ISSN: 0975-833X

Availableonlineathttp://www.journalcra.com

International Journal of Current Research
Vol. 11, Issue, 06, pp. 4717-4722, June, 2019

DOI: https://doi.org/10.24941/ijcr.35568.06.2019

INTERNATIONAL JOURNAL OFCURRENTRESEARCH

REVIEW ARTICLE

MINI IMPLANTS - A NEW ERA IN ORTHODONTICS

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ARTICLEINFO

Article History:
Received 22nd March, 2019
Received in revised form
19th April, 2019
Accepted 22nd May, 2019
Published online 30th June, 2019

Key Words:

TADS, Anchorage, Implants.

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ABSTRACT

Anchorage in orthodontics has been defined as the nature and degree of resistance to displacement offered by an anatomic unit when used for the purpose of performing tooth movement. 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; and they can be fixed to bone either mechanically (cortically stabilized) or biochemically (osseointegrated). It should also be pointed out that dental implants placed for the ultimate purpose of supporting prosthesis, regardless of the fact that they may be used for orthodontic anchorage, are not considered temporary anchorage devices since they are not removed and discarded after orthodontic treatment. Importantly, the incorporation of dental implants and TADs into orthodontic treatment made possible infinite anchorage or absolute anchorage

***Citation: Dr. Munaif, V., Dr. Jyothikiran H., Dr. Raghunath N. and Dr. Sanjeed Kabeer,* 2019.** "Mini Implants - A new Era in Orthodontics", *International Journal of Current Research*, 11, (06), 4717-4722.

INTRODUCTION

Traditionally, orthodontists have used teeth, intraoral appliances, and extraoral appliances, to control anchorage—minimizing the movement of certain teeth, while completing the desired movement of other teeth. The teeth are the most frequent anatomic units used for anchorage in order to move other teeth into a more desirable position. However, because of Newton's third law, i.e., for every action there is an equal and opposite reaction, there are limitations in our ability to completely control all aspects of tooth movement. In simple anchorage the resistance of the anchoring teeth unit to tipping is needed to move another tooth or teeth. The number, the shape, size and length of each root must be considered, because different teeth have different resistance values to tooth movement. This situation may cause undesired movements of the anchorage teeth. For example, we often have inadequate mechanical systems with which to control anchorage, which leads to anchorage loss of reactive units and often incomplete correction of intra- and interarch alignment problems. Moreover, in an attempt to overcome these limitations, clinicians often incorporate bulky acrylic appliances or extra oral appliances that, when combined with the ever challenging problem of uncooperative patients, are often a futile attempt at best. Although the principle of orthodontic anchorage has been implicitly understood since the 17th century, it does not appear to have been clearly articulated until 1923 when Louis Ottofy defined it as "the base against which orthodontic force or reaction of orthodontic force is applied."

Most recently, Daskalogiannakis[3] defined anchorage as "resistance to unwanted tooth movement." It can also be defined as the amount of allowed movement of the reactive unit. Ottofy[2] also summarized the anchorage categories previously outlined by E.H. Angle and others as simple, stationary, reciprocal, intraoral, intermaxillary, or extraoral. Moyers[4] expanded Ottofy's classification system by clearly outlining the different subcategories of extraoral anchorage, as well as breaking down simple anchorage into single, compound, and reinforced subcategories. Gianelly and Goldman[5] suggested the terms maximum, moderate, and minimum to indicate the extent to which the teeth of the active and reactive units should move when a force is applied. Marcotte6 and Burstone[7] classified anchorage into three categories—A, B, and C—depending on how much of the anchorage unit contributes to space closure. Tweed[8] went further to define anchorage preparation, or the uprighting and even the distal tipping of posterior teeth to utilize the mechanical advantage of the tent peg before retracting anterior teeth.

What is Temporary Anchorage Device ???

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; and they can be fixed to bone either mechanically (cortically

stabilized) or biochemically (osseointegrated). It should also be pointed out that dental implants placed for the ultimate purpose of supporting prosthesis, regardless of the fact that they may be used for orthodontic anchorage, are not considered temporary anchorage devices since they are not removed and discarded after orthodontic treatment. Importantly, the incorporation of dental implants and TADs into orthodontic treatment made possible *infinite anchorage or absoluteanchorage,* which has been defined in terms of implants as showing no movement (zero anchorage loss) as a consequence of reaction force.

CURRENT DEVICES - General Considerations

- Simple to use
- Inexpensive
- Immediately loadable
- Small dimensions
- Can withstand orthodontic forces
- Immobile
- Does not require compliance
- Biocompatible
- Provides clinically equivalent or superior results when compared withtraditional anchorage systems.

At a minimum, when initially placed, TADs must have primary stability andbe able to withstand orthodontic force levels. For integrated implants, the maximumload is proportional to the quantity of osseointegration, whereas for nonintegrated implants the maximum load is proportional to the surface area contact of the bone to the implant.

Indications

Indications	*Advantages*
Intrude/extrude teeth	Reduce complications and facilitate movement
	Mini-implants more feasible than conventional ones
Close edentulous spaces	Avoid need for prosthesis
	Reduce endodontic complications
	Enhance oral hygiene
Reposition malposed tooth	Improve anchorage
	Reconstruct the edentulous area
Reinforce anchorage	Maximize anchorage, eg, palatal implant systems
	Improve patient compliance (no headgear, Class II elastics)
Partial edentulism	Future restorative abutments
	Reduce dental complications
Correct undesirable occlusion	Provide solid anchorage to retract entire arch
	Facilitate localized bonding and treatment
Orthopedic movement	Accelerate sutural distraction (palatal expansion) and bone movement

Implant Criteria

A] IMPLANT MATERIALS:

The implant material must be

A.non-toxic
B.biocompatible
C.posess excellent mechanical properties
D.provides resistance to stress, strain and corrosion.
E.its effectiveness should be proven in clinical and experimental studies.

Commonly used materials can be divided into three categories

- Biotolerant (stainless steel, chromium-cobalt alloy)
- Bioinert (titanium, carbon)
- Bioactive (vetroceramic apatite hydroxide, hydroxylapatite, ceramic oxidizedaluminium)

Titanium

It consists of 99.5% titanium and remaining 0.5% other elements such as carbon, oxygen, nitrogen and hydrogen. The titanium metal has the characteristic of not producing any allergic and immunological reactions and neoplasm formation and hence considered an ideal material and is widely used. Its mechanical characteristics involve, very light weight, excellent resistance to traction and breaking, enabling it to withstand both masticatory loads and stresses of orthodontic forces. Bone grows along the titanium oxide surface, which is formed after contact with air or tissue fluid. Titanium has less fatigue strength than titanium alloys. Titanium alloy- titanium-6-aluminium-4 vanadium is used to overcome this disadvantage.

Implant Sizes

The implant fixtures must achieve primary stability and withstand mechanical forces. The maximum load is proportional to the total bone-implant contact surface. The factors that determine the contact are the length, diameter, shape and surface design (rough Vs smooth surface, thread configuration). The maximum load that can be applied to the fixture is proportional to the quantity of osseointegration making it dependent on the surface area of osseoimplant tissue contact. Because the implants are usually cylindrical, the parameters that contribute to the contact surface are length, diameter and shape. The combination of these variables must produce a contact surface that is sufficient for orthodontic and prosthetic needs, causes the least obstruction and requires the least surgical trauma, all while facilitating cleaning and allowing the distribution of the load onto the bone along the line of physiological force to avoid pathological reabsorption. The dimensions of the implants should be congruent with the amount of boneavailable at the point of insertion. The traditionally used sizes of implants are 6-10mm in length and 3-4mm in diameter. The relationship between length and diameter is inversely proportional. The implant must have a certain surface area forosseointegration to support the forces of orthodontic traction.

Implant Shape: The shape of the implant must provide mechanical anchorage through a surface area of fixture-bone contact that can distribute the functional load without damaging the physiology of the bone tissue. The design of the fixture must limit the surgical trauma at the time of insertion and allow good primary stability. The shape most used is cylindrical or cylindrical-conical (flared) with a smooth orthreaded surface. The surface of the fixture is sometimes treated to create rough areas to increase the osseointegrable surface area.

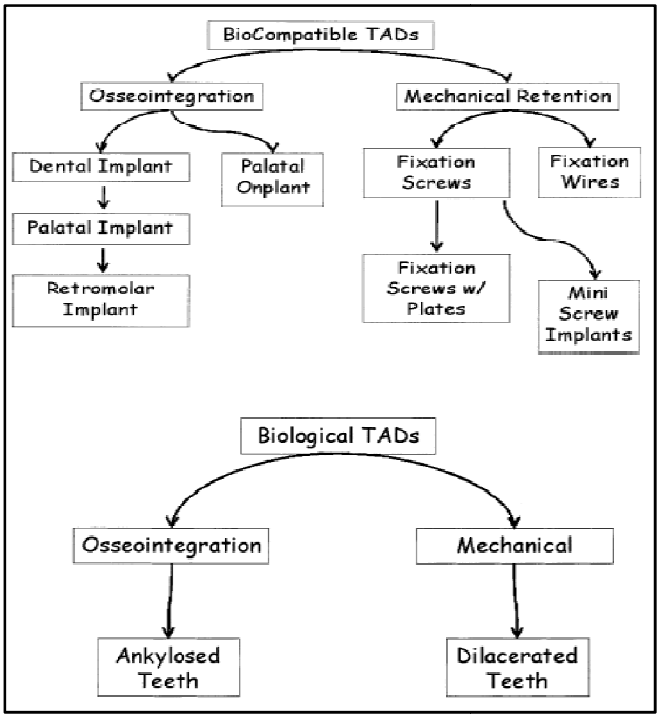
Classification

A) The currently available temporary anchorage devices can be classified as eitherbiocompatible or biological in nature[9].

Both groups can be subclassified based on the manner in which they are attached to bone, either biochemical (osseointegrated) or mechanical.

The biocompatible TADs are either

1) a modification of a dental implant, or
2) a surgical fixation method.



Based on the Fixture Materials Implants May be Classified As44

- **Bioinert**: Titanium, Titanium-Vandadium, Hydroxide-Apatite and vitreous Carbon
- **Bioactive**: Porcelain (Aluminium oxide Ceramics, Vetroceramic Apatite)
- **Biodegradable**: polylactide implants
- **Biotolerant**: Stainless steel (Vitallium, Cobalt-Chromium, Nickel-Chromium Vanadium alloys), Gold alloys, Ticonium etc.

The customized systems of implants can be categorized as:

Based on the implant morphology

a. Cylindrical
b. Onplants
c. Plates

a. Implant discs - Onplant
b. Screw designs- These include:

i. Mini-implant
ii. Orthosystem implant system
iii. Aarhus implant
iv. Micro-implant
v. Newer systems such as the Spider screw, the OMAS system, the Leone mini-implant, the Imtec screw etc.

Plate designs – These include:

I. Skeletal Anchorage system (SAS)
II. Graz implant supported system
III. Zygoma anchorage system

Based on implant sizes

- Dental Implants: 3-4 mm in diameter, 6-10 mm in length
- Mini-Implants (Kanomi): 1.2 mm in diameter, 6 mm long

Based on Anatomical sites

- Subperiosteal
- Transosseous
- Endoosseous
- Combinations

Site for insertion of implants

Several factors should be considered for selecting the site of implant insertion.

- The primary purpose of the implant (exclusively orthodontic or also forprosthodontic use)
- The patient's skeletal age
- Quality and quantity of bone available.

If the fixture is to be used exclusively for orthodontic purposes, the site of insertioncan be optimized as far as programmed orthodontic mechanism is concerned, with the added possibility of using very small fixtures. At the end of treatment the fixture is either removed or left in place (sleeping fixture). If the fixture has the dual role as both orthodontic anchorage and prosthetic post, the site of insertion must satisfy a 2-fold requirement; it must follow an accurate and strict setup on models so as not to interfere with the programmed orthodontic movement, and at the end of treatment it should maintain a position suited to the prosthetic rehabilitation. In terms of cost-benefit, the fixture's double function of anchorage and prosthetic post is the optimal solution.Skeletal age must be determined in younger patients. (if not possible, it might benecessary to use radiological tests, such as hand-wrist radiographs, to establish a more precise forecast of growth to optimize treatment timing. To correctly assess the quantity and quality of bone available, the clinician could use presurgical radiological tests (panoramic radiographs, teleradiography, endorals, computed tomography). an accurate objective examination by palpation, and bone and mucosa probing with thickness meters, with the possible creation of guide templates. The anatomical sites normally used are the alveolar bone in an agenesic or extraction site, the palate in the median or paramedian area, the retroincisve and retromolar site, the anterior nasal spine and the chin symphysis. It is possible to insert fixtures in an extraoral site, eg, the zygomatic bone, although this is an excessively invasive method for orthodontic requirements alone.

Force Application

If the implants are planned for future prosthetic abutments, a standard healingprotocol should be followed. Direct orthodontic forces generate less stress on implants due to limited force imposed on them (less than 3 N about 300gms). The stress is far less for indirect anchorage because implants are used to stabilize teeth). With dense bone and satisfactory

stability, immediate loading might be feasible. Threaded implants provide superior mechanical interlock compared with cylindrical designs. Waiting time should be longer for non threaded implants. Complete osseointegration is favourable but not essential for effective orthodonticanchorage implants. However stable mechanical retention or partical osseointegration is required and implants should not be overloaded during healing. Implants should have initial stability and also should withstand stress and strainapplied. The maximum load applicable is proportional to the diameter and the length of the fixture and to the quality of the bone rather to the degree of osseointegration.

Important Factors to Consider

Delayed Versus Immediate Loading: Currently, temporary anchorage devices can be fixed to bone in one of twoways—either biochemically (osseointegrated) or mechanically (cortically stabilized). Originally, however, based on Brånemark's work, it was thought that allimplants should undergo a 4- to 6-month healing period before functional loading. This was because the authors, based on both clinical and experimental evidence, felt that premature loading caused micromotion of the implants, which allowed theinvasion of fibrous tissue, and implant failure. This was supported by the findings of Roberts and colleagues38 using a rabbit model to study static orthodontic- type implant loading of 100 g after 6, 8, or 12 weeks of healing. Based on his findings, Roberts considered that 6 weeks (in rabbits) was the earliest an implant should beloaded after placement. Since sigma, or the duration of remodeling, in humans isaproximately 3 times longer than in rabbits, he considered that the same durationequaled 18 weeks in humans.

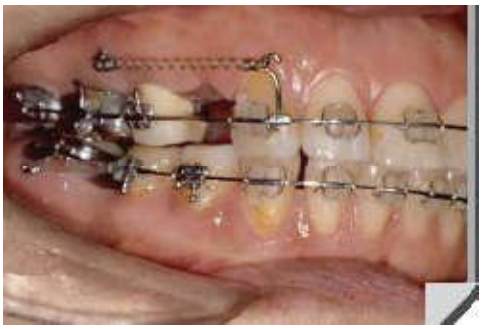
Dynamic Versus Static Loading: Duyck's group[13] recently evaluated the differences in load type on osseointegratedimplants. After 10-mm-long Brånemark implants were allowed to heal for 6 weeks,the implants were loaded for 14 days either statically (constant loads of uniform force levels), dynamically (cyclic loads of variable force levels), or left unloaded. Interestingly, similar bone: implant contact was seen for all implants, but a difference was seen in the marginal bone around the implant. The statically loaded and unloaded controls showed a more dense cortical lamellar bone at the neck and apex of the implants, whereas the dynamically loaded implants revealed bony craters and Howship's lacunae around the implants necks, indicating a higher level of bony resorption. Gotfredsen and colleagues[14] found similar results in laterally loaded experimental implants— higher bone density and bone:implant contact for the statically loaded implant compared with unloaded controls.

Implant Maintainace: After the surgery, the surrounding soft tissues must be maintained to ensure longevity of the implant. Plaque accumulation near the gingival margin can cause perimucositis. Prolonged inflammation leads to breakdown of bone around implants and peri-implantitis; this, without proper management, can lead to implant failure. Therefore, patients must be instructed to follow daily plaque control at home and have periodic professional care, similar to regular periodontal maintenance.

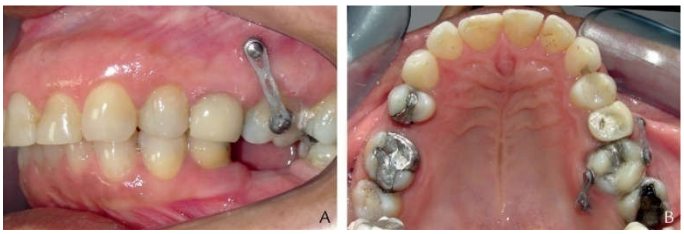
Evaluation and criteria for success : It is better to use the research to evaluate success. This may be invasive or noninvasive criteria. The noninvasive criteria include absolute implant stability, stability in relation to nearby oral structures or estimated from impressions taken at the beginning and end of treatment and absence of inflammation. Invasive criteria include radiologic proof of bone reasorption and normal bonestructure; the use of markers (almost always tetracycline) at regular intervals before, during and after loading and later analysis under a fluorescent microscope and histologic tests.

Application of mini implants in orthodontics

- **Provision of anchorage A**. Moderate to maximum anchorage need eg. Full cusp Class II relationship or adults and older adolescents (where functional appliances cannot be used to gain anchorage). B. Mild to moderate anchorage need when the anchor unit is limited by an inadequate number of anchor teeth (e.g early tooth loss or hypodontia) or periodontal support.



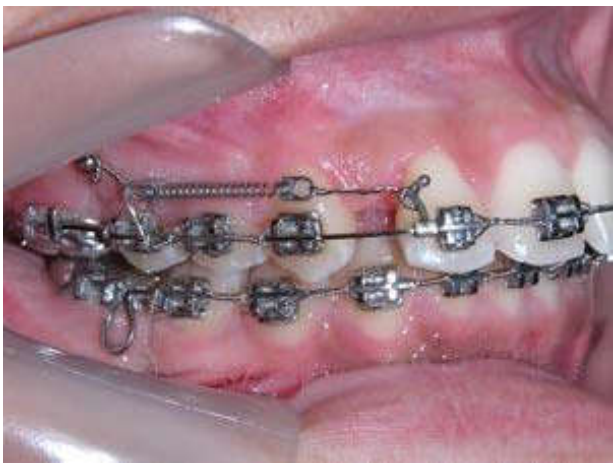
- **Specific teeth movement** En mass retraction especially in high angle class II malocclusion where the extrusive tooth movements would be unfavorable which contraindicates the use of intermaxillary traction to achieve the desired tooth movement (Park *et al*., 2005).



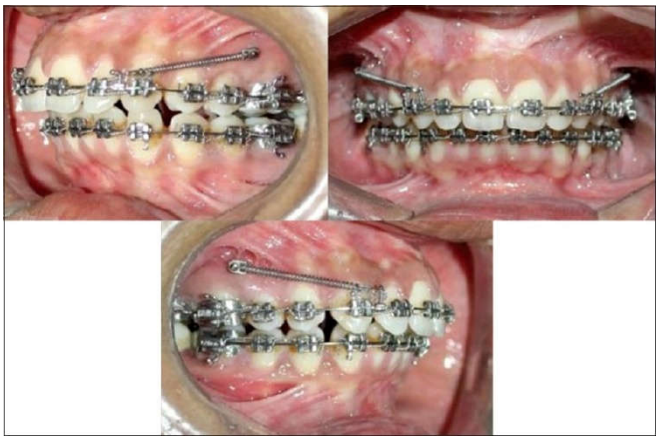
- **Canine retraction**: Sharma et al. compared the anchorage loss with the use of TPAs or TADs and found 2.5 mm of mesial movement of the U6s with the former while the latter provided absolute anchorage (Sharma et al., 2012).

- **Bimaxillary protrusion**: Liu et al concluded that a better dental, skeletal and soft tissue effects of the

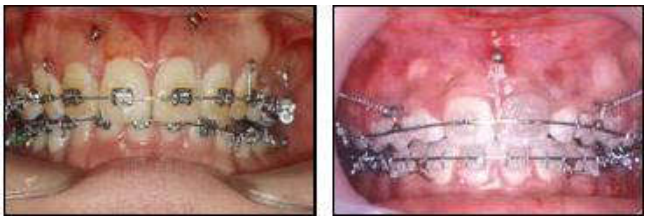
TADs in treating these groups. For this reason, they recommended the TADs as routine anchorage device in patients with bialveolar dental protrusion (Liu et al., 2009).



- **Molar distalization** (Sugawara et al., 2006, Sugawara et al., 2004)



- **For intrusion of anterior teeth** (Lee et al., 2009)



- **For intrusion of posterior teeth** (Cousley, 2010). Regarding stability of molar intrusion by TADs. It was 83% stable (Lee 2008), Minimum 3 months retainer after molar intrusion.
- **For unilateral intrusion to correct cant of occlusion** (Lee et al., 2009)
- Adjunctive treatment when full orthodontic appliance is not required and the aim is corrects the position of single tooth.
- **Skeletal orthopaedic correction of class III** (Ballard technique) (De Clerck et al., 2009)
- Miscellaneous ⎫ Provide attachment for artificial teeth in hypodontia cases.
- **To provide IMF during orthognathic surgery** (Harris and Reynolds, 1991)

Disadvantages of using dental implants for orthodontic anchorage

- Longer treatment time
- Financial concerns
- Anatomical limitations
- Application of implants might be limited by the amount and quality of bone.

Removal Procedure

When orthodontic treatment is completed, the temporary implant is removed. Performed under local anesthesia, the procedure varies with the type of implant used. For the Orthosystem® rotating preparation has been described. 111 A guide cylinder is attached to the implant with a screw and the implant is cut free with a suitable bur. This generates considerable heat and leaves an extensive defect. Alternatively, anosseous trephine is used to remove a small layer of bone around the implant, which is subsequently extracted. Currently, minimally invasive controlled rotation is the procedure of choice. Osseointegration is broken by counterclockwise turns with theratchet, and the implant is then removed with rotational movements. A force of up to 55 Ncm and a mechanical torque driver are needed for releasing osseointegrated implants.

Complications: Peri-implantitis and implant loosening may cause implant loss. Detected early, implant loosening without peri-implantitis need not mean that the implant is failing. During the initial healing period, slightly mobile implants may become stable again within 6 weeks. Peri-implantitis associated with implant loosening, by contrast, is likely to cause implant failure. Chlorhexidine digluconate rinses three times daily and mechanical cleaning with a soft toothbrush may control it. Otherwise the implant is likely to fail. Orthodontic implants rarely cause complications and are well accepted by the patients[16]. Wehrbein and co-workers investigated the stability of short implants subjected to horizontal loading in humans101 and in a long-term basis in dogs113 and the results showed the maintenance of stability and osseointegration of these implants. After a 2 month healing period the mucosa presented recovering of normal aspects.

Conclusion

Several alternative skeletal anchorage systems for orthodontic therapy were reviewed. Most of these devices and techniques are new with the published studies being low in sample size and lacking of long-term clinical follow-ups. However, the viability of these skeletal anchorage systems is an important adjunct to orthodontics. Orthodontic mini implants providing an absolute anchorage system have changed the treatment planning from mechanic centered to objective centered treatment as it was restricted by biomechanical limitations of the law of action and reaction. The newer type of orthodontic mini implants with enhanced stability and clinical efficiency increases the successes rate in clinical practice.Proper use of mini implants require through knowledge of anatomical, biological, and biomechanical limitations. Complete understanding of biomechanics and appropriate selection of mechanics will helps to avoid few side effects which are intrinsic when implants are used. Implants for the purpose of conserving anchorage are welcome additions to the

armamentarium of a clinical Orthodontist. They help the Orthodontist to overcome the challenge of unwanted reciprocal tooth movement. The presently available implant systems are bound to change and evolve into more patient friendly andoperator convenient designs. Long-term clinical trials are awaited to establish clinical guidelines in using implants for both orthodontic and orthopedic anchorage.

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