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Review Article

Skeletal Anchorage System [Miniplates] - An Orthodontic Perspective - A Review

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Abstract

In the orthodontic world paradigms have started to shift since the invention of mini-plates in the anchorage armamentarium. Miniplates as bone-borne anchor unit have enabled us with management of wider discrepancies than those with tooth-borne anchor unit by conventional biomechanics. Miniplate enables clinicians for having good control over tooth movement and anchorage control in three dimension that is sagittal, vertical and transverse plane. This present literature review will explain about how the skeletal anchorage system is versatile with usage of miniplates for the correction of malocclusion, emphasising on orthodontic and orthopedic movements within three dimensions. Management of impacted teeth and adult orthodontics along with periodontal conditions is also explained in this review.

Keywords: Miniplate; Anchorage; Skeletal Anchorage Systems (SAS); Molar Distalization

Introduction

The practice of clinical orthodontics is mainly reliant on the availability of anchorage. According to Graber, anchorage is defined as nature and degree of resistance to displacement offered by an anatomic unit when used for the purpose effecting tooth movement [1]. Its role in orthodontic treatment was appreciated since the 18th century, as prominent orthodontists such as Gunnell, Desirabode, and Angle realized the limitations of moving teeth against other teeth used for anchorage, introducing ideas such as the use of occipital, stationary, and occlusal anchorage [2]. Assuming ideal treatment goals, anchorage requirements need to be evaluated in three planes of space: anterior-posterior (AP), transverse, and vertical. Until recently, orthodontists relied on intra-and/or extra-oral devices that usually required patient compliance to prevent undesired tooth movement. Absolute anchorage is required to avoid unwanted tooth movement cause by reactive forces. In absolute or infinite anchorage due to force applied to move teeth there is no movement of anchorage unit [3]. Such an anchorage can only be obtained by means of skeletal anchorage which includes all the devices that are fixed to the bone. Miniplates were introduced to offer absolute orthodontic anchorage a year after the introduction of miniscrews. In 1998, Sugawara.,

et al. distalize lower molar for rectifying class III malocclusion using titanium miniplates and eventually evolved the skeletal anchorage system (SAS) [4]. In 1999, Unemori., *et al.* reported on the use of miniplates to intrude the posterior segment to correct anterior open bites [5]. While comparing TADs with mini plates, the miniplate system is advantageous as they do not interfere with tooth movement and the 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 [6].

Skeletal anchorage systems (SAS) - Miniplates

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 [7,8]. The miniplates are the most effective and anticipated treatment modality option [9,10]. Using miniplate the dentoalveolar complex can be remodeled beyond the limits of contemporary mechanics. Additionally, bone repositioning and growth modification[4]can be achieved by miniplates they transfer the orthopedic forces directly to the facial skeleton and reactions of periodontal anchorage, leading to a reduction in unwanted side effects [8].

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 [11-13].

Appliance design

Bone plates and fixation screws are the components of the skeletal anchorage system [7]. The plates and screws are made of commercially pure titanium that is biocompatible and suitable for osseo-integration; which is strong enough to withstand and resist the optimal orthodontic forces but it can also be bent with ease for fitting into the bone contour of the implantation site. The miniplate is shaped according to bone morphology and is fixed in the cortical bone area above roots using fixating screws; two or three screw according to plate used [14,15]. The surgical site requires at least 2 mm of cortical bone thickness to fix the anchor plate using monocortical screws, which are 2.0 mm in diameter X 5.0 mm in length. The shape of the screw is square head tapered internally and a body which is self-tapping and threaded.

The miniplate plate consists of the three components (Figure 1):

- The head
- The arm
- The body.

There are two types of head portion according to manner of tooth movement, which vary with regard to the direction of hooks [10].

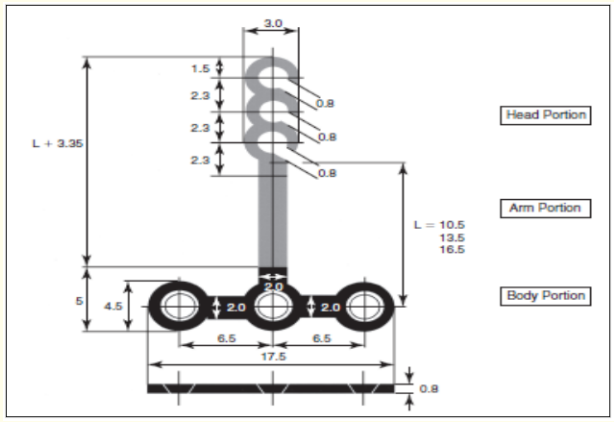

Figure 1: Design of a T-type miniplate [16].

The miniplate consists of a specially designed head with two segments:

- Hooks to attach elastics, coil springs, elastomeric modules;
- Reamed oblong apertures with a maximum cross-section of .022 - .028" for insertion of auxiliaries (cantilever or stabilization auxiliary).

There are three basic types (Figure 2):

- The T-plate,
- The Y-plate and
- The I-plate.

The choice of miniplate (T-, I-, Y- or L-shaped) and the length of the stem (5, 7 or 10 mm) will depend upon the chosen placement site, bone density (two or three screws), the depth of the buccal sulcus and the facial typology (Figure 3).

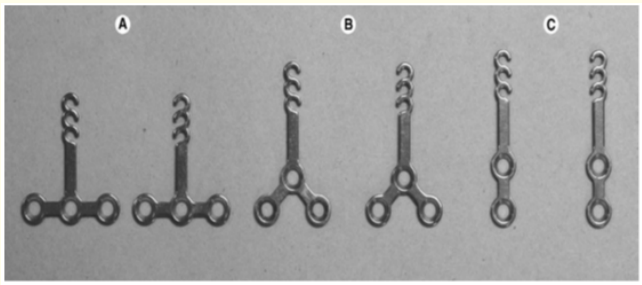

Figure 2: Miniplate. A) T-type, B) Y-type, C) I-type [8].

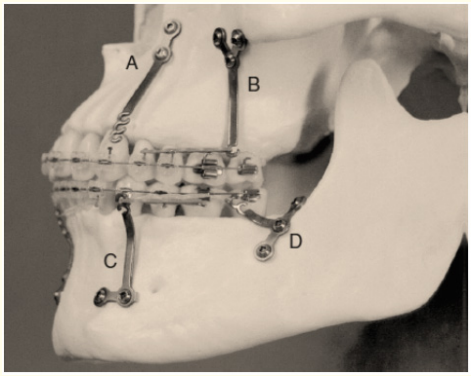

Figure 3: Position of miniplates. A) I-type, B) Y-type, C) L-type, D) T-type [4].

Site of miniplate placement

In the maxillary sites screw fixation is possible but they are limited to the zygomatic buttress and the piriform rim. The Y-plate is used to intrude or distalize upper molars which are usually placed in the maxilla at the zygomatic buttress. I-plate is routinely placed at the anterior ridge of the piriform opening for intrusion of upper anterior teeth or protraction of upper molars. The L-plate and/or the T-plate are usually placed at the anterior border of the ascending ramus for extrusion of impacted molars or in the mandibular body for intrusion, protraction, or distalization of lower molars.

Preparation for surgery

A team of oral surgeon and orthodontist is needed for placement of miniplates. Combined efforts of an orthodontist and oral surgeon where, the orthodontist selects the type and length of miniplate and plans on the exact position of the head over panoramic radiograph and the oral surgeon must assess anatomical limitations or any pathology at the miniplate placement sites through radiographic and clinical examinations [17]. General status of the patient is also considered.

Indications

Skeletal orthodontic anchorage devices are indicated when stationary anchorage is required involving diverse anchorage tasks [12,18]. In particular, these can include:

- Complete retraction of the arch (symmetrical or asymmetrical, maxillary or mandibular)
- Space closure from mesial
- Space closure from distal
- Intrusion and extrusion (anterior and posterior teeth)
- Distalization, mesialization, and midline corrections
- Molar uprighting.

In cases requiring absolute anchorage, miniplates are comparatively superior to miniscrews. The miniplate does not interfere with the roots of moving teeth and as the head of miniplate is closer to centre of rotation of arch, the force applied will induce controlled and continues movement. Thus miniplates are more reliable and no patient cooperation is required [9]. Miniplates offer supreme effectiveness even with conditions like asymmetrical retraction, full arch distalization [19].

Absolute contraindications include patients with titanium element allergies, any local active infection, blood-borne diseases, cardio-vascular diseases, metabolic bone disorders or any bone pathologies, ongoing bone radiation therapy, psycho-somatic disorders and current/previous bisphosphonate therapy. Relative contraindications are inadequate patient compliance, poor oral hygiene, parafunctional habits, and the use of drugs, alcohol, or tobacco; depending on whether the condition can be eliminated or resolved before surgical placement of miniplate [17].

Miniplate placement procedure

The surgical procedure is routinely accomplished under local anesthesia. A mucoperiosteal incision is made at the buccal vestibular of the implantation site -vertical incision in maxilla, -horizontal incision in mandible. As the mucoperiosteal flap is elevated the cortical bone surface is exposed and the Suitable type of mini-

plate is selected and contoured to fit the surface of cortical bone [17]. Miniplate is nicely secured to bone with monocortical screw (if self tapping type pilot hole is to be drilled first). In maxilla, for securing miniplates self-drilling screws are more pertinent [20]. At this moment it is important to ensure that: All of the miniplates are transfixed at the region of the buccal vestibule, does not disturb mandibular movement or adjacent soft tissues, emergence of the miniplate at the mucogingival junction or within the attached gingival is essential for good soft tissue healing and management, exposure of the miniplates through the mobile mucosa may result in increased irritation, inflammation, infection, and soft tissue overgrowth around the miniplates. Finally with resorbable suture the mucoperiosteal flab is sutured. The surgical placement of miniplate usually requires 10 to 15 minutes individually.

Miniplates with two or three screws have good mechanical stability at time of placement so immediate loading of orthodontic force is possible. It is usually applied about 3 weeks after implantation surgery. In general orthodontic force is usually applied 3 weeks following miniplate placement surgery to allow soft tissue healing and to subside facial swelling post-operatively [14]. Measures are to be taken to re-establish oral hygiene procedures.

Miniplate removal procedure

All miniplates and screws are routinely removed after the completion of orthodontic treatment, under local anesthesia. Initially a short mucoperiosteal incision is made and subperiosteal ablation is performed at the implantation site to expose miniplate body and fixation screw. Any remaining inflammatory tissue is curettage to accelerate healing of soft tissue and the mucoperiosteal flap is sutured with resorbable suture [17]. Medication like Analgesics, antibiotics are prescribed to control postoperative swelling and infection. Oral hygiene is reestablished with oral rinse solutions.

Orthodontic biomechanics with SAS (miniplates)

Presently the most significant advantage of SAS is its achievement of predictable 3D molar movement without the need for patient compliance [4,7,21]. 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 (Figure 4).

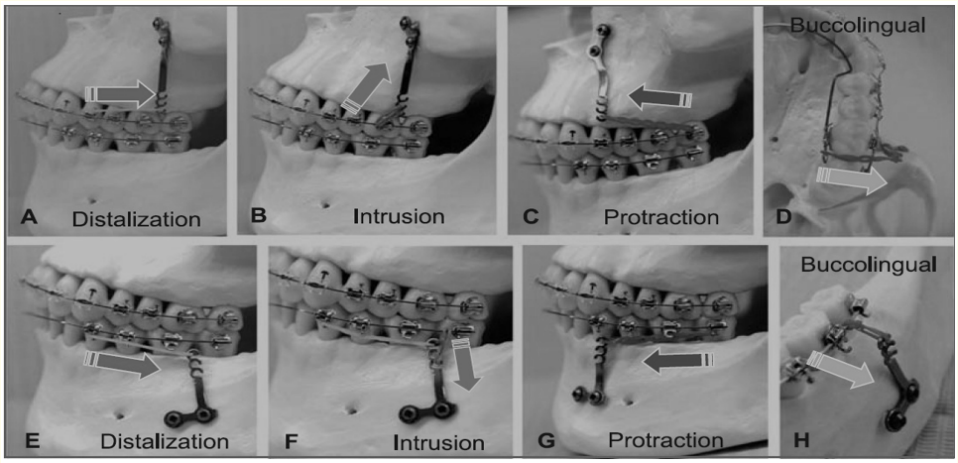

Figure 4: Miniplate position and biomechanics [4].

Molar distalization

While molar distalization has always been considered difficult, 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 [19]. 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 de-

compensation of the upper incisors before orthognathic surgery. And 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 [21].

Molar intrusion

With traditional orthodontic mechanics intrusion of molars is extremely difficult but orthodontic intrusion using a miniplates anchorage placed at the zygomatic buttress for maxillary molar, or at the posterior mandibular body for mandibular molar is now achievable [21]. After the placement of a rigid rectangular archwire in the buccal side and a transpalatal arch (TPA) in the maxilla or a lingual arch (LA) in the mandible, an elastic intrusive force will be provided from the miniplates anchorage [22]. Intrusion of maxillary molar is indicated for cases with anterior open bite cases, posterior vertical maxillary excess and moderate Class II relation. And 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 [23,24].

Molar protraction

With miniplate placed at the anterior mandibular body or at the piriform rim, orthodontic protraction of molar is effortless [25,26]. 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. And protraction of mandibular molar is indicated in cases with Class II molar relationship, a symmetrical mandibular dentition, congenitally missing second premolar, diastemas of mandibular dentition [27,28].

Clinical application of SAS (miniplates)

Non-surgical camouflage treatment: Majority of skeletal problems like anterior open bite, class II and class III deformity can be treated with camouflage or compensation methods using SAS (miniplate) that conventionally needed orthognathic surgery. As compared to other orthodontic TADs miniplates have more stability, high success rate, offer more controlled tooth movement and do not interfere tooth movement. Consequently, goal oriented approach and foreseen treatment outcomes can be executed [29,30].

- **Orthopedic movement:** A new orthopedic treatment for maxillary protraction using pure bone-borne orthopedic force between the maxilla and the mandible has been reported by De Clerck., *et al.* and Heymann., *et al.* orthopedic force is generated by Class III elastics connected with miniplates which are inserted into the infra-zygomatic crests and bilaterally between the mandibular canines and first premolar [30,31]. Since this intraoral appliance is invisible, long-time use (24 hours per day), prevent dentoalveolar compensation. Wilmes., *et al.* reported a technique of skeletally borne maxillary protraction by using miniplates combined with bone-borne rapid maxillary expansion [32].
- **Speedy orthodontics:** Chung., *et al.* reported 'corticotomy-assisted orthodontic treatment called speedy orthodontics' [10]. Peri-segmental corticotomy is carry out in two steps; first labial coricotomy and then two weeks later palatal coricotomy ; to outline the anterior or posterior teeth bearing segment. Orthopedic force of 500-900 gm per side is applied to the corticotomized segment which derives anchorage from miniplates to bring about faster space closure.
- **"Surgery First" orthognathics:** Nagasaka., *et al.* for the treatment of skeletal Class III malocclusion describe "Surgery First" orthognathics with the rigid fixation with miniplates [4]. The principle of "Surgery First" is to correct the skeletal discrepancy first and then correct the dental relation. This surgery first orthodontics has two significant advantages: a shorter treatment time and rapid improvement of the facial profile. The SAS is vitally important for intermaxillary fixation, a stable and functional occlusion is very likely obtained without extraction of bicuspid or segmental maxillary osteotomy. This technique represents a potential paradigm shift in field of surgical orthodontics.

Miniplate advantages, failure and complications

Advantages

- Bio-compatible.
- Miniplates are most rigid of the skeletal anchorage available.
- Located away from the dentition, and therefore, do not interfere with tooth movement.
- Reduces the need for significant patient compliance, with regard to extraoral appliances.
- Allows more predictable treatment results.

- An overall decrease in the number of teeth extraction and orthognathic surgery cases.
- Molars can be moved in any direction without taxing anchorage.
- Occlusal plane can be controlled by orthodontists, without the need for surgery.

Failure and complications

Nagasaka in 2012 showed in 210 consecutive patients, 551 miniplates were implanted in the first three year after development of the SAS [4]. Miniplates have low failure rate when compared with miniscrews. The failure rate due to miniplate mobility in the mandible (2.8%, 6 miniplates) and maxilla (0.3%, 1 miniplate) with an overall failure rate was 1.7%. The possible reasons for failure of miniplate are: infection from nearby extraction socket intervene healing process, rigid fixation of miniplate result in progressive compression bone necrosis around the screws, thin cortical bone support and low bone density (younger age patients) result in poor primary stability, excessive bending of miniplate by orthodontist causing fracture of miniplate, of lack of primary stability by fixation screw due to excessive sinus pneumatization in maxilla.

The most common complication is acute infection, with pain, swelling, and pus production at miniplate implantation site [34]. Other potential complications include mucosal overgrowth over miniplate head and very rarely numbness [34,35].

Conclusion

Skeletal Anchorage System has mainly changed the possibilities and paradigms in orthodontic treatment [13,35]. The use of the miniplate for absolute anchorage has proved to have many attractive features and 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 [36,37].

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.

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