

**Factors Affecting Stability of Orthodontic Mini Implants – A Literature Review**Sharath Kumar Shetty<sup>1</sup>, Vijayananda K. Madhur<sup>2</sup>, Ahammed Mahruf PP<sup>3\*</sup>, Mahesh Kumar Y<sup>4</sup><sup>1</sup>Professor & HOD, Department of Orthodontics and Dentofacial Orthopaedics, K. V. G. Dental College and Hospital, Sullia, Karnataka, India<sup>2</sup>Reader, Department of Orthodontics and Dentofacial Orthopaedics, K. V. G. Dental College and Hospital, Sullia, Karnataka, India<sup>3</sup>Post Graduate Student, Department of Orthodontics and Dentofacial Orthopaedics, K. V. G. Dental College and Hospital, Sullia, Karnataka, India<sup>4</sup>Professor, Department of Orthodontics and Dentofacial Orthopaedics, K. V. G. Dental College and Hospital, Sullia, Karnataka, India**Review Article****\*Corresponding author**

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**Abstract:** The stability of mini implants is affected by different factors. Factors like bone quality, implant placement torque, implant design factors like length, diameter, thread shape, location, time of load application, implant placement techniques, root contact, oral hygiene, systemic diseases, medications, habits found to influence the stability of mini implants. The aim of this review article is to conduct a review of current literature in order to update the knowledge about the factors affecting the stability of mini implants.**Keywords:** Mini implants, stability.**INTRODUCTION**

Stable anchorage is one of the most important prerequisites for successful orthodontic treatment. Especially in adult patients, periodontally-compromised, reduced dentition often detracts from the available anchorage potential [1]. In such cases, skeletal anchorage by means of endosseous implants has proven useful. In comparison to conventional solutions, the application of mini-implants reduces the need for patient compliance, thus broadening treatment options in orthodontics [2,3]. Among these anchorage devices, mini implants have increasingly been used for orthodontic anchorage because of their absolute anchorage, easy placement and removal, and low cost. The small size of mini implants allows them to be placed into bone between the teeth, thus expanding their clinical applications [4-7]. With more patients treated with mini implants as anchorage, their stability is gathering attention. The success of dental implants has been studied extensively. Long-term studies report success rates of more than 90% for prosthetic implants.

The long-term success rates of orthodontic mini implants have reported a variety of success rate from 37% to 94%. The success rates differ because:

- There are significant differences in the duration of use, patient age, level, and direction of the applied force, and placement site between the orthodontic mini implants and the prosthetic implants.
- Orthodontic mini implants have been used in younger patients rather than the prosthetic implants.
- Prosthetic implants sustain multi-directional and heavy occlusal force; the orthodontic mini implants bear a smaller force with a more regular direction.
- Several products from different manufacturers with various types of length, diameter, design, and material of the orthodontic mini implants have been combined in the previous studies [8-14].

Several studies have been done to analyze the success rate of mini implants and factors affecting the primary stability of mini-implants. Often these studies have contradictory conclusions regarding some factors that affect the stability of mini-implants. The aim of this review article is to critically analyze the available literature about the different factors affecting the stability of mini-implants.

**FACTORS AFFECTING THE STABILITY OF MINI-IMPLANTS:****BONE QUALITY**

Clinical, animal and artificial bone studies have demonstrated that the most important patient determinants of primary stability are the density and thickness of the maxillary and mandibular cortical plates.

### Density of bone

The maximum load for a non-integrated implant is proportional to the surface area of the implant in contact with the surrounding bone[15]. Bone density influences primary stability: thick dense, cortical bone provides better mechanical locking for the implant than less dense, cancellous bone[1] The regions between the maxillary second premolars and first molars, and mesial to the maxillary second premolars, are safe as far as bone quality is concerned for mini implant placement[16].

### Thickness of cortical plate

Cortical bone thickness might be important for the success of mini implants. A zone of cortical bone thickness of 1 mm or more was associated with fewer mini implant failures. Insertion sites with cortical bone thickness less than 1 mm were associated with more mini implant failures than sites with cortical bone thickness equal to or higher than 1 mm[17,18]. Greater cortical bone thickness was found to be associated with less deflection of mini implants. Cortical bone thickness less than 1 mm led to increased stresses that could cause resorption of the cancellous bone[17]. The risk of overheating when drilling sites of dense cortex is higher, continuous irrigation with saline solution must be used to prevent necrosis[19].

### IMPLANT PLACEMENT TORQUE

An adequate implant placement torque is an important factor determining the success rate of mini implants inserted in the buccal alveolar bone in the posterior regions of the mandible and the maxilla. Higher insertion torque (>10 Ncm) values during implant placement were associated with more mini implant failures. Because high levels of stress could cause necrosis and local ischemia of the surrounding bone, specific values of insertion torque have been proposed[17,20,21]. Wilmes *et al.* reported implants fracture near the implant head when using a crossdriver shaft at torques above 23 Ncm, and recommended that the torque should be generally limited to a maximum of 20 Ncm. A hexagonal head driver may distribute the stresses more evenly on the head of a miniscrew than a screwdriver[1].

### IMPLANT DESIGN

#### Diameter of mini implant

An increase in dimensions leads to greater bone surface engagement. Diameter is the most important factor in terms of primary stability because an increase in diameter leads to increased insertion torque[23-28]. Relatively large diameter mini-implants are also less likely to be deflected by prolonged loading, and importantly they are more fracture resistant[10,29,30,31]. However, 2 mm diameter mini implants are not easily accommodated in many interproximal spaces so most mini-implants have mid-body diameters of around 1.5 mm. The mini-implants with a smaller diameter are easier to be placed between

the roots, but a small reduction in this dimension decreases significantly the torsional strength and therefore increases the risk of fracture of the implant. It is advisable to avoid the implants smaller than 1.3 mm in diameter, especially when placed in the thick cortical bone in the lower jaw[10,19,31,32].

### Length of mini implant

Effect of length of mini-implants on its stability is contradictory according to different authors. Some authors in vivo studies [10,11,32-38] deny this relationship, while others confirm it[11,39,40]. Some authors found a positive correlation between the length of the mini-screw implants and the maximum possible loading, which can be identified with the primary stability[41-43]. However, others claim that the use mini implants that are too long may cause micro injuries to the bones, and they also emphasize the possibility of more frequent and more serious complications caused by the larger mini implants[44-46]. Wilmes *et al.*[47]. Have shown that the shape of the mini implants has a great impact on the success rate achieved, but they believe that the diameter and geometry of the longitudinal cross section rather than the length determine the results.

### Thread shape

The conical shaped mini-implants are known to be more stable because a conical shape is able to provide a tighter contact between the mini-implant and tissue than the cylindrical ones due to the different diameters between the upper and lower parts [48,49]. The taper shape needs high insertion torque. However, the removal torque of the taper shape was lower than the removal of torque of the dual-thread shape. The dual-thread shape showed a low insertion torque and a gentle increase of insertion torque. The dual-thread shape also showed higher removal torque on the broad range than the cylindrical and taper shapes. The modification of thread, such as dual-thread, may be less harmful to the surrounding bone tissue because of the low insertion torque. The modification of thread also may provide short and small mini-implants better mechanical stability with a high removal torque[42].

### LOCATION

Park *et al.* reported that the maxilla had a higher success rate than the mandible[10]. However, according to Miyawaki *et al.* and Moon the placement site of the mini implants in the maxilla or mandible was not related to the success rate[11,34]. According to Park *et al.*, the left side of the arches had a significantly higher success rate than the right side[10]. But according to Moon, there was no significant difference in the success rate between the right and left side of the arches[34]. Significantly higher failure rates were observed for mini implants placed in the posterior region compared with those placed in the anterior region of the maxilla. In addition, higher mini implant failure rates were observed at sites of the maxilla with

cortical bone thickness less than 1 mm compared with sites with cortical bone thickness of 1 mm or more. The area between the mandibular first and second molars had the highest failure rate, whereas the area between the mandibular first and second premolars had the lowest[34,50].

### **TIME OF LOAD APPLICATION**

A correlation between the time of force application and success rate is not always found[11]. Immediate loading seems to have a positive effect on bone, increasing the cellular turnover and density in the areas adjacent to loaded implants in comparison with implants with no force applied, suggesting that orthodontic loading may have a protective effect[51]. According to Kuroda *et al.* and Manni, immediate loading seemed to have a positive and significant influence on the success rate[32,52]. Nkenke *et al.* on the other hand, found no significant difference in terms of daily bone apposition, bone-implant contact, and bone density in the presence or absence of early loading[53].

Cheng *et al.* reported a success rate of 89 per cent with application of orthodontic forces after 2–4 weeks [19]. While Costa *et al.* found almost the same results with immediate loading (87.5 per cent)[54]. Immediate loading of mini-implants can be performed without loss of stability providing the tipping moment at the bone rim does not exceed the upper limit of 90 Ncm[15].

### **IMPLANT PLACEMENT TECHNIQUES**

#### **Method of placement**

Insertion methods of the mini implants are diverse. Costa *et al.* [54] inserted mini implants by the pilot-drilling method without soft tissue incision, Moon[1] by the self-drilling method without soft tissue incision; and Kanomi[4] Park[5] and Park[8] by the pilot-drilling method after soft tissue incision. Kim *et al.* [55], Kim and Chang [56] reported that after soft tissue incision, the self-drilling group was more stable than the pilot-drilling group, and Kim and Choi[39] reported that the pilot drilling method had a higher failure rate than the self-drilling method

Larger the diameter of the pilot hole in relation to the diameter of the implant the lower the primary stability, and the smaller the pilot hole in relation to the implant diameter, the more likely that the implant will fracture.<sup>1</sup> The self-tapping or drill-free screws have less mobility and more bone to-metal contact compared with that were inserted into a pilot hole[9,55].

#### **Surgical technique**

Surgery without a soft tissue flap is generally more comfortable for the patient than surgery with a flap. However, a soft tissue flap is necessary when a miniplate is used. A small incision in the mucosa may be necessary to visualize the underlying bone and

prevent the mucosa from wrapping around the thread of the screw during insertion[11].

#### **Placement angle**

Placement at 90° to the cortical plate is the most retentive insertion angle. Insertion at an oblique angle from the line of force reduces retention[41]. Mini implants loaded along their long axis have the greatest stability and resistance to failure. The more closely the long axis of the mini implants approximates the line of applied force, the greater the stability of the mini implants and the greater its resistance to failure[44].

#### **MANDIBULAR PLANES ANGLE**

According to Miyawaki *et al.* high mandibular plane angle is a risk factor for failure of mini implants[11]. Recent studies show that the thickness of buccal cortical bone in subjects with a high mandibular plane angle (1.5-2.7 mm) was thinner than that in subjects with a low angle (2.3-3.7 mm) in the mandibular first molar region[57,58]. According to Moon, low Frankfort-mandibular plane (Porion-Orbitale to Gonion-Menton) is more important factor for the success of mini implant than the mandibular plane angle (Sella-Nasion to Gonion-Menton)[59]. According to Kuroda *et al.* there is no correlation between the success rate of mini implants and the mandibular plane angle[32].

#### **ROOT CONTACT**

Root contact during insertion is associated with increased the failure rates of mini implants. The rate and pattern of root contacts have been reported to be associated with the surgery site and the operator's experience. Root contact produces greater stresses[60]. Which could result in irreversible loss of mini implant stability[61]. Mini implants with root contact were found to be surrounded by increased volumes of soft tissues, with inflammation around the mini implants, but the damaged areas of the roots were finally repaired with a narrow zone of mineralized tissue deposited on the root surface after screw removal[62,63].

Close proximity of the mini-implant body and adjacent roots should be avoided in order to avoid periodontal and root damage, although histological studies show that cellular cementum repair occurs after root trauma[62,64,65-70]. The major problem with close implant-root proximity is that this provides inadequate bone coverage for the threads, destabilizes the mini-implant, and increases failure rates[71-76]. Root proximity appears to be more of a risk factor than variations in cortical thickness[76]. Root contact, or proximity, is usually detected during mini-implant insertion by a sharp increase in insertion resistance blunting of the mini-implant tip, patient discomfort[62,67,77] These signs should be taken as indicators of close proximity and the mini-implant withdrawn and re-inserted at a different location or angle.

## **ORAL HYGIENE**

Poor oral hygiene and peri-implant soft tissue inflammation are risk factors for secondary failure [10,11,19,38,78,79] These problems are more likely in loose (non-keratinized) mucosa and once inflammation occurs, it tends to persist in nonkeratinized mucosa areas. Therefore it is almost always recommended that mini-implants are inserted through attached mucosa. This should minimize soft tissue disruption and the destabilizing effects of mobile peri-implant tissue [10].

## **AGE**

The primary stability of mini implants in adults is higher compared to that of adolescents. This is due to their reduced cortical thickness and density [71] and higher bone remodeling levels, which may compromise the stability of mini implant. Mini-implants are still successful in adolescents, but it is advisable to be cautious and keep the loading force low (e.g. 50 g) for the initial six weeks after insertion [80].

## **GENDER**

Most of the studies show that mini-implant success appears to be unaffected by patient gender[10,11,34]. But according to Lim female subjects had a higher success rate than the males[81].

## **SYSTEMIC DISEASES**

### **Risk of infective endocarditis**

Since placement of orthodontic mini implants causes an insult to the oral mucosa and underlying bone, a prophylactic antibiotic has been recommended for patients who are at risk of infective endocarditis[82].

### **Diabetes**

Placement of mini implants and orthodontic treatment should be avoided in patients with poorly controlled insulin-dependent diabetes mellitus, as these individuals are particularly susceptible to periodontal breakdown and have poor wound healing[83,84]. Even in well-controlled diabetics good oral hygiene is essential, since these patients are more prone to gingival inflammation which can cause an implant to fail[85].

### **Juvenile idiopathic arthritis**

There is no contraindication for the use of orthodontic mini implants in patients with juvenile idiopathic arthritis. The clinician should, however, assess whether the wrist joint is affected, since affected patients may find tooth brushing and flossing difficult[85].

## **MEDICATIONS**

Any medication likely to hinder wound healing, gingival health and tooth movement should be taken into account prior to placement of mini implants. Examples of medication that may lead to failure of mini implants are: bisphosphonates, immunomodulators, anti-

epileptics, anti-aggregation medication and anticoagulants[85].

## **HABITS**

### **Tobacco smoking**

Patients who smoke more than 10 cigarettes a day are considered to be 'heavy smokers' and have poor wound healing[86]. A higher failure rate and greater loss of marginal bone around titanium implants occurs in patients who smoke[87]. If dental plaque cannot be controlled, it is advised to stop smoking at least one week before and eight weeks after dental implant surgery[86]. Since orthodontists have regular contact with teenagers, one author considers that orthodontists can play an important role in discouraging youngsters from smoking[88].

## **CONCLUSION**

It can be concluded that various factors affect the stability of mini implants. Among different factors, bone density and cortical bone thickness are the most important patient determinants of primary stability. Higher insertion torque values during implant placement were associated with more mini implant failures. Diameter is the most important factor among design factors for primary stability because an increase in diameter leads to increased insertion torque. Positive correlation between the length of the mini-screw implants and the primary stability, but mini implants that are too long may cause injury to root of the teeth and adjacent structures. Placement at 90° to the cortical plate is the most retentive insertion angle. Poor oral hygiene and peri-implant soft tissue inflammation are risk factors for failure of mini implants. Systemic diseases, different medications, tobacco smoking have a negative effect on the stability of mini implants.

**Conflict of interest:** None

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