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# Factors that contribute to the failure of orthodontic mini-implants: A literature review

Irfan Qamaruddin[a], Mohsin Nazir[b], Mohammad Taimur Khalid[c], Mashaal Alam[d], Fazal Shahid[e]

## Abstract

**Introduction**: The successful correction of various malocclusions in orthodontics requires absolute anchorage. Hence it is thought that temporary anchorage devices (mini-implants) could provide a good solution for the problems that are encountered in conventional mechanics used for absolute anchorage. The aim of this review is to analyze the available literature on mini-implants in orthodontics so that the reader is familiarized with their ever growing importance and with the factors that account for their failures.

**Material and Methods:** Various databases were searched to write a review article that could provide information about the usage, classification and the factors that resulted in failures of mini-implant systems.

**Results:** The factors found in literature include mini-implants related failures, operator related failures and patient related failures.

**Conclusions:** It should be comprehended that mini-implants ought to be selected and used with immense precaution to decrease rate of failures.

**Key Words:** Temporary anchorage devices, implant systems, absolute anchorage

## Introduction

Orthodontic anchorage is the resistance to unwanted tooth movement.[1] It is basically the ratio of incisor retraction to molar protraction.[2] The successful correction of a lot of malocclusions in orthodontics require sound anchorage. Anchorage can be classified into three categories, namely Type A, Type B and Type C. Type A stands for absolute anchorage in which no movement of anchored teeth takes place, in Type B the anterior and posterior segments move towards each other and in Type C there is total anchorage loss i.e. the anchored teeth are allowed to move freely.[3]

In the recent past, the application of headgear had been the only option to procure anchorage that was not tooth borne. The prescribing of headgear to patients with orthodontic needs resulted in various complications, firstly patient compliance and secondly the force against the teeth was larger than the optimal. It has also been well documented that the usage of headgear can be injurious to the eye and may lead to infection and even blindness.[4] Hence it is thought that temporary anchorage devices (TADs) or mini-implants could provide a good solution for the problems that are encountered in conventional mechanics used for absolute anchorage.

Initially in 1945, vitallium screws were used in dogs to obtain absolute anchorage for tooth movement.[5] Since then, little trust was invested into mini-implants as absolute anchorage units till 1980's. In 1983 Creekmore and Eklund[6] performed maxillary incisor intrusion with the help of titanium screws. Although the results were promising, the technique did not gain immediate popularity because it was too premature to be used clinically without an in depth comprehension

[a] Corresponding Author. BDS, FCPS, Associate Professor, Department of Orthodontics, Baqai Dental College, Karachi. drirfan_andani@yahoo.com

[b]BDS, Lecturer, Department of Prosthodontics, Ziauddin College of Dentistry, Karachi.

[c]BDS, Lecturer, Department of Dental Materials, Ziauddin College of Dentistry, Karachi.

[d]BDS, Lecturer, Department of Orthodontics, Ziauddin College of Dentistry, Karachi.

[e]BDS, Demonstrator, Department of Orthodontics, Baqai Dental College, Karachi.

of its reliability. In 1997 Kanomi[7] reported a successful case with mini screws which had a diameter of 1.2mm and was 6mm in length. The mandibular incisors intruded 6mm with no root resorption or periodontal pathologies. After that a lot of reports were printed on orthodontic absolute anchorage systems reflecting their increasing acceptance and importance. Some of these involved screws only and some used screws with mini-plates.

The aim of this review article is to analyze the available literature on mini-implants in orthodontics so that the reader is familiarized with their ever growing importance and with the factors that account for their failures.

## Material and Methods

The method for this review was based on the guidelines published in the Pakistan Orthodontic Journal and a literature review was conducted. Terms used in this literature search were mini-implant, mini-screw, micro-implant, microscrew, screw, temporary anchorage device (TAD). Internationally published research literature, review articles and relevant citations were included. After the electronic literature search, a hand search of key orthodontic journals was undertaken to identify recent articles. The data were extracted from each article separately. All articles that appeared to meet the inclusion criteria on the basis of their abstracts in which relevant information was provided were also retrieved. Exclusion criteria included articles that did not follow the objective of this review.

## Results

Electronic and hand searched articles on mini-implants as anchorage were selected at the first stage according to the inclusion criteria. The remaining articles which seemed to be potentially unuseful were rejected. At the final stage of article selection, 56 were selected as they met the inclusion criteria. A qualitative analysis of failure factors is given.

## Discussion

Classification according to origin and insertion: The classification of extra-dental intra-oral anchorage according to the origin incorporates firstly the systems that were developed from dental implants. These include palatal implants and retro-molar implants.[8,9] Pre-drilling and a healing period for osteointegration are prerequisites of these systems before loading is achieved. The last entity in the category that is developed from dental implants is the on-plant, which was presented by Block and Hoffman.[10]

The second tributary in the classification includes the mini-plates,[11-13] mini-implants[14] and Aarhus mini-implants.[15] These were developed from surgical screws, have smooth surfaces and are loaded immediately.

There are two methods of inserting mini-implants firstly self drilling and secondly self tapping. Self drilling mini-implant systems have cutting tips that make the pilot hole. On the other hand self tapping mini-implant systems need a pilot hole because they have a non-cutting tip. Self tapping systems are thought to be more advantageous than self drilling systems because in the self drilling type, a high pressure can be called for and this can cause compression of the bone which can further provoke bone resorption and sub-sequential failure.[16,17]

Uses of Mini-Implants: Since mini-implants have only gained international popularity in the last 15 years, their indications are not well registered. Most publications are case reports that portray new devices as alternatives to anchorage methods. E.g. Melson et al used patients with missing molars and performed retraction and intrusion of anterior teeth. The usage of mini-implants instead of headgear in extraction cases has also been reported[18,19] and it is mentionable that for posterior tooth movement mini-implants have replaced other types of fixed appliances.[20-22]

Patients who can genuinely benefit from the usage of mini-implants are the ones in which traditional anchorage is impossible to obtain

because of insufficient teeth. Also, in patients where the forces to the reactive unit would induce radical consequences, mini-implants are the chief aid for anchorage. If asymmetric tooth movement in all planes of space is needed in a patient TADs are utilized. Plus it is reported that borderline cases of orthognathic surgery can be avoided by their use. In some cases, a mini-implant can be used to develop bone through tooth movements, so that a prosthetic replacement can be provided.[23]

Contributing Factors to Mini-Implant Failure: It is documented that approximately 10% of all orthodontic mini-implants fail. This is a greater percentage than that of prosthetic dental implants because osteointegration is not achieved. The various factors that contribute to the failure include implant related factors, operator dependent factors and patient related factors.[24–26]

Implant related factors: The length of a mini-implant system is an important feature of its design. Previously it was proposed that the length of mini-implants should be at least 6mm but recently smaller ones have produced higher success rates.[27]

An appropriate diameter is also an integral part for the success of a mini-implant system. A diameter of 1mm or less resulted in failure of the mini-implants according to Miyawaki et al.[28] It was put forward that a mini-implant of diameter 1.2mm-1.3mm was appropriate for insertion in the safe zones of the maxilla and the mandible. If the device is 2mm in diameter, it ought not to be determined secure for the placement in the posterior inter-radicular spaces of the maxilla, with the exemption of spaces between the first molar and the second pre-molar on the palatal side and between the canine and the first pre-molar.[29] Mini-implants with a diameter of less than 1.5 mm were destined for tooth bearing areas, in particular the inter-radicular area.

Another prerequisite for the success of a mini-implant is that it should possess a smooth surface. If this is not the case, infection around the mini-implant could occur and lead to its failure.[23]

If the neck area of a mini-implant is not strong enough or if the mini-implant itself is too narrow there are chances that it might fracture when stress is applied on it. Hence a conical mini-implant with a strong neck and an appropriate diameter in relation to the quality of the bone is necessary if failure is to be avoided.[30]

Operator related factors: It is said that there is no match for experience. If the orthodontist exerts excessive pressure at the commencement of the insertion of mini-implants, it can lead to the fracture of the cutting tip. Therefore it should be kept in mind that the screw driver should not be "wiggled" while extracting it from the mini-implant head. Intense heat generation in the pre-insertion drilling phase can account for local necrosis of bone and consequentially lead to failure of the mini-implant.[30]

When the mini-implant head has a bracket like slot, putting a ligature around it will render it hopeless for the patient to keep the mini-implant area free of inflammation. It is also noted that flap surgery causes a greater risk of infection whereas a flapless surgery is relatively more acceptable to the patient. A self drilling mini-implant system should be desired in a flapless procedure.[23,28]

Considering that mini-implants are used for absolute anchorage, it is worth mentioning the amount of forces that can be applied to them. The maximum force that can be withstood by a mini-implant system is 50N-450N. Delayed mobility may breed failure of a mini-implant system if overloading beyond 450N is performed.[31] During placement, high torsional stress may cause implant bending or fracture or yield small cracks in the peri-implant bone. This can greatly influence mini-implant stability.[32,33]

In the factors that lead to the failure of mini-implant systems, the placement protocol is of fundamental concern for the orthodontist. Mini-implants should be placed in an area

where the damage to related structures is unlikely and the anatomy is amicable for its long term success. It should not touch the dental roots as osteosclerosis, dentoalveolar ankylosis and even tooth vitality can be at stake because of injury to the roots.[34,35] If only the periphery of the dental root is injured without the pulp being involved, the tooth's prognosis is not hindered.[36]

During placement in the maxillary posterior dento-alveolar, maxillary incisal and zygomatic regions, perforation of the nasal and maxillary sinuses can occur. If the maxilla is atrophic posteriorly there are greater chances of sinus perforation.[37] Major veins and arteries should be avoided during placement of the mini-implant as well.

Long term stability of mini-implants consists of sufficient primary and secondary stability. Adequate primary stability is dependent upon appropriate cortical bone thickness. Therefore according to various authors mini-implants should not be placed in less than 0.5 mm to 1 mm of cortical bone thickness.[38]

It is noted by various authors that in orthodontic loading anchorage failure maybe 11% to 30%.[39-42] Anchorage is related to bone density.[43-45] If there is low bone density because of inapt cortical thickness, failure occurs.[36] According to Hounsfield units (HU), bone density is divided into four groups, D1, D2, D3 and D4.[46] It was stated by Sevimay et al[47] that self drilling screws are ideal for D1 to D3 bone. Greater anchorage is achieved when mini-implants are inserted in D1 and D2 bone. Placing mini-implants into D4 bone is contraindicated due to a higher rate of failure.[48,49] The chances of anchorage failure are higher in the maxilla due to greater trabeculae and lesser bone density[44,50,51,53] (Figure 1).

If the cortical bone is not fully engaged during mini-implant placement, it can slide under the mucosal tissue along the periosteum bringing about mini-implant slippage. When an angle of 30° from the occlusal plane is used and immense forces are applied there are greater chances of mini-implant slippage.[53]

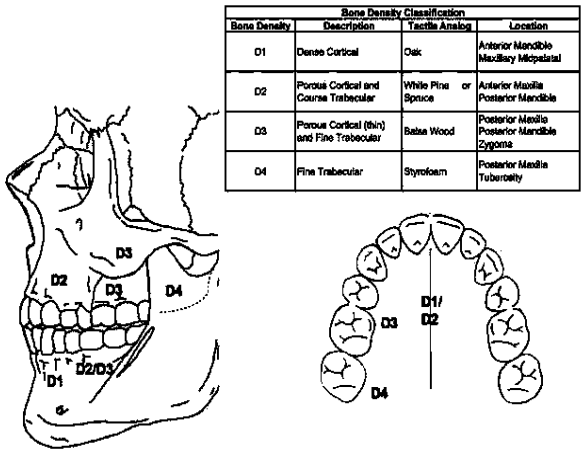


Figure 1: Bone Density Diagram (Courtesy Nel D. Kravitz and Budi Kusnoto)

If misplacement of the mini-implant in the retro-molar region, maxillary palatal slope or mandibular buccal dento-alveolus slope occurs, it can lead to nerve involvement or injury. However in cases where there is minor nerve damage, full recovery takes place in approximately six months.[54]

When air infiltrates the skin or the sub mucosa causing soft tissue distention, air subcutaneous emphysema occurs.[55] If the clinician does not manage this properly and the treatment is not discontinued it could lead to mini-implant failure.

Patient related factors: The patient should be informed and educated of the advantages and disadvantages of the treatment and consent should be sought.

There are numerous factors that effect the insertion of mini-implants like poor oral hygiene, gingivitis, thick mucosa, application of force, post extraction healing etc.[23,30]

The contraindications of mini-implants include factors such as tobacco smoking, uncontrolled diabetes, arthritis, medication (immunosuppressants), gingivitis, periodontitis, reduced mouth opening, bone quality, and radiotherapy.[3]

## Conclusion

This review has highlighted the importance of temporary extra-dental intra-oral anchorage by mini-implants and the factors that contribute to their failure. The success of orthodontic mini-implants is at the mercy of bone density, mini-implant design, soft tissues, placement protocol, force, load, patient compliance and surgical technique. Taking all the methods and regulation plus advantages and disadvantages into consideration, it should be comprehended that mini-implants ought to be used with immense precaution so that there is a decreased rate of failure.

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