

THE EFFECT OF CORTICAL BONE THICKNESS ON THE PRIMARY STABILITY OF MINISCREWS, USING CBCT (CROSS-SECTIONAL CLINICAL TRIAL)

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ABSTRACT

Objectives: The aim of the present study was to determine the correlation between the thickness of both cortical bone thickness, total bone thickness and the primary stability of mini-implants.

Methods: Twenty-six mini-screws (Absoanchor) were inserted into the buccal alveolar bone between the roots of the second premolar and first molar on the right and left side of the patient. The mobility of the mini-screws was clinically assessed using the periotest device and the buccal cortical bone thickness of the maxilla was measured on the right and left side in the inter-radicular area between the second premolar and first molar at the site of the miniscrew insertion. The patient's head was oriented in all 3 spatial planes by adjusting the Frankfort plane horizontal and the orbital plane parallel to the floor.

Results: There was a statistical significant differences between mean measurements of the cortical bone thickness penetrated by the mini-screw and the negative stability scores. (P=0.03)

Conclusions: There was a weak correlation between the primary stability of the mini-screw and the cortical bone thickness. However, a minimum thickness of 1.0 mm cortical bone thickness is necessary for adequate stability.

KEYWORDS miniscrews - stability - cortical bone thickness)

INTRODUCTION

Anchorage control is a critical consideration when planning orthodontic treatment for patients with dental and skeletal malocclusions. Demands of orthodontic mini-implants as an absolute anchorage devices are becoming more popular.¹ Despite their

advantages over the extra-oral anchorage devices, mini-implants can be loosened during treatment and eventually fail to provide firm anchorage.² The success criteria of mini-implants can be defined as: (A) no inflammation of soft tissues surrounding the mini-implants, (B) no clinical detectable mobility

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and (C) anchorage sustained till the end of treatment. Primary stability is a key factor for the success of mini-implants which has an important role in preventing premature loosening of mini-implants³. The primary stability of mini-implants during the early phase of placement is achieved by mechanical retention rather than osseointegration.⁴ The primary stability can be defined as the absence of mobility in the bone at time of placement.⁵ Absence of immediate stability can lead to progressive mobility of the mini-implant and its subsequent loss.⁶ Several studies found that the primary stability is affected by age, sex of the patient, mini-implant design, the time of loading and the quality and quantity of bone.⁷

Knowledge of the buccal cortical bone thickness in various areas of the jaws should guide clinicians in selecting the optimum position for miniscrew placement. Huja et al and Wilmes et al, reported that cortical bone thickness was related to the stability of mini-implants.^{8,9} A study was done by Motoyoshi et al investigated the relationship between cortical bone thickness and the success rate of mini-implants. The study concluded that the cortical bone thickness should be 1mm or more to improve the success rate.¹⁰ Deguchi et al reported the optimum location for a mini-implant was mesial or distal to the first molar and that the inclination of the mini-implant should be slanting to the bone surface to minimize the injury to the adjacent roots.¹¹

Recently, some researchers have proposed that the cortical bone thickness has an important role in the primary stability of mini-implants.¹² The optimal sites for the mini-implant insertion have been evaluated using different methods including periapical radiographs, panoramic radiographs and computed tomography.¹³ Recently, CBCT which provides a clear 3-dimensional images with small voxel size, has been widely used in head and neck diagnosis, orthodontics and implant dentistry and for accurate

surgical guidance of miniscrew placement.¹⁴ The final accuracy studies involving CBCT imaging have shown that 3D measurements are more close to reality and more accurate than 2D measurements.¹⁵

Different techniques has been used to evaluate the mini-implant stability including reverse/removal torque value, pullout test, resonance frequency analysis (RFA) and periotest value (PTV). The periotest device (*Medzintechnik Gulden, Modautal, Germany*) is a non-invasive method that is used to assess the mobility of natural teeth.¹⁶ Moreover, it can be used to evaluate the stability of implants and orthodontic mini-implants. The periotest values ranges from -8 (clinically stable) to +50 (loose implant). Clinically, it can be used easily showing reproducible results from implant-bone contact.¹⁷

The aim of the present study was to determine the correlation between the thickness of both cortical bone thickness, total bone thickness and the primary stability of mini-implants.

MATERIAL AND METHODS

Study Design and Setting: The study was carried out as a cross-sectional clinical trial. The estimated sample size was calculated according to <http://epitools.ausvet.com.au/>, by taking the mean stability from previous similar study conducted by Mariana et al,¹⁸ where the means \pm (SD) were 9.76 (+3.84) and 5.3 (+2.59), where the variance was calculated to be 15, assuming the confidence level of 95% and a study power of 80%. The calculated sample size was 24 mini-implants. Ten percent was added to the sample size to eliminate the possibility of drop-out through the clinical trial. Therefore, 26 mini-implants were inserted in the maxillary arch of 13 patients between the age of 14 and 28 from the outpatient Department of orthodontics, Faculty of Dentistry, Beirut Arab University.

The inclusion Criteria included patients required

bilateral extraction of upper first premolar and absolute anchorage with good oral hygiene. On the other hand, the exclusion criteria were patients with systemic disease, medications affecting gingival health and periodontal disease.

The Institutional Research Review Board of the Beirut Arab University, Faculty of Dentistry had revised and approved the study for scientific validity and methodology with an approval code: 2015H-0026-D-P-96. Consent forms were collected from the patients according to the guidelines of the Institutional Review Board (IRB) at Beirut Arab University. The maximum exposure of the radiation for each patient was less than exposure limits reported from the recommendations of the International Commission on Radiological Protection, ICRP publication 103.

METHODS

Initial phase:

Diagnostic records were collected from each patient including study casts, photographs, lateral cephalometric and panoramic radiographs. Transpalatal arches were cemented to avoid the mesial movement of the first molar. After finishing the leveling and aligning of the upper arch and reaching stiff arch wire (0.17x0.25 stainless steel), the 2 upper first premolars were extracted by an oral surgeon.

Miniscrew placement

Two miniscrews (Absoanchor Dentos) were inserted at the buccal cortical bone between the roots of the second premolar and first molar, one on each side the right and left side of each patient under local anesthesia consisting 2% lidocaine with epinephrine (3M ESPE). The miniscrew was inserted in an oblique direction (60°) to avoid touching to the tooth root. When the head of the screw lied at the level of the surface of the gingiva, indicating its final position.

Stability Assessment

After placement of the miniscrews, its mobility was immediately assessed using the periotest device (Siemens AG, Bensheim, Germany). The periotest was held perpendicular to the miniscrew head at distance of 2.0 to 3.0 mm. (Fig.1) Measurements were taken at a frequency of around four times per second, then a numerical value was shown ranging from -8 (good stability) to +50 (failure).



Fig. (1) Stability measurement using periotest

CBCT Assessment

The patients were sent for CBCT scan on the maxilla to determine the position of the miniscrews. Images were taken with care-stream cone beam 3D dental imaging system (Kodak 9000C) at 76 Kvp 5.0 mA and slice thickness 1.4mm. The buccal cortical bone thickness in the maxilla was measured on both sides at the site of the miniscrew placement between the roots of the second premolar and first molar. The patient's head was oriented in all 3 spatial planes by adjusting the Frankfort plane horizontal and the orbital plane parallel to the floor. To measure the buccal cortical bone thickness, coronal images were used to locate the miniscrew insertion site. The slice was oriented along the vertical reference line passing through the head of the miniscrew until the whole length of the miniscrew appears (7mm). Linear measurements were taken just below the miniscrew for the buccal cortical bone parallel to the long axis of the miniscrew. (Fig.2)

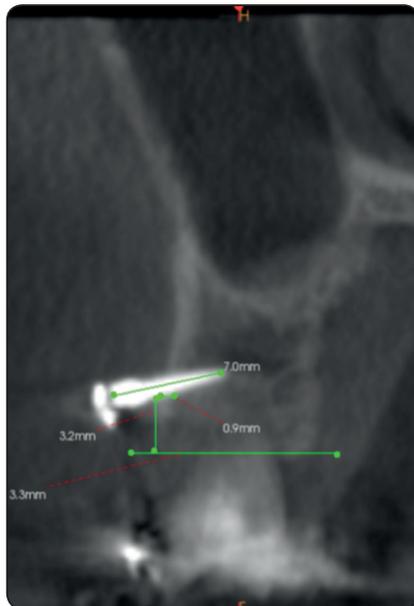


Fig. (2) Measurement of cortical bone thickness

Statistical Analysis

The data was tested for normality using Kolmogorov-Smirnov test and it showed not normally distribution. Hence, the comparison of the means regarding the clinical study variables was done using t-test (non-parametric test) with p value less than 0.05. Significance level was set at the 5% level. The Pearson correlation test was applied to verify the correlational relationships between variables. Statistical analysis was performed using the SPSS.

RESULTS

This study was conducted as a cross-sectional clinical trial. Twenty-six mini-implants were inserted into the maxilla of 13 patients at the buccal cortical bone between the roots of second premolar and first molar.

Table 1 showing significant difference regarding stability scores. The mean CBT penetrated by the mini-implant with negative stability scores was 1.2 (+0.33), whereas the total depth of penetration of mini-implant in CBT with positive stability was 0.98 (+0.15). When comparing both values together,

it was found that there is a statistical difference between them ($P=0.03$).

The stability scores increased with increasing the depth of mini-implant penetration within the cortical bone.

TABLE (1) Comparison between the primary stability and cortical bone thickness

	Mean(SD)		T test P value
	Negative stability (Good stability)	Positive stability (Poor stability)	
Cortical bone thickness	1.20 (0.33)	0.98 (0.15)	2.25 0.03*
Total length	5.37 (0.80)	5.36 (0.83)	0.01 0.99

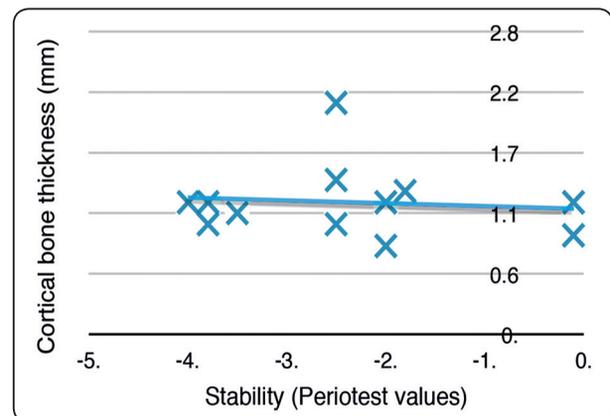


Fig. (3) Correlation between cortical bone thickness and stability

Table 2 showing the correlation between the depth of penetration of mini-implant within the cortical bone with the stability regarding the positive and negative scores measured by the periotest. It was observed that there was a weak correlation (-0.1) for the negative stability values and also a weak correlation (0.1) for the positive stability values. Those values were non-statistically significant with P-values (0.75, 0.74) respectively. (Fig.3)

TABLE (2) Correlation between the primary stability and the cortical bone thickness

	Pearson correlation (r) P value	
	Negative stability	Positive stability
Correlation between cortical bone thickness and stability values	-0.10 0.75	0.10 0.74
Correlation between cortical total length and stability values	0.18 0.59	-0.46 0.10

DISCUSSION

Maintaining a proper anchorage was always an interest to clinical orthodontists and researchers. Problems with traditional forms of anchorage had been reported.⁵ Miniscrews as an absolute anchorage devices in orthodontic treatment had definite advantages and efficacy. Their stability was critical in achieving successful skeletal anchorage, studies had shown different factors having correlation with the stability of miniscrews.¹⁹ As miniscrews pass through the soft tissue and cortical bone, therefore their thickness at the miniscrew insertion site were critical factors for achieving successful stability.

The primary stability of miniscrews is considered essential in clinical use because most patients require early loading to enhance the treatment time.²⁰ Cortical bone thickness is one of the important factors that plays a major role in miniscrew stability.²¹ A study by Myawaki et al, looseness of titanium screws is associated with thin cortical plate.²² Motoyoshi et al, stated that greater cortical bone thickness was required for the success of orthodontic miniscrews.¹⁰

It might appear logical that a longer miniscrew could provide greater stability because of greater surface area contacting the bone. However, Wilmes et al, Miyamoto et al. recommended that the miniscrew stability at time of insertion largely depend on cortical bone thickness rather than miniscrew length.^{23,24}

This study was carried out as an experimental cross-sectional clinical trial design. The aim of the current study was to evaluate the correlation between the cortical bone thickness, the total bone thickness and primary stability of miniscrews.

Researchers had evaluated the reliability of the periotest device for assessing the implant stability and reported that it could significantly evaluate differences in inter-implant stability.²⁵ In the current study, the periotest device was used in evaluating the primary stability of the miniscrews immediately after placement.

CBCT technology had been used in the current study to provide 3D images with more detailed 3D visualization of the miniscrew site in the maxilla. Although the miniscrew placement sites in the maxilla had been studied extensively, a systematic evaluation of maxillary inter-radicular bone has not been done.²⁶ In the current study, CBCT was used as the effective dose of radiation is much lower than for medical Computed tomography scans.²⁷

Most miniscrews have a thread diameter from 1.2 to 2.0 mm and a length from 4 to 12mm.²⁸ Decreased thread diameters could facilitate insertion into sites with small root proximities and reduce the risk of root injury. Moreover, a major concern regarding the thread diameter of miniscrews was the increased risk of fracture with diameter less than 1.2 mm.²⁹ In the current study, the miniscrew design was standardized to 1.5mm diameter and 7 mm length in all patients.

Miniscrews should be placed in keratinized gingiva when possible,³⁰ the frenulum and muscle tissues should be avoided. Hence, the optimum initial point for miniscrew insertion should be near the mucogingival line in the attached gingiva.³¹ In the current study, the miniscrew was placed in the buccal inter-radicular bone between the roots of 2nd premolar and 1st molar, since it was the preferable site for the retraction of canine. The miniscrew was placed apical to the CEJ in the most stable position clinically.

The clinical results showed a statistically significant increase in primary stability of the mini-implants when the cortical bone thickness increased where $P=0.03$. However, there was no statistically significant difference between the primary stability and the total length of the mini-implant inside the alveolar bone. This could be attributed due to the role of the cortical bone in maintaining the stability of the mini-implants as shown from the finite element analysis, when a lateral force was applied to the mini-implant, the stress distribution was mainly distributed in the neck region, which embedded in cortical bone.³²

In agreement with our results, Marco et al evaluated the primary stability of different shaped mini-screws regarding the maximum insertion torque, pullout force and radiographic evaluation of bone characteristics. The study resulted in a moderate positive correlation between the cortical bone thickness with the torque measures.³³

In accordance with our results, Huja et al investigated the pull-out strength of screws in bone as related to the placement location of the mini-implants using dogs and found a positive correlation between cortical bone thickness and pull-out strength. Initial stability after insertion of the mini-implant was facilitated by greater cortical bone thickness.³⁴

On the other hand, Motoyoshi et al examined the relationship between the cortical bone thickness, the implant placement torque and the success rate of mini-implants placed for orthodontic anchorage. After computerized tomography examination, mini-implants of 1.6 diameter and length 8mm were placed in the posterior alveolar bone. The mini-implant was judged for success when force applied for at least 6 month without pain or clinical mobility. The study concluded that was no relationship between the stability after implant placement and the width and height of peri-implant bone. The site of insertion should have a minimum thickness of 1mm of cortical bone thickness for adequate stability, however, greater thickness of cortical bone thickness did not improve the success rate.³⁵

CONCLUSIONS

- 1- The cortical bone thickness is related to the primary stability of the mini-implants, as the stability of the mini-implants improved when placed in thicker cortical bone.
- 2- The thicker the total bone length where the mini-implants were inserted did not have any influence on the stability of the mini-implants.

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