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Review Article

A COMPREHENSIVE REVIEW: MICRO-IMPLANTS IN ORTHODONTICS

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ABSTRACT

Anchorage has been a crucial topic since the origin of orthodontics. In the orthodontic process, gentle, constant pressure is applied to the teeth that need to be moved against the other teeth which serve as the anchoring unit. The anchoring teeth must be completely stable. Introduction of implants to orthodontic field have made this a possibility. Orthodontic implants also known as mini-implants have widened the horizon of orthodontic field. The mode of anchorage facilitated by these implant systems has a unique characteristic owing to their temporary use, which results in a transient, albeit absolute anchorage. The foregoing properties together with the recently achieved simple application of these screws have increased their popularity, establishing them as a necessary treatment option in complex cases that would have otherwise been impossible to treat. The aim of this comprehensive review is to present and discuss the development, clinical use, benefits, and drawbacks of the miniscrew implants used to obtain a temporary but absolute/skeletal anchorage for orthodontic applications. Topics to be discussed include classification, types and properties, types of, screw head, and thread, clinical applications, site and placement method selection, clinical procedures for implant insertion is presented.

INTRODUCTION

Anchorage is defined as resistance to unwanted tooth movement. It is an essential prerequisite for the orthodontic treatment of dental and skeletal malocclusions. Prominent orthodontists namely, Gunnell, Desirabode, and Angle realized the limitations of moving teeth against other teeth used for anchorage thereby frontiering ideas such as the use of occipital, stationary, and occlusal anchorage.

From the far ages, orthodontists have used teeth, intraoral appliances, and extraoral appliances, to control anchorage thereby minimizing the movement of certain teeth, at the same time completing the desired movement of other teeth

Anchorage control helps to avoid undesirable tooth movements. However, even a small reactive force can cause undesirable movements. Therefore, it is important to have absolute anchorage to avoid them. Absolute or infinite anchorage is defined as no movement of the anchorage unit (zero anchorage loss) as a consequence to the reaction forces applied to move teeth. Such an anchorage can only be provided by using ankylosed teeth or dental implants as anchors, both relying on bone to inhibit movement. Anchorage provided by devices, such as implants or miniscrew implants fixed to bone, may be obtained by enhancing the support to the reactive unit (indirect anchorage) or by fixing the anchor units (direct anchorage), thus facilitating skeletal anchorage.

In 1945, Gainsforth and Higley used vitallium screws in mongrel dogs to create absolute anchorage for tooth movement. In 1983, Creekmore and Eklund were the first orthodontists to suggest that a small metal screw could withstand a constant force of sufficient magnitude and duration to reposition an entire anterior maxillary dentition without becoming loose, painful, infected, or pathologic, thus opening an entirely new area for managing orthodontic anchorage.

The aim of this comprehensive review is to present and discuss the development, clinical use, benefits, and drawbacks of the miniscrew implants used to obtain a temporary but absolute skeletal anchorage for orthodontic treatment applications.

Definition

A temporary anchorage device (TAD) is a device that is temporarily fixed to bone for the purpose of enhancing orthodontic anchorage either by supporting the teeth of the reactive unit or by obviating the need for the reactive unit altogether, and which is subsequently removed after use. They can be located transosteally, subperiosteally, or endosteally;

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and they can be fixed to bone either mechanically (cortically stabilized) or biochemically (osseointegrated).

Classification

Implants can be classified under the following headings:

Based on the Location

- ***Subperiosteal*:** Implant body lies over the bony ridge.
- ***Transosseous*:** Implant body penetrates the mandible completely.
- ***Endosseous*:** Partially submerged and anchored within the bone-endosseous implants are most commonly used for orthodontic purposes.

Based on the Configuration Design

- *Root form implants*: These are the screw typeendosseous implants and the name has been deriveddue to their cylindrical structure.
- *Blade/plate implants*: Flatter and can be used in resorbedand knife-edge ridges.

According to the Composition

- Stainless steel
- Cobalt-chromium-molybdenum (Co-Cr-Mo)
- Titanium
- Ceramic implants
- Miscellaneous, such as vitreous carbon and composites.

According to the Surface Structure

Threaded or Nonthreaded

The root form implants are generally threaded as this providesfor a greater surface area and stability of the implant.

Porous or Nonporous

The screw type implants are usually nonporous, where as the plate or blade implants (nonthreaded) have vents in the implant body to aid in growth of bone, and thus a better interlocking between the metal structure and the surrounding bone.

According to the Implant Morphology

Implant disks

- Onplant
- Screw designs
  - Mini-implant
  - Ortho system and implant system
  - Aarhus implant
  - Microimplant
  - Newer systems, such as the spider screw, the OMAS system, the Leone mini-implant, the Imtec screw, etc.
- Plate designs
  - Skeletal anchorage system (SAS)
  - Graz implant-supported system
  - Zygoma anchorage system

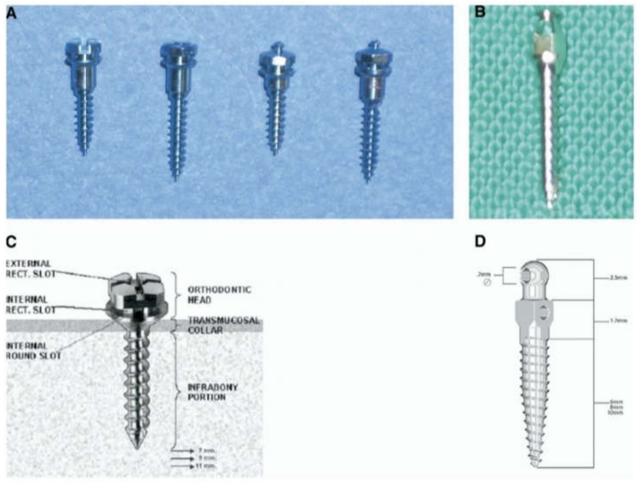

Figure 1

Miniscrew Design

For orthodontic implants, both physical stability and osseointergration depends on adequate bone-fixture surface contact, which in turn is a balance between diameter and length of the implant. More the length, lesser should be the diameter and vice-versa. The conical screws used in the Miniscrew Anchorage System* (MAS), made of medicalgrade 5 titanium, are available in three sizes. Type A has a diameter of 1.3mm at the top ofthe neck and 1.1mm at the tip. Type B is 1.5mmin diameter at the neck and 1.3mm at the tip.Both types are 11mm long. Type C, which is9mm long, has a diameter of 1.5mm at the neckand 1.3mm at the tip.The screw head consists of two fusedspheres (the upper 2.2mm in diameter, the lower2mm), with an internal hexagon for insertion ofthe placement screwdriver. A .6mm horizontalslot at the junction of the two spheres allows for the attachment of elastics, chains, coil springs, ligature wires, or auxiliary hooks.

Self tapping body design helps to improve the transfer of compressive forces to the adjacent bone, thus minimizing micro-motion and increasing bone-implant surface area. Self drilling mini-implants simplifies the insertion stage by avoidance of pre drilling.

Head design: mini implants usually features two-piece designs with specific healing abutments and intraoral attachments.

Table I. Currently available miniscrew implant systems (in alphabetical order)

Product	*Company*	*Postal address*	*Web site*
Aarhus Anchorage System	MEDICON eG	Gänsäcker 15, D-78532, Tuttlingen, Germany	www.medicon.de
	ScanOrto A/S	Hans Edvard Teglers Vej 2, 2920-Charlottenlund, Denmark	www.aarhus-mini-implant.com
AbsoAnchor System	Dentos	258 BunJi, Dong-In Dong, Jung-Gu, Taegu, Korea	www.dentos.co.kr
C-Implant	Dentium Inc.	6F Dahn World B/D, 154-11 Samsung-dong, Kangnum-gu, 135-897 Seoul, Korea	www.implantium.com
Cizeta Titanium Miniscrew	Cizeta Surgical	San Lazzaro di Savena, Bologna, Italy	www.cizetasurgical.it
Dual-Top Anchor System	Jeil Medical Corporation	775-3 Daesung B/D, Daelim 3 Dong Youngdeungpoku, Seoul, Korea	www.jeilmed.co.kr
	Distributed by RMO Inc.	P.O. Box 17085, Denver, CO 80217	www.rmortho.com
IMTEC Mini Ortho Implant	IMTEC Corporation	2401 N. Commerce, Ardmore, OK 73401	www.imtec.com
Lin/Liou Orthodontic Mini Anchorage Screw (LOMAS)	Mondeal Medical Systems GmbH	Moltkestrasse 39, D-78532 Tuttlingen, Germany	www.mondeal.de
	Distributed by Mondeal North America, Inc.	6895 Lake Bluff Drive, Comstock Park, MI 49321	
Miniscrew Anchorage System (MAS)	Micerium S.p.a.	Via Marconi 83, 16030 Avegno, Italy	www.micerium.it
Orthoanchor K1 System	Dentsply Sankin Corporation	Tokyo, Japan	www.dentsply-sankin.com
Orthodontic Mini Implant (OMI)	Leone S.p.A.	Via P. a Quaracchi 50, 50019 Sesto Fiorentino, Firenze, Italy	www.leone.it
	Distributed by Leone America	501 W. Van Buren, Suite S, Avondale, AZ 85323	
Spider Screw Anchorage System	HDC	Via dell'Industria 19, 36030 Sarcedo, Italy	www.hdc-italy.com
Temporary Mini Orthodontic Anchorage System (TOMAS)	Dentaurum	Turnstrasse 31, D-75228 Ispringen, Germany	www.dentaurum.de
Universal Skeletal Anchorage System	Stryker Corporation	Stryker Leibinger Micro Implants, 750 Trade Centre Way, Suite 200, Portage, MI 49002	www.stryker.com

Placement Sites

Miniscrews are used in place of traditional appliances such as headgear and lingual arches in cases where absolute anchorage is necessary. From a biomechanical standpoint, miniscrews allow more bodily tooth movement during space closure by placing the force vectors closer to the center of resistance of the teeth. The sites most often utilized for MAS insertion in the maxilla include:

- Interradicular spaces, both buccal and lingual
- Extraction spaces
- Inferior surface of the anterior nasal spine

In the mandible, the most common miniscrew placement sites are:

- Interradicular spaces, both buccal and lingual
- Lateral to the mentalis symphosis
- Extraction spaces

In our experience, the most useful locations are the interradicular spaces, either buccal or lingual, between the second premolars and first molars in both arches, or the buccal space between the upper lateral incisor and canine.

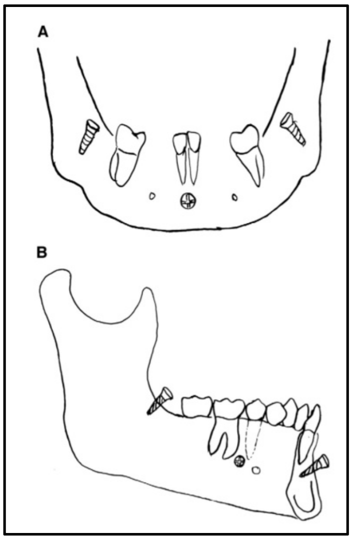

Figure 2

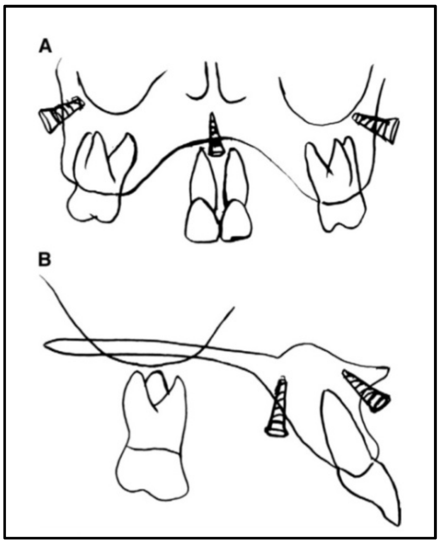

Figure 3

Selection of Mini-Implant Size

The diameter of the miniscrew will depend on the site and space available. In the maxilla, anarrower implant can be selected if it is to be placed between the roots. If stability depends oninsertion into trabecular bone, a longer screw is needed, but if cortical bone will provide enoughstability, a shorter screw can be chosen. The length of the transmucosal part of the neck should be selected after assessing the mucosal thickness of the implant site.

Placement protocol

1. After the local anesthetic is applied, the assistant washes the implant area with .02% chlorhexidine.
2. a. In case of non–self-drilling miniscrew implants, a pilot hole is necessary. Pilot drilling should be done in asurgical environment. Firstly, soft tissue from the site of the placement is either incised or removed using a soft tissue punch. Thereafter, a pilot hole is drilled using a drill rotating no more than 1000 rpm. The pilot drill is usually 0.2 to 0.3 mm thinner than the miniscrew implant. The miniscrew implant is then screwed in place by using an appropriate screwdriver.
   b.) In case of self-drilling miniscrew implants, no incision or soft tissue removal is necessary. Infection control is similar to that for an extraction. After selecting the appropriate site, the miniscrew implant, and the corresponding site of placement, it is inserted in place. (preferably between the free and attached gingival)
3. When properly placed, the screw head will protrude through the soft tissue. Once the initial stability of the miniscrew has been confirmed, an orthodontic force of 50-250g can be applied immediately. The head of the miniscrew has been designed to prevent compression of the mucosa, but if this occurs after placement of a chain or nickel titanium coil spring, we suggest using Monkey Hooks** instead.

Applications

Defining specific indications where orthodontic mini-implants can successfully be used has 2 potential benefits. First, using mini-implants appropriately will lead to improved treatment results. Second, not using them when traditional mechanics could lead to equally satisfying results prevents overtreatment. However, because of the versatility of mini-implant– enhanced mechanics, some situations that could be resolved with traditional mechanics might be treated in a shorter time or at least with a more predictable outcome. The following treatment objectives might benefit from mini-implants:

Closure of extraction spaces

Maxillary titaniumscrews can be used as anchorage for distal retraction ofthe anterior teeth, whereas mandibular titanium screwscan be used to apply uprighting and intrusive force to themandibular posterior teeth and for vertical control ofthe mandibular posterior teeth.

Figure 4

Skeletal class II correction

Severe skeletal Class II malocclusion can be treated using miniscrew anchorage rather than traditional orthodontic mechanics of headgear and transpalatal arch.

Figure 6

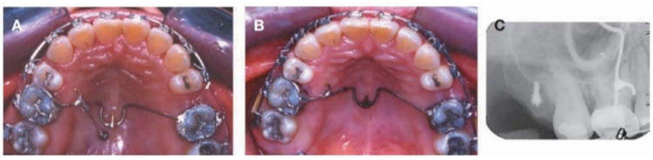

Figure 7

Maxillary protraction for correction of Class III malocclusions

Maxillary hypoplasia in patientswith Class III malocclusion can be corrected with the use of Class III elastics betweenminiplate skeletal anchorage in both jaws (boneanchoredmaxillary protraction which showed significant maxillary and zygomaticprotraction.

Figure 8

Figure 9

Figure 10

Open bite and large lower anterior facial height

A skeletal Class IIanterior open bite and a large Frankfort-mandibularplane angle can be corrected bynonsurgical treatment combined with TADs which showed molar intrusion with TADs followed by forward rotation of the mandible leading to anterosuperior movement of the soft tissue menton. thus contributing to correctionof the open bite and improvement of the soft tissue profile.

Figure 11

Figure 12

Figure 13

Figure 14

Gummy smile and facial profile correction

The placement of a singleminiscrew between the roots of the maxillary incisors,providing direct anchorage for incisor intrusion toreduce excessive gingival display. Miniscrews for intrusion of incisors are placedbetween the roots of the anterior teeth.

Figure 15

Correction of a canted occlusal plane

Patients with facial asymmetry have canted occlusal planes caused by unilaterally extruded maxillary molars or asymmetric mandibular vertical development. TADs can be used to change canted occlusal plane by either intrusion of extruded molars or extrusion of intruded molars

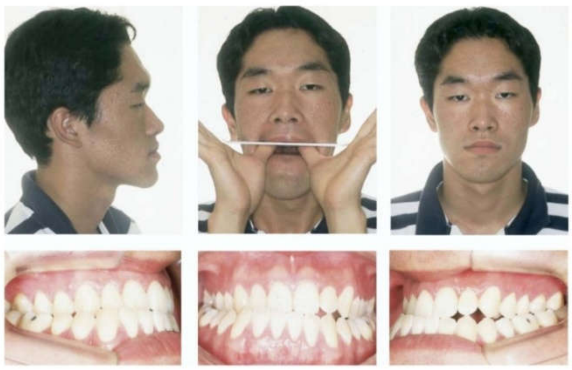

Figure 16

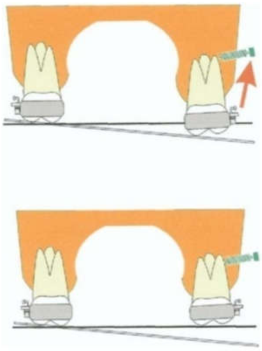

Figure 17

Figure 18

Management of palatally impacted canines

Management of palatally impacted canines requires surgical and orthodontic interventions. Skeletal anchorage is required if we were to move only impacted teeth before fixed-appliance orthodontic treatment onset.

Figure 19

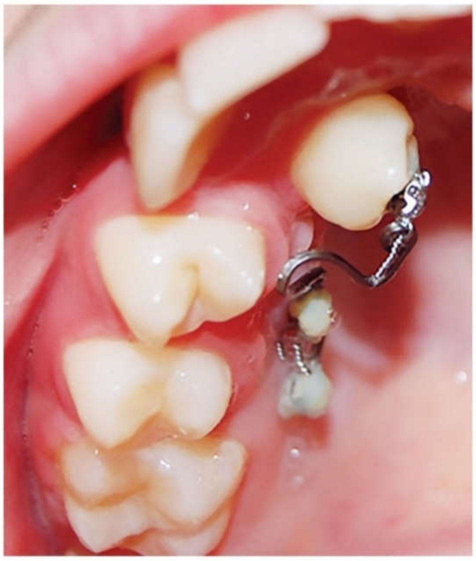

Figure 20

Preprosthetic Molar Uprighting Using Skeletal Anchorage

The second molar may tip mesially after extraction or loss of a first molar, into the edentulous space. Mini-implant can be used in an dentulousfirst-molar site as anchorage for uprighting amesially tipped second molar.

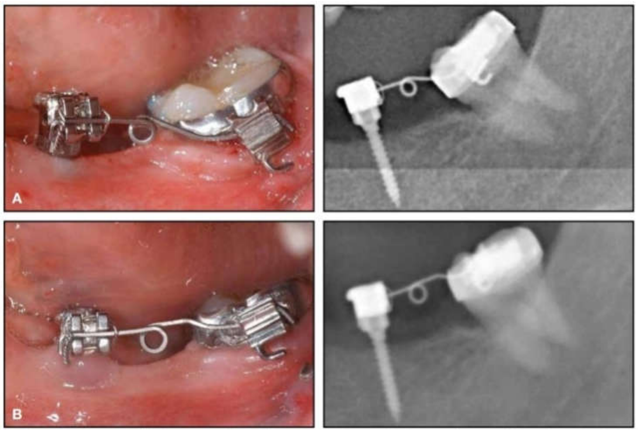

Figure 21

Miniscrew for molar distalisation

The miniscrews provide sufficient anchorage for incisor retraction in Class II treatment without unwanted orthodontic side effects. Miniscrew anchorage not only prevents flaring of maxillary incisors, an undesirable side effect of molar distal movement.

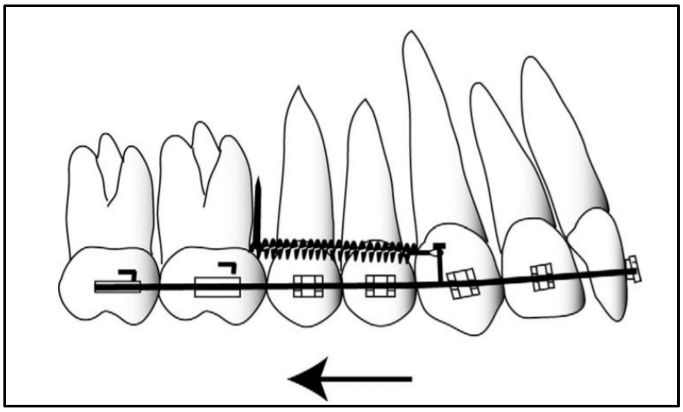

Figure 22

Upper Third Molar Alignment

An upper third molar can be uprighted with a fixed sectional wire, utilizing a palatal miniscrew for skeletal anchorage to limit unwanted extrusion of the molar.

Figure 23

Figure 24

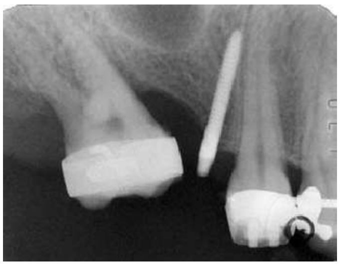

Figure 25

Alignment of Dental Midlines

When an entire arch needs to be moved laterally to correct the posterior malocclusion a screw canbe placed either lingually or buccally so that the head stands out at the crown margins to align the dental midlines without exerting vertical forces as exerted by intermaxillary elastics.

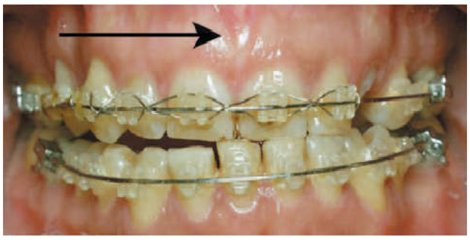

Figure 26

Figure 27

Figure 28

Figure 29

Complications

During insertion

Trauma to the periodontal ligament or the dental root

Potential complications of root injury include loss of tooth vitality, osteosclerosis, and dentoalveolar ankylosis. Trauma to the outer dental root without pulpal involvement will most likely not influence the tooth's prognosis.

Miniscrew slippage- The clinician might fail to fully engage cortical bone during placement and inadvertently slide the miniscrew under the mucosal tissue along the periosteum. High risk regions for miniscrew slippage include sloped bony planes in alveolar mucosa such as the zygomatic buttress, the retromolar pad, the buccal cortical shelf.

Nerve involvement- Nerve injury can occur during placement of miniscrews in the maxillary palatal slope, the mandibular buccal dentoalveolus, and the retromolar region.

Subcutaneous emphysema- Air subcutaneous emphysema is the condition in which air penetrates the skin or submucosa, resulting in soft-tissue distention. During miniscrew placement it can occur through the loose alveolar tissue of the retromolar, mandibular posterior buccal, and the maxillary zygomatic regions.

Miniscrew bending, fracture, and torsional stress- Increased torsional stress during placement can lead to implant bending or fracture, or produce small cracks in the peri-implant bone, that affect miniscrew stability.

Nasal and maxillary sinus perforation **-**Perforation of the nasal sinus and the maxillary sinuses can occur during miniscrew placement in the maxillary incisal, maxillary posterior dentoalveolar, and zygomatic regions

Complications under Orthodontic Loading

1. ***Stationary anchorage failure –***it is often a result of low bone density due to inadequate cortical thickness.
2. ***Miniscrew migration-*** Orthodontic miniscrews can remain clinically stable but not absolutely stationary under orthodontic loading. Orthodontic miniscrews achieve stability primarily through mechanical retention and can be displaced within the bone.

Complications during Removal

1. ***Miniscrew fracture -*** The miniscrew head could fracture from the neck of the shaft during removal.
2. ***Partial osseointegration -*** Although orthodontic miniscrews achieve stationary anchorage primarily through mechanical retention, they can achieve partial osseointegration after 3 weeks, increasing the difficulty of their removal.

Soft-Tissue Complications

1. ***Aphthous ulceration -*** Minor aphthous ulcerations, or canker sores, can develop around the miniscrew shaft or on the adjacent Buccal mucosa in contact with the miniscrew head.
2. ***Soft-tissue coverage of the miniscrew head and auxiliary-***Miniscrews placed in alveolarmucosa, particularly in the mandible, might become covered by soft tissue. The bunching and rubbing of loose alveolar tissue can lead to coverage of both the miniscrew head and its attachments within a day after placement.
3. ***Soft tissue inflammation, infection, and periimplantitis -*** Tissue inflammation, minor infection, and peri-implantitis can occur after miniscrew placement.

Hard Tissue Complications

Root Fracture-Precise placement and avoidance of roots is paramount not only to the clinical success of the TAD but also in the prevention of iatrogenic complications and their subsequent medico legal consequences

Osseous Damage-Although not a very common occurrence, damage to bone can occur, particularly during pilot hole creation

Future Forecasts

The ability to have bone anchored growth modulation devices has expanded the envelope of growth modulation .The ability to treat even adult cases conventionally indicated for surgery by TAD supported assemblies has introduced the term "*Orthognathic like Orthodontics* ".

Micro implants can be used to help treat craniofacial patients by supporting distraction osteogenesis procedures, maxillary protraction procedures, cleft segment expansion and stabilization, and tooth movement into narrow alveolar cleft sites. As an adjunct to orthodontic treatment, they can offer a potential method for solving troublesome orthodontic and surgical problems such as guiding distraction procedures with orthodontics when primaryteeth are exfoliating, addressing residual maxillarycants after vertical distraction osteogenesis of aramus, stabilizing an edentulous premaxilla, and moving teeth into atrophicalveolar ridges.

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