REVIEW ARTICLE

Implants in Orthodontics- A Brief Review

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ABSTRACT

In orthodontics, Anchorage has been a worrisome factor for many years. Many modalities have been tried in the scientific literature for preventing the anchorage using the extraoral and intraoral devices, yet the speciality of orthodontics did not find any convenient solutions to this problem until the introduction of mini- implants. Various skeletal anchorage devices were introduced in the 20th century which includes prosthetic implants, palatal implants and implants, mini-plates and screws. The implants used in orthodontics are also known as temporary anchorage devices (TADs), have become increasingly popular because they are small and easy to insert and remove, they can be loaded immediately after insertion, and they can provide absolute anchorage for many types of orthodontic treatment, with minimal need for patient compliance. This article reviews their indications, contraindications, safety zones for TADs, their insertion procedure, complications, failures and medicolegal aspects.

KEYWORDS: Anchorage, Mini-Implants, Tads

INTRODUCTION

Many years have passed , Sir Issac Newton phrased his laws in which his 3rd law (Actions=Reaction) has a great importance in orthodontics as it explains many of the phenomenon we observe during treatment[1]. As the orthodontic treatment proceeds ,teeth are exposed to forces & moments. All these forces generate the reciprocal forces in opposite direction. These forces need to be directed for the success of treatment & to avoid unwanted tooth movements. Here comes the anchorage protocols which is the of any orthodontic treatment. Anchor management methods or modalities are of great concern in orthodontics. The final goal in orthodontics treatment is to achieve desired tooth movement along with improvement in patients esthetics[2].

Much of the efforts & time is spent on planning the anchorage requirements & taxing the demands of their execution. Anchorage being a worrisome factor in orthodontics , many modalities have been suggested like extraoral anchorage , use of opposing anchors , increasing no of teeth in anchorage units.

The extraoral anchorage is a bit cumbersome to use & causes injury which in then affects patients compliance to use it. Also, the term 'Absolute anchorage' can be achieved when the anchorage unit remains completely stable , which is doubtful in traditional orthodontics mechanics. The skeletal Anchorage is Absolute anchorage which is achieved with the advent of mini-implants. With the use of Mini-implants for the anchorage ,maximum anchorage is possible with the reduction in the unwanted side-effects[3].

Mini-screws are also known as TAD'S Temporary Anchorage Device or Micro-implants or Ortho-implant which has brought about the significant revolution in the field of clinical Orthodontics.

Evolution of Implant System: In 1700's John Hunter , Scottish Surgeon suggested the possibility of transplanting human teeth. In the 18th century it was common practice to replace lost teeth which teeth of another individual which met with the failure as human immune system rejected the foreign body leading to infection.In 1809, Maggiolo placed single tooth sized gold implant in fresh extraction site just above gingiva. In 1911, Greenfield described the fabrication & insertion of an endosseous implant.

REPORTS OF IMPLANTS IN ORTHODONTICS

As early as 1945, Gainsforth & Higley introduced the concept of implant supported anchorage. They used Vitallium screws & SS wires in the ramal area of the mandible in dogs to bring about the retraction of upper canines. However, initiation of orthodontic force resulted in the loss of screw in 16 to 31 days. This is considered to be the first published case of an implant for orthodontic anchorage[4].

In 1970, Leonard Linkow used an implant for replacement of missing molar. The case report was described by him which stated use of endosseous blade implant to anchore rubber bands that was used to retract maxillary anterior teeth[5].

In 1964, Branemark and associates had reported the use of titanium optical chambers implanted into femur of a rabbit. The chamber was developed for in vivo in situ microscopic study of bone marrow. Their result showed that it was possible to secure a firm anchorage of titanium

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to the bone with no adverse effect.They then placed titanium endosseous implant into healed extraction site in upper and lower jaws of dogs. In 1969, they reported that titanium implants remained stable for 5 years without sign of tissue injury or rejection. The implant had become firmly osseointegrated in the bone. The success has attributed to material development, less invasive surgical procedure in which implants were loaded[6].

In 1984, Robert & fellow researchers collaborated the findings of Branemark in an extensive study of titanium implants in rabbits. 6 – 12 weeks after placing titanium screws in a rabbit femur, 100 gm of force was loaded for 4 – 8 weeks by stretching a string between the screws. All of 1 but 20 implants remained rigid. Robert result indicated that titanium implants developed a rigid osseous interface and continuously loaded implant remains stable within the bone. The study concluded that titanium endosseous implants provides firm osseous anchorage for orthodontics & dentofacial orthopedics[7].

In 1988, Creekmore used Vitallium implant for anchorage for intruding upper anterior teeth[8]. In 1985, ITI implant was introduced by Straumann Company. In 1997, Kaomi introduced mini implant system. Maino et al, introduced spider screw system implant for skeletal anchorage. Kyu Rhim Chung developed C micro implant system.

CLASSIFICATION OF IMPLANTS

a) According to site of placement/ anchorage components
- Subperiosteal implant
- Transosteal implant
- Endosteal/ Endosseous implant

b) According to surface texture –
- Small
- Treaded
- Perforated

c) According to form –
- Solid
- Hollow
- Vented

d) According to spray of coating of hydroxyapatite or plasma sprayed titanium –
- Coated
- Non-coated

e) Based on head type[9] –
- Small head type
- Long head type
- Circle head type
- Fixation head type
- Bracket head type

f) According to implant morphology –
- Plate design
  - Skeletal anchorage implant
  - Graz implant supported system
  - Zygoma anchorage system
- Screw design
  - Orthosystem implant
  - Straumann ortho implant
  - Aarhus implant
  - Mini implant system
  - Micro- implant
  - C – implant
  - Spider screw
- Implant disc

g) According to March 2005 classification –
- Biocompatible TADS[10]
- Biological TADS

USE OF IMPLANTS AS ANCHORAGE

The osseointegrated implant (endosteal) were the first one to be used for the purpose of orthodontic anchorage. They worked well providing the orthodontic anchorage, but they have limited application in terms of orthodontic use. They were basically needed to be used in edentulous spaces, which were not available in routine orthodontic cases.

Also, the waiting period was another shortcoming. The waiting period is nearly 3 – 4 months for the implant to integrate before they could be loaded.

Even the size of implant and the placement procedure were also problematic. The size is large, and the surgical procedure for the placement is complicated[11].

Non – osseointegrated mini implants used in orthodontics have overcome these problems & complications and also they were mechanically stabilized cortical implant. The screw that was 2mm or more wide are termed mini screws and those that were less than 2mm wide are termed as micro screws.

The initial mini screw system was from HDC Italy, Lomes Mondeal, Taiwan and Oleus, Korea. Also, the original miniscrew or microimplant anchorage was from Dentos Inc. degu, Korea named Abso Anchor micro-implant.

It has an added advantage of a screw with different lead forms. Theses head forms allow the screw to be used for various application depending on the mechanism.

BIOMATERIAL USED IN IMPLANTS

The following are the ideal requirements for implant biomaterial –
- Biological properties
- Physical properties

Biological properties –
- Provide effective osseointegration.
- Should not be harmful to hard and soft tissue.
- Should not contain the toxic diffusible substance.
- Should be free of a potentially sensitizing agent that may cause an allergic reaction.

- Should have no carcinogenic potential.
- Should be tasteless and odorless.

Physical properties –

- Should be dimensionally stable.
- Should possess adequate strength and resilience and resist biting or chewing.

The osseointegrated dental implants / screws are composed of 99% titanium. The medical grade titanium used for general body implants is classified as grade I to IV .

Commercially pure titanium (C P Ti) is used widely as a material of choice for implants because of its suitable mechanical properties and excellent biocompatibility. In the case of non –osseointegrated / mechanical retentive miniscrews uses of Ti grades I to IV has resulted in frequent failures as screw were thinner.

Hence the titanium alloy (Ti - 6Al - 4V) (grade V) is the material of choice for orthodontic miniscrews. Use of this alloy increases the modulus of elasticity to six times that of bone so that long and thinner screws can be used without any risk of breakage[12].

MINI IMPLANT SCREW DESIGN

The orthodontic mini- implant made up of titanium alloy grade V (Ti - 6AL - 4V) is designed to be used transmucosally for osseous orthodontic anchorage. Orthodontic mini screw has 4 components –

- Head – Has a slot for placement of orthodontic archwire.
- Neck –Iit is an isthmus between head and platform for attachment of an elastic, NiTi coil spring or other accessories.
- Platform – It is of three different sizes (1mm, 2mm, 3mm) for an accommodation of different soft tissue thickness at different implant site.
- Body – It is parallel in shape and is self- drilling with the wide diameter and deep thread pitches. It provides better mechanical retention, less loosening breakage, and stronger anchorage.

SAFE ZONES FOR IMPLANT PLACEMENT

As the mini screw is small and thin, it is easy to place in any part of alveolus for its needed mechanical stabilization. The placement is entirely operator dependent. While using micro implants,the clinician has the option of varying the location of miniscrews that functions as anchors in order to serve the task for purposefully. The most commonly used placement sites for miniscrews In maxilla and mandible are –

In Maxilla[13]: Inter radicular alveolar areas like the width of buccal cortical bone on the entire maxillary alveolar process is limited (3mm to 4mm), so longer screws are needed. Most commonly used sites are –

- Between second premolar and first permanent molar
- Between the first and second permanent molar
- Between the two central incisors, which is particularly good for intrusion
- Infrazygomatic region – zygomatic buttress
- Palatal areas where the thickness and quality of cortical bone are excellent.
- Maxillary tuberosity region
- Mid palatal area

In Mandible[13]: Inter radicular alveolar area – as the cortical bone on the buccal area in the mandible is very dense, so the screws are smaller in size, so the possibility of root contact is remote. Most common sites are –

- Between second premolar and first permanent molar
- Between first and second permanent molar
- Between two central incisors
- Between mandibular canine and premolar buccally
- Retromolar area
- Mandibular symphysis facially

The sites that should be avoided are: Some of the anatomical and vital structures that should be kept care of during micro-implant placement includes- inferior alveolar nerve, artery, vein, mental foramen, maxillary sinus and nasal cavity

As these implant sites are reasonably close to archwire plane, the force applied to move the teeth and control of resultant counter forces are much easier. The screws used for orthodontics anchorage purpose must be thin (1.3mm to 1.5mm) and tapered to prevent accidental root contact.

Generally, for maxilla length should be 8mm to 10mm and for mandible length should be 6mm to 8mm because of dense bone.

SCREW ANGULATION

If we see at the area from canine to the second premolar in the maxilla, the cortical bone buccally is thin. So the angulation in this area is mandatory to make sure that the screw does not touch the roots. The space between the roots is shaped like an inverted pyramid. The Space gradually goes on increasing in width to about 5mm as the root taper apically. If we place the micro- implant at 30- degree to 40 -degree angle to the long axis of the teeth in the maxilla, it will keep the screw in the widest space available between the roots apically.

In the mandible, the buccal cortex is of dense bone and curves out more buccally from gingival margins. So the shorter screw can be used than those used in the maxilla. Also the angle is reduced to 10- degree to 20- degree with little risk of touching the roots.

DRIVING METHODS OF MICRO SCREWS / MICRO IMPLANTS

The method of insertion of a screw into the bone depends upon the type of screw chosen. There are two different types of screws available –

Self tapping	Self drilling
Pre – drilling	Drilling free
A tunnel is drilled into the bone first with pilot drill and then implant is driven into tunnel Tips: blunt, smooth and rounded Threads :- thick rounded and blunt	Here the implant itself acts as a drill and it is directly inserted into bone Tips :- sharp, hooked and pointed Thred :- thin, pointed

SURGICAL PROCEDURE

1. Topical anesthesia – recommended before soft tissue infiltration to reduce the needle prick pain.
2. Infiltration anesthesia – only the soft tissue infiltration anesthesia is required to determine that whether the implant is touching the roots of teeth or not. If it is touching the roots, the drill can be redirected away.
3. Aseptic preparation – a disinfecting agent can be used to prepare an intraoral or extraoral site for keeping the surgical area aseptic.A guide bar can be placed on the tooth before exposing IOPA. The guide bar can be placed in such a manner that it should be retained during micro implant insertion, which helps in placement of a micro- implant.
4. Drilling – loading of the selected micro screw into the driver is done, and the screw is inserted at the registration point. The direction of insertion is first horizontal and then angulated at 30 -degree to 40-degree in the maxilla and 10- degree to 20- degree in the mandible. The act of turning the screw should be smooth alternating between turns and stops. Wobbling in the axis of a driver should be avoided to ensure proper stability of implants.
5. The final root position of the screw should be such that the curved funnel at the neck should be cutting against the bone. The head, neck , and hox of screw should be away from the soft tissues.

LOADING OF IMPLANTS

It includes the Delayed loading and immediate loading. According to the studies carried out by Branemark, it was thought that all implants should undergo a healing period of 4-6 months before functional loading. Many of the clinical experiences and researches have proven that premature loading causes the micromotion of the implants which leads to the implant failure.

Tarnow et al in their studies showed that the immediate loading of implants could also be carried out if the implants are splinted together which minimizes the micromotion.

Loading also includes the dynamic(variable force levels) and Static (constant loads of uniform force) loading which has shown that statistically loaded and unloaded implants has more cortical lamellar bone at the neck and the apex of implants. The implants which are dynamically loaded showed the bone craters and howships lacunae around the implant neck which show higher levels of bone resorption[14].

The timing of Orthodontic force application- In terms of orthodontic mini-implants, the primary stability is more important than the osseointegration. So it has been found clinically that no significant difference exists between the immediate loading and delayed loading when the force of 200- 300 gms.is applied after achieving primary stability. However, it may be better to wait approximately 2-3 weeks for soft tissue healing.

STABILITY OF IMPLANTS

Stability of implants is the factor of great concern whether the implant is osseointegrated or mechanically retentive. It includes the – Primary stability and the secondary stability

Primary stability or initial stability is achieved immediately after the insertion of an implant. It is the prime factor of consideration for healing and loading.The contributing factors responsible for achieving the primary stability includes- Implant diameter,the length of implant,the number of flutes and design of threads, cortical bone thickness and also the bone density. It also depends on the placement technique and the location of implant placement.

Secondary stability after the implant placement the bone regeneration and remodeling contributes to increasing the stability which is referred to as the secondary stability[15].

RISK AND COMPLICATION OF ORTHODONTIC IMPLANTS

Orthodontic implants have proven to be a useful addition to the orthodontic armamentarium for control of skeletal anchorage. But there are certain risks involved with the placement of Temporary Anchorage Devices which should be taken into consideration by both the clinician and the patient.

Complications can arise during the placement and after orthodontic loading of TAD's in regard to stability and patient safety..

- Complications During Insertion
  1. Trauma to the periodontal ligament or the dental root
  2. Orthodontic implant slippage
  3. Nerve involvement
  4. Air subcutaneous emphysema
  5. Nasal and maxillary sinus perforation
  6. Implants bending, fracture, and torsional stress
- Complications under Orthodontic Loading
  1. Miniscrew migration
  2. Soft-Tissue Complications
     a. Aphthous ulceration
     b. Soft tissue inflammation, infection, and peri implantitis
     c. Soft-tissue coverage of the miniscrew head and auxiliary
- Complications During Removal

1. Screw fracture
2. Partial osseointegration

PSYCHOLOGICAL AND MEDICO-LEGAL ASPECTS[17]

Psychological Aspects:The increased use of implants for orthodontic purposes makes it necessary to deal with psychological aspects, for both the operator and the patient.

The operator (orthodontist or oral surgeon)

1. There is certain restraint which exists on the part of orthodontists while using implants for orthodontic purposes. This could be due to various factors.
   a. Some clinicians are not convinced of the efficacy of implants (implant systems have not yet been perfected).
   b. Clinicians prefer to avoid unnecessary surgery.
   c. Methods are currently limited to an adult patients (not growing patients).
   d. The mechanical setup, with respect to anchorage sites, might be difficult to manage.
   e. Implant systems, especially superstructures, have not been standardized.
   f. Traditional anchorage methodologies (without implants) still offer valid results.
   g. Waiting times (healing-osseointegration) may be inconvenient.
   h. Interdisciplinary relationship between the orthodontist and the oral surgeon are required.
2. To counteract some of these factors, several fundamental objectives must be met:

a. Manufactures must document and carefully control their products.
b. Improved techniques are needed to minimize surgery during all the stages (insertion, possible re-entry and removal).
c. New techniques are needed to extend treatment to growing patients.
d. Suggested biomechanical routes must be developed, standardizing the fixtures, the orthodontic movements, and the biomechanics that can be used in specific situations.
e. Different superstructures must be developed that allow versatile and multiple uses.
f. Continuing education opportunities must be expanded.
   g. Interdisciplinary training must be standardized.

The patient: When presenting implant treatment to an adult patient. The clinician must explain the advantages and the disadvantages of this method. All the different possibilities are to be be discussed with the patient in an attempt to understand his or her motivation. The informed consent document should be signed by the patient.

Particular care is needed when discussing implant treatment with younger patients. Use suitable, clear and positive language and present more detailed and technical information to the parents or the guardians. Special care will be needed with patients who are especially anxious or uncooperative.

Medico-legal aspects: As far as the medical-legal field is concerned, certain civil and professional responsibilities are mandatory which includes-

Age of treatment: In younger patients, where there is a possibility that the implant might interfere with bone growth, especially the osseointegrated structures, the ankylotic behavior of the fixtures must be considered, including the processes of resorption and apposition and that of dislocation linked to the growing period; the temporary nature of the implant must be taken into account. Implants must not interfere with structures that govern the processes of growth (sutures) or with non-osseous anatomical structures (nervous, vascular).

Indications for the use of implants for anchorage: The choice of using implants must be made in relation to the principle of maximum results with a minimally invasive method (cost/benefits) so that over-treatment can be avoided.

Informed consent: The informed consent document should contain appropriate information about the method of placement, its characteristics, the surgical techniques (in the various phases), and the possibility of irritation or local inflammation during traction.

The possibility of failure should also be considered; this would involve the renewal of the procedure. Treatment alternatives should be presented. The written informed consent will be the responsibility of the professional person proposing the treatment (the orthodontist), and possibly the oral surgeon will receive a countersigned copy.

CONCLUSION

The introduction of dental implants into dental treatment plans has had a tremendous impact on the field of dentistry. With the increased interest in the area of implantology, there has been a great deal of extensive research exploring the use of dental implants. The devices themselves are evolving which would support the best combination of ease of placement (able to be placed by orthodontist), least invasive procedure, and best physical design properties to deliver optimum mechanical forces.

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