is quite effective biomechanics for adult patients, retreatment cases, and patients with complex orthodontic problems. In the future, the widespread use of Skeletal Anchorage System (miniplates) in orthodontic practice will likely be the dawn of a new era in dentofacial orthopedics and orthognathic surgery.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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