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A Review on Mini-Implant.

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ABSTRACT

Anchorage in orthodontic is the main key for the success of treatment; so, the development in dental implant recently, allows stationary anchorage without the need for extraoral or intraoral anchorage device. The implants used in orthodontics are also known as temporary anchorage devices (TADs), have become a popular concept in orthodontics because they are small and easy to insert and remove, can be loaded immediately after insertion, cost effectiveness and provide absolute anchorage for many types of orthodontic treatment with minimal need for patient cooperation, in addition to reduce the need for extraction treatment or orthognathic surgery in some moderate and sever skeletal malooclusion. So, the indications, contraindications, safety zones for mini implant insertion, insertion procedure, complications and reason of failures have been explained in this review.

Keywords: Mini-implants, Anchorage, Screw

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INTRODUCTION

A goal of any orthodontic treatment is to achieve desired tooth movement with a minimum number of undesirable side effects and eventually to improve patient's esthetics , *SO* different methods for anchorage control has been suggested, such as using the opposing arch, extra oral anchorage, increasing the number of teeth in the anchorage unit or circum-oral musculature. [(1)]

Nowadays, with the advent of implantation, maximum anchorage has become possible and unwanted side effects have been reduced to a minimum, so what we mean by implantation?

Implantation is the transfer of nonliving tissue into a biologic system; this concept differs from transplantation, which is the transfer of living tissue. [(2)] Mini-implants which are also known as Temporary Anchorage Devices (TADs) are small titanium bone screw or stainless steel bone screws which are placed either in buccal alveolar bone or the palatal side and can be placed also on the paramedian areas of the palate in growing children. [(3)]

The use of TADs can ensure a rigid intra-oral anchorage through which different tooth movements in all three planes of space can be provided. This might as well serve as an alternative to orthognathic surgery, especially in those instances where changes in the vertical dimension are required; they can vary in size form 5-12 mm in length and from 1.2-20 mm in diameter. [(4)]

Historical Background

Because of the limitations of headgear, clinicians sought other means of anchorage. For example, orthopedists have used stainless steel bone screws for leg lengthening since before 1905. [(5)]

In 1945, research into the concept of using a pin or screw attachment to the ramus was initiated not only for moving teeth, but also for exerting a pull on the mandible. [(6)]

As early as the nineteen seventies, maxillary anterior teeth had been retracted against a surgical wire anchor inserted into a hole drilled through the inferior part of the zygomatic arch [(7)].

This method of skeletal anchorage, however, was limited to use in those patients who only required retraction of maxillary teeth and thus it did not fulfill the anchorage requirements [(7)].

An alternative to the zygoma wire was the use of palatal implant [(8)] as introduced by Werhbein and Glatzmaier (1996), the palatal implant met the requirements for anchorage for retraction of maxillary anterior teeth, but these were introduced primarily as an alternative to extra-oral anchorage and other types of anchorage requiring patient compliance[(8)] .

The use of small osseointegrated implants allowed tooth movements that had not previously been possible, i.e. movement of teeth mesially without introducing any forces to the reactive units [(9)].

The first use of a surgical screw as anchorage was described by Creekmore in a case report of a single patient but this did not immediately attract a lot of attention [(10).]

One study involved placing Vitallium screws (DENTSPLY) in dogs. Using basal bone for anchorage, tooth movement was successful; however, it was found that an effective force could be maintained for no longer than 31 days. The loss of all screws was attributed to infection from communication between the Vitallium screw and the oral cavity. [(6)]

It has taken 60 years to progress from stainless steel to Vitallium (used in dogs) to the current standard, titanium. Titanium has many valuable properties: it is three times stronger than stainless steel; exhibits little response to electricity, heat, or magnetic force; is highly biocompatible; and is inert. [(6)]

Implant Classification

Implants are classified as:

Depending on area of implantation as:

- Subperiosteal is placed under the periosteum and rests on the bone surface without penetrating it.
- Endosteal is partially submerged and anchored within the bone.
- Transosseous penetrates the bone completely. [11]

Depending on their shapes as:

- Screw-type.
- Blade type.
- Cylinder-type implant. [12]

Based on the condition of exposure as:

- Open implants (have contact with the oral cavity).
- Closed implants (usually used for skeletal fixation) [12].

Screws are classified according to the method of insertion to:

- Pretapped screws.
- Self-tapping screws.
- Self-drilling screws.

Pretapped screws are used in harder, less compressible materials, such as in metal or in cortical bone and not suitable for thin bone, such as the maxilla, because the screw threads cannot be readily compress these firm materials. [13, 14]

Pretapped screws require the use of a tap to precut the thread

Self-tapping screws are used in softer, less compressible materials and form threads by compressing and cutting the surrounding materials. [14]

They have a fluted leading edge and require only a predrilling procedure, meaning that the tapping procedure is omitted. [14]

Self-drilling screws also referred to as *drill-free screws,* have a corkscrew-like tip; therefore, neither predrilling nor tapping procedures are needed. [14]

Indication for Mini-implant:

The most common clinical indications are [15]:

- Insufficient number of teeth and/or lack of occlusion in the anchorage unit, e.g. patients with agenesis or who have lost teeth for various reasons.
- Extrusion or intrusion of single teeth or units of teeth without antagonists (no opposing vertical forces acting on them).
- Asymmetric tooth movements: the displacement of teeth in a single direction, as in the case of A-anchorage, C-anchorage, unilateral expansion; or the displacement of all teeth, in either an arch or quadrant, in the same direction.
- Retraction and/or intrusion of anterior teeth with insufficient anchorage in the reactive unit.
- Mesial movement of molars in cases where the anterior teeth cannot afford to be retracted.

- Proclination of anterior teeth in cases where no posterior anchoring element is available, or the reactive forces would have an adverse effect.
- Space closure in maximum anchorage cases.

Contraindications for Miniimplant:

While there are many legitimate reasons to consider the use of mini-implants in orthodontic treatment, it may also be considered an imprudent use of them when the case can be just as easily treated with conventional biomechanics [15].

- Patients who are suffering from metabolic bone diseases
- Patients receiving immune suppressive therapy
- Patients on chronic steroid or bispfosphonate medication
- Patients who are incapable of following the instructions for postoperative care. Causes for this are, for example, patients with psychological/mental or neurological problems
- Patients with bone tissue either insufficient or of poor quality to provide primary stability
- Patients with circulatory disturbances or latent infections
- Patients with hypersensitivity to specific materials
- Acute infections
- Radiotherapy in the head region and patients with tissue damaged by radiation
- Recurring diseases of the oral mucosa and poor oral hygiene

Complications of Miniimplant:

- Root injury from inadequate interradicular space.
- Vessel injury and sinus injury.
- Soft tissue inflammation around the implant (Periimplantitis especially when placed in alveolar mucosa).
- The screw may break during insertion or removal or, if placed on the lingual aspect of the mandible, may be very uncomfortable for the patient.
- Screws can sometimes loosen and become lost.
- Sometimes it is difficult to attach elastics and wires to different types of screw heads. [24]

However, because complications are minimal, advantages and clinical applications favor the use of the miniscrew for successful treatment. In addition, screws are temporary, easy to remove and economical .The potential for application of the miniscrew is limited only by the imagination and the clinical proficiency of the individual clinician. These devices have provided superior alternatives that previously were not possible in orthodontic treatment. [16]

Healing Process and Formation of the Tissue-Implant Interface:

In any kind of insertion procedure, surgical trauma and consequent damage to the adjacent bone are inevitable. The damage triggers the healing process of the bone tissue, and typical bone wound-healing processes are initiated. [17]

The healing process progresses in three phases: the inflammation phase, the reparative phase, and the remodeling phase. From the viewpoint of stability, an osseous interface is more desirable than a fibrous interface. [17]

During the healing process, a broad spectrum of interface types is formed between the implant and tissue. The biomechanical characteristics differ, depending on the interface. A direct biochemical attachment to the bone surface has the strongest bond strength at the interface. Cell viability is not essential for the composite structure of a bone-implant interface to function. Dead bone can support the implant, but it also has the potential to become unstable as microdamage becomes more concentrated. [18]

Factors affecting formation of the interface:

Because the bone is an extremely well-organized and highly differentiated tissue, this process is affected by:-

General conditions:

Metabolic diseases such as osteoporosis, Calcium metabolism, and Hyperparathyroidism and irradiation therapy may affect the healing process of bone tissue clinically, however, local bone density seems more important than systemic bone density, and orthodontic mini-implants can be used as long as sufficient primary stability can be obtained from the existing cortical bone. [19]

Local conditions:

The quantity and quality of the host bone bed of the implantation site also greatly influence primary stability (i.e., the mechanical stabilization immediately after implantation).

Primary stability is closely related to healing conditions and loading conditions; the blood supply also influences the healing process. [20]

Biocompatibility of the implant:

Implants for orthodontic anchorage are made of alloplastic materials. Biocompatibility is strongly influenced by the surface characteristics of the materials, because the primary chemical interaction between an implant and its host tissue takes place over a few atomic radii.

In other words, the biocompatibility of the surface texture greatly influences which type of interface is formed or how fast the adjacent tissue reacts and it is also strongly related to the long-term maintenance of the interface. [20]

Implant materials can be classified by their biocompatibility into:-

Bioactive, bioinert, and *biotolerant* materials. Bioactive materials, such as hydroxyapatite or aluminum oxide, can create chemical bonds with bone.

Additionally, implants have sufficient strength, and mechanical failure or fatigue failure should not occur during the functioning of implants. There should be no ion leakage or corrosion products in vivo. Generally, stainless steel and chrome-cobalt alloy are considered stabilized materials. Chronic inflammation and fibrous encapsulation can result from corrosion products. [20]

Size of the implant-bone space:

Shortly after implantation, the implant-bone space fills with a blood clot and host bone chips that arise from the surgical procedure.The dimension of the implant-bone space influences the results of the healing process and the mode of ossification. As the space is widened over the critical threshold, the amount of bone-implant contact decreases. [21]

For areas where new bone formation occurs, the appropriate implant-bone space may enhance establishment of circulation for bone formation.

In addition, the effect of the space on bone healing may differ depending on whether bone growth occurs *toward* or *from* implant surfaces, which is influenced by the biocompatibility of the implant. On the other hand, for areas where existing bone provides initial mechanical stabilization, the dimension of the implant-bone space should be minimal. [21]

Surgical trauma:

Bone will permanently heal with fibrous tissue as a response to severe trauma, whether it is of a physical, a chemical, or another nature.

The larger the area of injury, the greater the chance that healing will result in poorly differentiated fibrous tissue instead of highly differentiated bone tissue.

Mature bone is temperature sensitive. If the temperature raises, an element of bone, alkaline phosphatase, is destroyed; as a result, alkaline calcium synthesis and bone formation do not occur. It has been found that bone tissue damage occurs when the bone temperature reaches 47°C for 1 to 5 minutes. [22]

Surgical trauma can be reduced with the use of well-sharpened drills under flowing saline cooling at a high speed during the drilling procedures and at a low speed during the insertion procedures. [22]

Healing conditions:

Excessive movement or excessive micromotion adversely affects the healing sequence that leads to direct bone anchorage of implants.

Low levels of micromotion may be tolerated or may even stimulate bone formation, but micromotion over the critical threshold may prevent bone ingrowth and depress bone formation. This threshold can be determined according to the implant surface and design. [23]

Loading conditions:

Bone healing around endosseous dental implants is affected by peri-implant loading conditions; Orthodontic loading may affect the modeling and remodeling activity of the peri-implant bone tissue (i.e., bone-to-implant contact, marginal bone level, marginal bone apposition, bone density, and turnover rate of the bone). Whereas appropriate loading may stimulate increased bone formation early loading or excessive loading could have detrimental effects on bone formation, However, it is not the loading itself or its timing but rather the strain applied to bone that affects the healing process [24]. If loading is well controlled clinically, immediate loading will not compromise stability in cases where mechanical stabilization of implants from the existing cortical bone ensures sufficient primary stability, it is generally possible to apply orthodontic forces immediately; however, a 4- to 6-week healing period may be advisable in a growing patient even the same loading conditions may induce different bone responses depending on the biocompatibility of the implants. [24]

Orthodontic Applications:

Clinically, one implant can tolerate 200 to 400 g of orthodontic force. Generally it is used for retractive mechanics but can also be used for pulling mechanics.

Direct application:

It is possible to hook an elastic chain or a nickel-titanium coil spring directly to the button in the coronal part of the implant .However, the bone-implant interface is vulnerable to impact stress, so orthodontic force should first be applied to teeth or hooks, and the force can later be applied to the implant to avoid unnecessary stress to the implant. [25]

Indirect application:

If the coronal head part of an implant is used, splinting with teeth or an implant is possible, and various attachments can be bonded without surface treatment. However, a sandblasting surface treatment does increase bond strength and is recommended where bonding stability is critical. [25]

Insertion Depth:

As the amount of implant exposure increases, the discomfort of the patient and stress from the oral environment also increase. This can have adverse effects on the healing process and maintenance of the implant.

However, if the exposure is inadequate, particularly in the oral mucosa or areas in which the soft tissue moves a great deal, soft tissue covering, persistent inflammation, or the development of abscesses may occur.

An adequate exposure of mini-implant is determined by the condition of the soft and hard tissues and the surrounding environment within the oral cavity. [26]

When poor bone quality or insufficient primary stability is an issue, it is better to place the implant deeper, even though soft tissue problems are likely to occur.

Deeper placement of the implant decreases the stress to the implant from the oral environment and, hence, produces more favorable conditions for the healing process.

Furthermore, when placed deeper, the tapered core of an implant increases the bone-condensing effect, which then improves the quality of bone so as to enhance primary stability. [26]

In the palatal interdental area, it is best that the implant be inserted at a sufficient depth, because the palatal gingival is keratinized thick and is specialized mucosa; when tissue problems do occur, they rarely progress to infection. Deep placement increases stability while maintaining a minimal area of exposure, which consequently reduces irritation from the tongue.

When an implant is placed in the mucosa, adequate exposure is needed to ensure that the implant does not become covered. However, it should be kept in mind that the greater the exposure, the more negative the effect on the healing process, which, in turn, could adversely affect the stability of the implant.

Covering the implant head with an elastic, light-curing provisional filling material can prevent soft tissue coverage to some extent. [27]

Insertion site and angle:

Generally, a mini-implant should be inserted near the mucogingival junction (MGJ). For this reason, at the start, the tip of the implant should be placed about 1 mm apically to it depending on the diameter of the implant.

The vertical positioning of the implant should generally be slightly closer to the root apex than to the mucogingival junction.

The closer the implant is positioned to the root apex, the greater the intrusive forces that can be obtained and the greater the space that can be utilized for mesiodistal movement. Alveolar structures underneath the gingival must be considered. So; the safety zone for the maxilla is located between alveolar crest and maxillary sinus while the mandible the safety zone is between the alveolar crest and mandibular canal. [27]

For molar distalization, the insertion position is located 1 to 2 mm (1.5mm for mandibular insertion) distal to the imaginary central line between the two teeth, while for molar protraction; the insertion position is placed 1 to 2 mm mesial to the imaginary central line. If there is to be no mesiodistal movement of the adjacent teeth, the insertion position is located on the central line.

When the attached gingival is narrow or the sulcus is shallow, insertion toward the root apex is restricted. The implant head should never be exposed more laterally than the vestibular fornix [27].

Preparation for Insertion:

Selecting the Proper Screw for the Case: [28]

Head selection: The manner in which the skeletal anchorage is used, direct or indirect, will determine the type of head to select. If indirect anchorage is indicated, (meaning that the point of force application is not identical to the screw head) a mini-implant with a bracket like head is indicated.

Diameter selection: It depends on the placement site. Between roots in the upper jaw a 1.3mm screw of 11mm is recommended as the stability is also dependent on the trabecular bone. In the alveolar process the 1.5 mm diameter with a shorter length is recommended. In areas with very thick cortical bone, as in the retro molar area of the mandible, it is recommended that a 2.0mm screw be used, as the torsion necessary for insertion in this region may lead to fracture of a thinner screw.

Thread length selection: In patients with a cortical thickness of 1mm or more, a 6mm screw may provide sufficient primary stability. When the cortical bone is thin and the primary stability is primarily dependent on trabecular bone, a mini-implant with longer thread length (8mm or more) may be indicated. In edentulous areas where the cortex may be very thin, bi-cortical anchorage may be the only alternative and should be considered.

It has been shown that bi-cortical anchorage is superior to uni-cortical anchorage. If planning for bi-cortical anchorage, both the total thickness of the alveolar processes and the thickness of both labial and lingual mucosa should be measured and the insertion direction accurately determined. Perforation of the lingual cortex and trauma to the periosteum will frequently lead to inflammation and loss of the screw, therefore one must be very precise when attempting bi-cortical placement. [28]

Site selection: One recommendation is to bend a small wire template and to fixate this to either a bracket with a ligature wire or to the occlusal surface in the proximity with a light cured acrylic**.** A placement site with attached gingiva is much preferred. If this is not possible due to the low border between attached gingival and the free mucosa, screws can be inserted in the mucosa and then covered so that only a coil spring or a wire passes through the mucosa. [29]

Soft tissue consideration: Not only the bony cortex but also the thickness of the mucosa has to be considered in the selection of the proper screw. Because it is desirable to avoid the presence of any threads in the soft tissues, the thread length of the screw has to be chosen giving due consideration to the mucosal thickness at the placement site.

Mini-implant Application Fields [30]:

- Rapid palatal expansion.
- Maxillary molar distalization.
- Molar protraction.
- Maxillary protraction.
- Extrusion of four anterior teeth.
- Posterior intrusion.
- Direct.
- Indirect anchorage.

Failure of the mini-implant:

Failure of the mini-implant can be divided into [31]:

- Early (short-term).
- Later (long-term) failure.

These categories can be further subdivided into:

Hard tissue-implant interface failure:

It results in loosening of the implant. Early failure at the hard tissue-implant interface is related to primary stability; which is obtained from mechanical support from the surrounding bone tissue. In other words, primary stability is related to the thickness of the cortical bone at the implantation site, the amount of damage caused by surgical trauma, and the closeness of the contact between the bone and the implant [31].

Later failure at the hard tissue-implant interface is related to the type of interface formed through the healing process following implantation.

Long-term failure is also associated with the type of stress loaded on the implant. Formation of fibrous tissue at the bone-implant interface is regarded as the most important risk factor in the loosening of screws. [32]

Soft tissue-implant interface failure:

Plaque accumulation around the implant or persistent mechanical irritation can cause soft tissue interface problems, such as acute or chronic inflammation or infection.

Epithelial hyperplasia or epithelial covering may also occur. In severe cases, infection can progress to abscesses. The potential for this kind of problem to develop is significantly increased when the implant is placed on movable tissue.

Inflammation around an implant could also be a sequela of loosening. The orthodontic implant should be removed immediately from patients with infection plus any general symptoms such as fever or abscesses, sustained discomfort, and affected adjacent periodontal attachments. [33]

Implant failure from fracture:

Implant fracture may occur during surgical placement or removal but will not occur during orthodontic force application. [33]

Psychological failure:

Psychologically, implant placement is not always accepted by patients or the parents of patients. A cost benefit analysis of implant placement should be thoroughly explained at the consultation. For example, implant placement is one of several treatment options to relieve crowding. However, to achieve nonsurgical correction of a long face, placement of an implant is the only option. [34]

In case of removal, deep anesthesia is generally unnecessary. According to the preference of the individual patient, topical anesthetic or infiltration anesthetic may be administered.

In most cases, simple topical anesthetic is adequate. There is no serious difficulty in bleeding control, and wet gauze held by the patient is normally sufficient. However, if the implant head is covered with soft tissue or an implant has been inserted deeply, infiltration anesthetic is needed.

Patients should avoid eating hot and salty foods for 2 to 3 days to prevent pain or aggravation of the wound. Generally, extraction wounds tend to heal quickly without any unwanted sequelae. [34]

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