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# Bone Screws in Orthodontics: A Review

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## Abstract

Anchorage preparation is decisive in achieving successful orthodontic treatment. Often anchorage in an orthodontic appliance attempts to dissipate the reaction forces over as many teeth as possible and thus keep pressure in the periodontal ligaments of the anchor teeth to a minimum. Theoretically, anchor values for teeth can be estimated from their root surface areas, but this is not always reliable since anchorage capacity is also influenced by attachment level, density and structure of the alveolar bone, periodontal reactivity, muscular activity, occlusal forces, craniofacial morphology and friction within the appliance resulting from tooth movement. Use of an extraoral appliance such as headgear to reinforce anchorage is effective in that the reactive forces that normally create anchorage loss do not affect the dentition. However, these techniques require unconditional compliance; consequently, various intraoral appliances have been developed with minimal compliance demands. The need for maximal anchorage control in these intraoral appliances has also led to increased use of implants. The use of skeletal anchorage to obtain absolute anchorage has recently become very popular in clinical orthodontic approaches. The mode of anchorage facilitated by these implant systems has a unique characteristic owing to their temporary use, which results in a transient, absolute anchorage. Among the skeletal anchorage systems, the most popular being – mini implants or micro-screws which have an intra-radicular site of placement. They are easy to use and are minimally invasive with a disadvantage of early loosening during the course of treatment. A more rigid alternative was then introduced called as the SAS -Skeletal Anchorage Systems (I-plate, Y-plate etc) with its extra-radicular site of placement, which did overcome the high failure rates of a regular mini-implant but then their placement required raising of flaps and extensive surgical intervention. More recently the –Orthodontic Bone Screws (OBS) which not only had an extra-radicular site of placement in the infra-zygomatic crest of the maxilla and the buccal shelf area of the

mandible, with significantly less failure rates than regular mini-implants. OBS doesn't require extensive surgical intervention for their placement. This article is aimed at providing an overview - to the recently introduced OBS system, their technical, bio material and bio-mechanical differences with the commonly used mini-implant system, the case selection criteria, advantages, disadvantages.

**Keywords:** Bone Screw, Mini Implants, Micro Implants

## Introduction

Controlling anchorage helps to avoid undesirable tooth movements. However, even a small reactive force can cause undesirable movements; it is important to have absolute anchorage to avoid them.[1] 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.1 Such an anchorage can only be obtained by using ankylosed teeth or dental implants as anchors, both relying on bone to inhibit movement.[1,2] 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.

## Definitions

Terms such as *mini-implants*, *miniscrews*, *microimplants*, and *microscrews* have been used to describe devices of skeletal anchorage. Although the group of these terms describes devices smaller than conventional dental implants that provide skeletal anchorage which is discontinued after treatment, they should not be used interchangeably.

The prefixes *mini-* and *micro-* are currently used to describe implants or screws of the same dimension without any differentiation. However, since the Greek word *micro* is mainly used for very small dimensions, better seen under microscope, we advocate as more appropriate the use of the term *miniscrew implants*, which will be used in this article instead of the terms mini-implants, microimplants, miniscrews, and microscrews.

## Historical Development

The idea of using screws fixed to bone to obtain absolute anchorage goes back to 1945, when Gainsforth and Higley placed vitallium screws in the ascending ramus of 6 dogs to retract their canines.[3] The first clinical use reported in the literature came in 1983 when Creekmore and Eklund used a Vitallium bone screw inserted in the anterior nasal spine to treat a patient with a deep overbite.[4] However, the use of miniscrew implants for orthodontic anchorage was not immediately embraced. Thereafter, a number of papers focused on the use of other means to obtain skeletal anchorage for orthodontic tooth movement, such as dental implants, onplants, and palatal implants.[5–8] In 1997, Kanomi described a mini-implant specifically made for orthodontic use, and in 1998, Costa et al. presented a screw with a bracketlike head.[9,10] Several other miniscrew implants have been introduced since then, each presenting different designs and features. Further, during the last decade, other means of bone anchorage have also been proposed, including zygoma wires, miniplates and zygoma anchors.[11,12]

## Classification

Skeletal anchorage devices can be classified into 2 main categories, based on their origin. The first category has its origins in osseointegrated dental implants and includes the orthodontic mini-implants, the retromolar implants, and the palatal implants. The second category finds its origin in the surgical mini-implants, such as the one used by Creekmore and Eklund and those described later by Kanomi and Costa et al.[4,9,10] The main differences between the 2 categories are that devices of the second category are smaller in diameter, have smooth surfaces, and are designed to be loaded shortly after insertion.

In a similar manner, Cope classified the current available methods of skeletal anchorage as either biocompatible or biologic in nature. [13]The biologic group included ankylosed and dilacerated teeth, whereas the biocompatible group included temporary anchorage devices. He further subclassified both groups—based on the manner in which they are attached to bone—into biochemical (osseointegrated) or mechanical. In a more thorough classification of implants used for orthodontic anchorage, Labanauskaite et al. suggested the following classification:

*According to the shape and size*

- Conical (cylindrical)
- Miniscrew implant
- Palatal implants
- Prosthodontic implants
- Miniplate implants
- Disc implants (onplants)

*According to the implant bone contact*

- Osseointegrated
- nonosseointegrated;

*According to the application*

- used only for orthodontic purposes (orthodontic implants)
- used for prosthodontic and orthodontic purposes (prosthodontic implants).

**Types and Properties**

The main differences between the currently available miniscrew implants relate to their composition, size, and design and include: (1) the alloy or metal used for their fabrication (2) the diameter of threaded portion, (3) the length of the implant, and (4) the design of the head. An ideal miniscrew implant used for orthodontic anchorage would satisfy a large set of requirements, which basically make it biocompatible; available in different diameter calibers and length sizes, and different designs (i.e., button or bracket head); simple and easy to insert, with the option of self-taping and self- drilling; capable of immediate loading; removal without the need for complicated accessory equipment; and low cost.

**Biocompatibility**

With the exception of the Orthodontic Mini Implant, which is fabricated from stainless steel, all other aforementioned systems are made of medical type IV or type V titanium alloy.

**Osseointegration**

Because complete osseointegration of screws used in orthodontic applications is a disadvantage that complicates the removal process, most of these devices are manufactured with a smooth surface, thereby minimizing the development of bone ingrowth and promoting soft tissue attachment at ordinary conditions and in the absence of special surface treatment regimens.[10,14,15]

**Types of anchorage**

The miniscrew implants can provide 2 different types of anchorage: direct and indirect. When used for indirect anchorage, they are connected through bars or wires to the reactive unit, whereas when used for direct anchorage, they directly receive the reactive forces by acting as an anchor unit.

**Head design**

Most miniscrew implant systems are available in different designs to accommodate both direct and indirect anchorage and avoid tissue irritation. The most frequent is the buttonlike design with a sphere or a double spherelike shape or a hexagonal shape. Miniscrew implants available with this design include the Aarhus Anchorage System, the AbsoAnchor System, the Dual-Top Anchor System, the IMTEC Mini Ortho Implant, the Lin/Liou Orthodontic Mini Anchorage Screw, the Miniscrew Anchorage System, the Orthoanchor K1 System, and the Spider

Screw Anchorage System. With a hole through the head or the neck of the screw, usually 0.8 mm in diameter, this design is mostly used for direct anchorage. A bracket like design is also available, which can be used for either direct or indirect anchorage as provided by the Aarhus Anchorage System, the AbsoAnchor System, the Dual-Top Anchor System, the Spider Screw Anchorage System, and the Temporary Mini Orthodontic Anchorage System. Finally, a further hook design is used by the TOMAS miniscrew implant.

**Thread design**

The thread body can be either conical as in the Aarhus Anchorage System, the AbsoAnchor System, the Miniscrew Anchorage System, and others, or parallel tapering only at the end as in the Orthodontic Mini Implant. Miniscrew implants are available in different lengths and diameters to accommodate placement at different sites in both jaws. Costa et al. evaluated the depths of the hard and soft tissues of 20 patients and concluded that miniscrew implants of 4 to 6 mm in length are safe in most regions, but individual patient variation dictates individual evaluation of bone depth in all patients. Decreased diameter threads facilitate insertion to sites with root proximity without the risk of root contact.[16]

However, a major concern regarding the thread diameter of the miniscrew implants is the increased fracture noted in diameters less than 1.2 mm. Most miniscrew implants have a thread diameter ranging from 1.2 to 2.0 mm and a length from 4.0 to 12.0 mm,32-36 although some of them are also available at lengths of 14.17 or even 21 mm.

**Clinical Applications**

In general, the various miniscrew implant systems can be used in cases where the support of dental units is quantitatively or qualitatively compromised, as in partial edentulous patients or periodontally involved teeth. In addition, an absolute indication is the requirement for minimum undesired reactive forces.

Melsen suggested using miniscrew implants as anchorage for tooth movements that could not otherwise be achieved, such as in patients with insufficient teeth for the application of conventional anchorage, in cases where the forces on the reactive unit would generate adverse side effects, in patients with a need for asymmetrical tooth movements in all planes of space, and finally in some cases as an alternative to orthognathic surgical procedure.

During the past few years, the application of miniscrew implants has been expanded to include a wide array of cases, including the correction of deep over- bites, closure of extraction spaces, correction of a canted occlusal plane, alignment of dental midlines, extrusion of impacted canines, extrusion and uprighting of impacted molars, molar intrusion, maxillary molar distalization (Fig. 2), distalization of mandibular teeth, en-masse retraction of anterior teeth, molar mesialization, upper third molar alignment, intermaxillary anchorage for the correction of sagittal discrepancies, and correction of vertical skeletal discrepancies that would otherwise require orthognathic surgical procedure.[4,16–18,19]

The clinical impact made in orthodontics by micro-implants and the recently introduced infra-zygomatic crest (IZC) and buccal shelf (BS) orthodontic bone screws throughout its evolution has been massive. Mini- implants and extra- radicular bone screws have brought about a renaissance to the field of orthodontics with its concept of absolute anchorage in the past decade.

They have not only been able to solve the problems related to anchorage but also mini-implant mediated segmental distalization or full arch distalization with extraradicular bone screws have been able to treat cases the non-extraction way or even retreat cases with anchorage loss.

Due to poor mechanics, orthodontic retreatment is being common these days. It is the need of the hour that the able orthodontist finds an alternative means of rehabilitating debilitated clinical situations. The introduction of infrazygomatic and buccal shelf screws can just provide that ray of hope together with limiting the time required for retreatment. However, they need to be used judiciously. The anatomic limits, art, biomechanical perspectives, and the side effects are of prime considerations to master the technique.

**Extra Radicular Bone Screws V/S Micro-Implants:**

Both extra-radicular bone screws (IZC, BS) and micro implants are classified under temporary anchorage devices. Bone screws are placed away from the roots in the infra zygomatic areas of the maxilla and the buccal shelf areas of the mandible. Mini-implants are placed in between the roots of teeth (mostly) – intraradicular.[20]

Regular size of a micro-implant ranges between 6 and 11 mm in length and 1.3–2 mm in diameter depending on the clinical situation, it needs to be used for; bones screws are comparatively larger in size ranging from 10 to 14 mm in length and a minimum diameter of 2 mm. Just like a micro-implant may be available as a short or a long head one, bone screws are also available as a short or a long collar depending on the anatomic site and the clinical situation it needs to be used for. Their head shapes may also vary just as mini-implants, the common being mushroom shaped.[20]

Most of mini-implants are made with an alloy of – titanium, aluminum and vanadium (Ti6Al4Va). Bone screws are also available with the same composition as that of micro-implants but the choice of material is pure stainless steel. Bone screws require requires greater fracture resistance since they are generally placed in areas of DI (>1250 HU) quality bone (IZC and BS areas) and therefore Stainless steel provides greater fracture resistance than Ti alloy. Therefore the preferred material of choice for bone screws is Stainless Steel.

**Bone Screws: Indications**

Because of their larger dimension orthodontic bone screws can be used in almost every clinical situation that a mini-implant is used for, except that they cannot be placed interdentally. Full arch distalization of maxillary and mandibular dentition to camouflage a Class II and a Class III malocclusion is one of the main indication for bone screws. Another important indication is distalization of arches in retreatment cases of anchorage loss, which are otherwise difficult and time consuming to be treated with conventional mechanics or mini-implants.[20]

They can be used for segmental or full arch distalization, molar uprighting, intrusion of single tooth to full arch, protraction and retraction of dentition.

**Orthodontic Bone Screws: Sizes**

Orthodontic bone screws in the maxilla (IZC) are available in two sizes commonly (manufacturer specific) – 12 and 14 mm in length and 2 mm in diameter. When the soft tissue in the buccal vestibule is thick as in most clinical situations, the preferred choice is a 14 mm screw which have 7 mm of head and collar area and 7 mm of cutting spiral. Orthodontic bone screws of 12 mm length are preferred in cases of thin soft tissue at the vestibule. The length of cutting spiral, head, and collar dimensions may vary according to the choice of manufacturer. Bone screws in the mandible are available in two sizes commonly (manufacturer specific) – 10 mm and 12 mm in length and 2 mm in diameter. Buccal shelf area in the Indian population is mostly found to be thin and deep; therefore, the preferred choice will be a 12mm screw. The head and collar sizes of both the variants (10 and 12 mm) are almost the same but may vary according to the choice of the manufacturer.

**Orthodontic Bone Screws: Sites**

**Maxilla**

Infra-zygomatic crest is the most preferred site for placement of Orthodontic bone screws in maxilla. It lies higher and lateral to the 1st and 2nd molar region [Figure 2].[1,2] [20]Some authors (Lin) prefer bone screws to be placed in the 1st and 2nd molar region others (Liou) opine a more anterior placement, closer to the MB root of the 1st molar **[Figure 1 & 3 ]**.

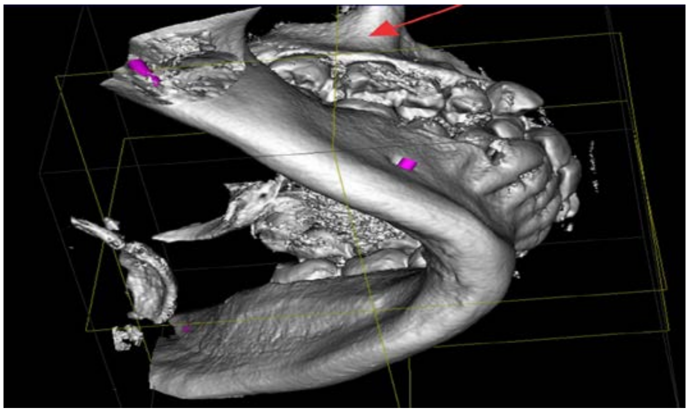

**Figure 1:- Site of insertion of bone screw in the Maxilla: Infra-zygomatic Crest.**

**Mandible**

Buccal shelf area is the preferred site for placement of bone screws in the mandible, which lies lower and lateral to the 2nd molar region [Figures 4 and 5]. if the buccal shelf area is found to be too thin or too deep, as is so commonly seen in the Indian population buccal shelf bone screws can also be placed in the external oblique ridge of the mandible. Both the areas have D1 (>1250 HU) quality bone. **[Figure 2 & 3 ]**[20]

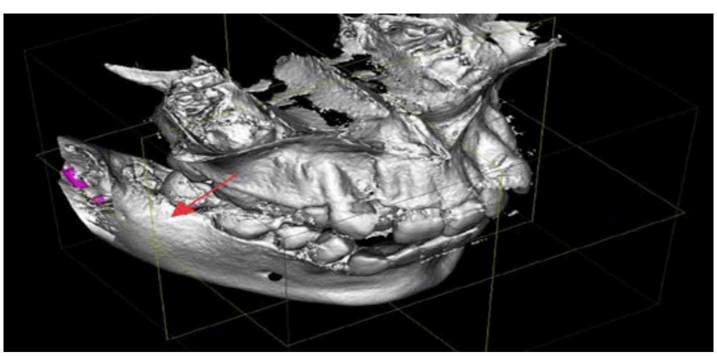

**Figure 2:- Site of insertion of bone screw in the Mandible: Buccal Shelf Area.**

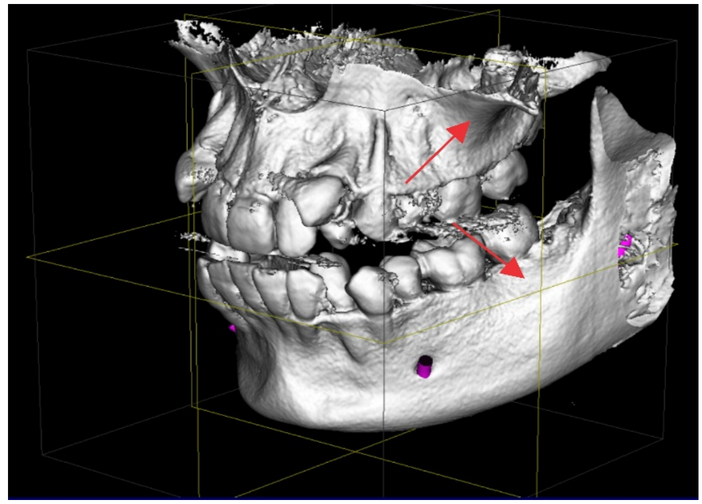

**Figure 3:- Site of insertion of bone screw in the Maxilla and Mandible: Infra-zygomatic Crest & Buccal Shelf Area.**

**Technique of Placement of Bone Screws in the Infra-Zygomatic Crest**

The initial point of insertion for placement of bone screws in the IZC is inter-dentally between the 1st and the 2nd molar and 2 mm above the muco-gingival junction in the alveolar mucosa. The self- drilling screw is directed at 90° to the bone surface at this point when viewed from frontal aspect. After the initial notch in the bone is created, two to three turns of the driver is done, then the bone screw driver is reversed by one turn and then direction is changed by approximately 30° towards the tooth, downward, and subsequently 45° and then around 70°-80° which aid in bypassing the roots of the teeth and directing the screw to the infra- zygomatic area of the maxilla. The bone screw is screwed in till only the head of the screw is visible outside the alveolar mucosa. No pre- drilling, raising of flap or vertical slit in the mucosa is required for insertion of IZC screws. Immediate loading is possible and a force of up to 300–350 g can be taken up by a single bone screw.

**Technique of Placement of Bone Screws in the Buccal Shelf Area**

Initial point of insertion is inter-dentally between the 1st and the 2nd molar and 2 mm below the mucogingival junction for placement of bone screws in the buccal shelf area of mandible. The self- drilling screw is directed at 90° to the bone surface at this point when viewed from frontal aspect. After the initial notch in the bone is created, two to three turns of the driver is done, then the bone screw driver is reversed by one turn and the direction is changed by approximately 30° towards the tooth, upward, and subsequently 45° and then around 75° which aid in bypassing the roots of the teeth and directing the screw to the buccal shelf area of the mandible. In the mandible, however, sometimes vertical slit or pre-drilling in the mucosa is necessary if the bone density is too thick, however, raising of flap is never required. Immediate loading is possible and a force of up to 300–350 g can be taken up by a single bone screw.[1,2] However, there are varied concepts of bone screw placement and it is best left to the clinician to determine which is preferable for him.[20]

**Complications**

Gingival overgrowth on the screw is the most common complication associated with bone screws. Early loosening of the screw is another possibility. Minor bleeding is one of the Complications associated with the insertion process of bone screws are very less. If pure stainless steel good quality screws are used breakage of tip of the screw is never a problem. Oral hygiene maintenance is of utmost necessity to avoid problems related to gingival overgrowth. The incidence of gingival overgrowth is far less with screws having larger heads. In case of early loosening of the screw– replacement of the screw is advisable in a different site.

The stability and success rate of bone screws are far more superior as compared to mini-implants because of their larger dimension and placement sites having excellent quality of cortical bone. Reports suggest overall failure rates of micro- implants to be 13.5% while bones screws to be – BSS (7.2%) and IZC (7%).[17]

The aim of any new clinical protocol is to improve the quality of treatment delivered together with the addition of precision, broadening the horizons of treatment, and improve the compliance factor for both the patient and the clinician, and this is the same with orthodontic bone screws.

The distalization techniques with these extraradicular bone screws when used judiciously could help in overcoming newer challenges and go beyond boundaries in achieving the ultimate goal of – “Clinical Excellence.” Orthodontic Bone Screws free clinicians from the need for patient’s compliance and increase the amount of treatment options, thus providing ease to cases initially seen as too complex or unfeasible in terms of conventional orthodontic treatment methods.

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