Original Article

Three-dimensional Evaluation of Interradicular Areas and Cortical Bone Thickness for Orthodontic Miniscrew Implant Placement Using Cone-beam Computed Tomography

Garadappagari Dharmadeep1, Moode Kaladhar Naik2, Yellampalli Muralidhar Reddy1, Sreekanth Cheruluri1, Kranthi Praveen Raj1, Badepalli Reddeppa Reddy1

1Department of Orthodontics and Dentofacial Orthopedics, G. Pulla Reddy Dental College and Hospital, Kurnool, Andhra Pradesh, India, 2Department of Orthodontics and Dentofacial Orthopedics, Government Dental College and Hospital, Kadapa, Andhra Pradesh, India

Background: Factors that influence anchorage of the orthodontic miniscrew implants are interradicular areas and cortical bone thickness. Aims and Objectives: The aim of this study was to evaluate the three-dimensional interradicular areas and the buccal cortical bone thickness in Indian patients using cone beam computed tomography (CBCT) images, and to find the suitable and safe sites for orthodontic miniscrew implant placement. Materials and Methods: CBCT images of 20 patients were divided into three planes as axial, coronal, and sagittal. Measurements, that is, mesiodistal distance and buccal cortical bone thickness were taken at five different heights from the cementoenamel junction (CEJ) toward apical region. Results: In the maxilla, the safe sites for placing miniscrew implant were between the second premolar and first molar at 10-mm height, whereas in the mandible, the safe sites for placing miniscrew implant were between the first and second premolar at 6-, 8-, and 10-mm height, between the second premolar and first molar at 10-mm height, and between the first and second molar at 8- and 10-mm height. Conclusion: CBCT can be effectively used to evaluate interradicular areas and cortical bone thickness in predicting the safe and suitable sites for placing orthodontic miniscrew implants.

Keywords: Anchorage, cone beam computed tomography, cortical bone thickness, interradicular area, orthodontic miniscrew implant

INTRODUCTION

In recent times, miniscrew implants are in use to attain anchorage. The main advantages of these implants are their small size, uncomplicated surgical procedure, cost-effectiveness, immediate load, minimal patient cooperation, and multiple insertion positions.[1] The most commonly selected site for placing miniscrew implants is buccal interradicular area, due to the ease of placement, and also as it allows relatively simple orthodontic mechanics.[2] The disadvantage noticed in studies is loosening of these implants during treatment and ultimately failure to offer firm anchorage. The rates of microimplant failure were found to be between 11% and 30%.[3]

While placing implants, surgeons should keep in mind the two factors, safety and stability. Safety factor avoids damage to anatomical structures, such as blood vessels, nerves, and maxillary sinus, and stability is dependent on the cortical bone thickness at the site of placement, and it prevents premature loosening and dislodging of the miniscrew implants. Previously, microimplants were placed based on the two-dimensional radiographs.

Address for correspondence: Dr. Moode Kaladhar Naik, Department of Orthodontics and Dentofacial Orthopedics, Government Dental College and Hospital, Rims Campus, Putlampalli Village, Kadapa 516004, Andhra Pradesh, India. E-mail: marvelviks@gmail.com

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Dharmadeep G, Naik MK, Reddy YM, Cheruluri S, Praveen Raj K, Reddy BR. Three-dimensional evaluation of interradicular areas and cortical bone thickness for orthodontic miniscrew implant placement using cone-beam computed tomography. J Pharm Bioall Sci 2020;12:S99-104.
Nowadays, microimplants are placed with three-dimensional (3D) information about the thickness of bone and interradicular space, and there is a reduction in the failure rates.

Poggio et al.\textsuperscript{[4]} suggested having a minimum 1.0 mm of alveolar bone clearance around the miniscrew implant for optimal periodontal health. According to Monnerat et al.,\textsuperscript{[5]} in maxillary molar region, the placement of miniscrew implant more than 8.0 mm above the alveolar crest or 9.5 mm above the cementoenamel junction (CEJ) should be avoided due to chances of perforating maxillary sinus. Similarly in case of mandibular premolars, one should be careful regarding mental foramen, particularly at the height of 9 mm from the alveolar crest or 10.5 mm from CEJ.\textsuperscript{[4,5]}

Moreover, Poggio et al.\textsuperscript{[4]} suggested that it should not be embedded for more than 6–8 mm of buccolingual alveolar process width because it might reach the narrowest interradicular space. In maxillary molar region, one should be careful if miniscrew implant has to be placed 8.0 mm above the alveolar crest or 9.5 mm above the CEJ, because of the presence of the maxillary sinus. The mental foramen is usually located between the apices of the mandibular premolars. Therefore, the caution is advised when placing miniscrew implant in this area, particularly starting at the height of 9 mm from the alveolar crest or 10.5 from CEJ. The cortical bone thickness is related to the stability of miniscrew implant. Motoyoshi\textsuperscript{[6]} recommended that the recipient site should be an area with a cortical bone thickness of more than 1.0 mm.\textsuperscript{[4,5]}

The purpose of this study, therefore, was to evaluate the 3D interradicular areas and the buccal cortical bone thickness in Indian patients using cone beam computed tomography (CBCT) images, and to determine the safe and suitable sites for orthodontic miniscrew implant placement.

**MATERIALS AND METHODS**

Twenty patients (10 each of males and females; aged between 20–35 years) were included in the study.

Inclusion criteria consist of the following:

1. Fully erupted permanent dentition (except for third molars)
2. No history of previous orthodontic treatment, no missing teeth (excluding third molars), no severe craniofacial disorders, no severe periodontitis, and no severe crowding and spacing in posterior teeth

Ethical clearance was obtained from the institutional ethics committee. Informed and written consent of the patients was obtained before they were subjected for the study.

All patients were imaged with Carestream CS 9300 CBCT unit [Figure 1], at 10 cm field of view, 74 kV, 12 mA, and exposed for 15.3 s. Initially, the patient was exposed to X-ray for scout image. If any corrections were required, they were carried out, and again scout image was taken. If no corrections were required, then the patient was exposed for final image [Figures 2–4]. After acquiring final images of CBCT using Kodak CS 3D Imaging DICOM Software, rendered images were divided into three planes as axial, coronal, and sagittal. Using software tools for each interradicular area in the maxilla and the mandible, the measurements, that is, mesiodistal distance (MD) and buccal cortical (BC) bone thickness were taken at five different heights from the CEJ toward apical region. For each patient, all parameters were measured and performed by one investigator only. The CBCT images of five patients were randomly selected and remeasured by the same examiner after a 4-week interval to test for intra-observer reliability.

**RESULTS**

The Statistical Package for the Social Sciences (SPSS) (IBM, Armonk, New York) software, version 20.0 was used for analyzing the data. Paired \textit{t} test was used to determine the intra-observer reliability. Unpaired \textit{t} test was used to analyze the differences between measurements of the right and the left side. The mean values and standard deviations of the MD and BC bone thickness of the maxilla and mandible are shown in Tables 1 and 2.

**DISCUSSION**

Anchorage reinforcement may require supplementary usage of extraoral units such as headgear and
intermaxillary elastics. Headgear requires 24 h continuous appliance wear and full cooperation of the patient, whereas elastics have a risk of vertical side effects and tipping. Transpalatal bars and lingual arches passive and active have also been used as alternates to headgear and elastics, but none provided absolute anchorage. Hence, in recent times, implants are used as the method for absolute orthodontic anchorage.[7,8]

The critical factors that need to be considered for the stability of implants are the quality (bone density) and quantity (bone volume) of alveolar bone. The anatomical characteristics, such as cortical bone thickness and interradicular bone width, have some affect on implant success rate.[9]

Commonly used investigation methods for assessing available bone and soft tissue quantity, such as
periapical radiographs, orthopantomogram, and lateral cephalogram, do not provide accurate information. Hence, advanced imaging techniques, such as CBCT, are used in recent times for 3D information.\[^6,9\]\(^\text{[5]}\)

Interradicular distance assessment is significant as it has a role in the safety and stability of microimplants. According to Kuroda et al.\[^10\] and Asscherickx et al.\[^11\] the root proximity is a key factor for screw failure, suggesting that sufficient interradicular space is crucial for both safety and late stability. Schnelle et al.\[^12\] considered 3–4 mm of interradicular distance as the minimum amount for a microimplant.

In the maxilla, between central incisors, safe site for miniscrew implant placement is present at 10 mm from CEJ, whereas between central and lateral incisor, only average risk site for mini implant placement is present at 10 mm from CEJ. Between lateral incisor and canine, safe sites for mini implant placement are present at 10 mm from CEJ. Average risk site for mini implant placement is present at 8 mm from CEJ. These values are correlating with previous studies of Lee et al.\[^13\] and Hu et al.\[^14\] whereas between canine and first premolar, first and second premolar, and first and second molar, no safe zone for mini implant placement is present. Between second premolar and first molar, safe sites for mini implant placement are present at 10 mm from CEJ. Average risk site for mini implant placement is present at 10 mm from CEJ. These values are correlating with previous studies by Park and Cho\[^15\] and Schnelle et al.\[^12\]

The safe sites for placing miniscrew implant in the maxilla of our study are between the second premolar and first molar at 10-mm height (4.01 ± 1.27 mm); however, one should be careful about maxillary sinus position at this height.

These data show that, for all variables, the measurements gradually increased from cervical area to apical area. Small variations from this trend were observed between the first and second premolar at the 8-mm height (for MD, BC), the second premolar and first molar at the 8-mm height (for BC), and the first and second molar at the 6- and 8-mm height (for MD).

In the mandible, between central incisors, central and lateral incisor, and lateral incisor and canine, no safe zone for mini implant placement is present. Between canine and first premolar, the average risk site for mini implant placement is present at 10 mm from CEJ. Between first and second premolar, safe sites for mini implant placement are present at 6, 8, and 10 mm from CEJ. Average risk site for mini implant placement is present at 4 mm from CEJ. This finding is in accordance with Lee et al.\[^13\] and Hu et al.\[^14\]

Between second premolar and first molar, safe sites for mini implant placement are present at 10 mm from CEJ. Average risk site for mini implant placement is present at 8 mm from CEJ. Between first and second molar, safe sites for mini implant placement are present at 8 mm and 10 mm from CEJ. Average risk site for mini implant placement is present at 6 mm from CEJ. This finding is
### Table 1: Mean values and standard deviations of measurements of the mesiodistal distance and buccal cortical bone thickness of the maxilla

| Area | Height (mm) | 1–1 | 1–2 | 2–3 | 3–4 | 4–5 | 5–6 | 6–7 |
|------|-------------|-----|-----|-----|-----|-----|-----|-----|
|      |             | Mean | SD  | Mean | SD  | Mean | SD  | Mean | SD  |
| MD   | 2           | 2.4  | 0.51| 2    | 0.45| 2    | 0.71| 1.6  | 0.65|
|      | 4           | 2.8  | 0.65| 2.2  | 0.63| 2.4  | 0.57| 1.8  | 0.72|
|      | 6           | 3.2  | 0.72| 2.4  | 0.7 | 2.8  | 0.55| 2    | 0.79|
|      | 8           | 3.5  | 0.79| 2.5  | 0.8 | 3.1  | 0.78| 2.2  | 0.89|
|      | 10          | 3.6  | 0.87| 3.1  | 0.37| 3.6  | 0.83| 2.4  | 0.92|
| BC   | 2           | 0.5  | 0.31| 0.5  | 0.22| 0.5  | 0.32| 0.6  | 0.4 |
|      | 4           | 0.6  | 0.38| 0.7  | 0.34| 0.7  | 0.28| 0.9  | 0.32|
|      | 6           | 0.8  | 0.39| 0.9  | 0.35| 0.9  | 0.34| 0.9  | 0.33|
|      | 8           | 1    | 0.35| 1    | 0.36| 1.2  | 0.24| 1.2  | 0.44|
|      | 10          | 1    | 0.4 | 1    | 0.35| 1.2  | 0.42| 1.3  | 0.43|

1–1 = between central incisors, 1–2 = between central and lateral incisors, 2–3 = between lateral incisor and canine, 3–4 = between canine and first premolar, 4–5 = between first and second premolars, 5–6 = between second premolar and first molar, 6–7 = between first and second molars

*Average risk site, **safe site

### Table 2: Mean values and standard deviations of measurements of the mesiodistal distance and buccal cortical bone thickness of mandible

| Area | Height (mm) | 1–1 | 1–2 | 2–3 | 3–4 | 4–5 | 5–6 | 6–7 |
|------|-------------|-----|-----|-----|-----|-----|-----|-----|
|      |             | Mean | SD  | Mean | SD  | Mean | SD  | Mean | SD  |
| MD   | 2           | 1    | 0.23| 1.8  | 0.63| 1.7  | 0.73| 2.2  | 0.32|
|      | 4           | 0.9  | 0.31| 2    | 0.54| 2.3  | 0.64| 2.5  | 0.34|
|      | 6           | 0.9  | 0.32| 2.2  | 0.64| 2.4  | 0.74| 2.7  | 0.43|
|      | 8           | 1    | 0.34| 2.4  | 1.24| 2.6  | 1.14| 2.9  | 0.5 |
|      | 10          | 1    | 0.38| 2.6  | 1.2 | 2.9  | 1.21| 3.2  | 0.53|
| BC   | 2           | 0.6  | 0.21| 0.8  | 0.11| 0.9  | 0.24| 0.9  | 0.36|
|      | 4           | 0.8  | 0.38| 0.9  | 0.22| 1.2  | 0.38| 1.2  | 0.39|
|      | 6           | 0.8  | 0.62| 0.9  | 0.23| 1.5  | 0.63| 1.6  | 0.42|
|      | 8           | 0.9  | 0.29| 1    | 0.39| 1.6  | 0.39| 1.8  | 0.45|
|      | 10          | 1    | 0.38| 1.2  | 0.42| 1.9  | 0.48| 2    | 0.48|

1–1 = between central incisors, 1–2 = between central and lateral incisors, 2–3 = between lateral incisor and canine, 3–4 = between canine and first premolar, 4–5 = between first and second premolars, 5–6 = between second premolar and first molar, 6–7 = between first and second molars

*Average risk site, **safe site
in accordance with Monnerat et al.,[5] Schnelle et al.,[12] Lee et al.,[13] and Hu et al.[14]

Several studies showed that the safe sites are between the first and second premolar at 6-, 8-, and 10-mm height (3.91 ± 1.00, 4.46 ± 1.15, and 4.94 ± 1.20 mm, respectively), between the second premolar and first molar at 10-mm height (4.14 ± 1.13 mm), and between the first and second molar at 8- and 10-mm height (3.81 ± 1.16 and 5.04 ± 1.51 mm, respectively). However, one should be careful about the mental foramen position between the first and second premolar. The average risk sites are between the first and second premolar at 4-mm height (3.27 ± 0.80 mm), between the second premolar and first molar at 8-mm height (3.41 ± 0.80 mm), and between the first and second molar at 6-mm height (3.21 ± 0.94 mm). These data show that, for all variables, the measurements are generally increased from cervical area to apical area.[5,12-15]

CONCLUSION

In the maxilla, the safe and suitable sites for placing miniscrew implant were located between the second premolar and first molar at 10-mm height, whereas in the mandible, between the first and second premolar at 6-, 8-, and 10-mm height, between the second premolar and first molar at 10-mm height, and between the first and second molar at 10-mm height.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Chung KR, Nelson G, Kim SH, Kook YA. Severe bidentaloveolar protrusion treated with orthodontic microimplant-dependent en-masse retraction. Am J Orthod Dentofacial Orthop 2007;132:105-15.

2. Farnsworth D, Rossouw PE, Ceen RF, Buschang PH. Cortical bone thickness at common miniscrew implant placement sites. Am J Orthod Dentofacial Orthop 2011;139:495-503.

3. Kravitz ND, Kusnoto B. Risks and complications of orthodontic miniscrews. Am J Orthod Dentofacial Orthop 2007;131:S43-51.

4. Poggio PM, Incorvati C, Velo S, Carano A. “Safe zones”: a guide for miniscrew positioning in the maxillary and mandibular arch. Angle Orthod 2006;76:191-7.

5. Monnerat C, Restle L, Mucha JN. Tomographic mapping of mandibular interradicular spaces for placement of orthodontic mini-implants. Am J Orthod Dentofacial Orthop 2009;135:428.e1-9; discussion 428-9.

6. Motoyoshi M. Clinical indices for orthodontic mini-implants. J Oral Sci 2011;53:407-12.

7. Brandão M, Pinho HS, Urias D. Clinical and quantitative assessment of headgear compliance: a pilot study. Am J Orthod Dentofacial Orthop 2006;129:239-44.

8. Wichelhaus A, Sander C, Sander FG. Development and biomechanical investigation of a new compound palatal arch. J Orofac Orthop 2004;65:104-22.

9. Silva MA, Wolf U, Heinicke F, Bumann A, Visser H, Hirsch E. Cone-beam computed tomography for routine orthodontic treatment planning: a radiation dose evaluation. Am J Orthod Dentofacial Orthop 2008;133:640.e1-5.

10. Kuroda S, Yamada K, Deguchi T, Hashimoto T, Kyung HM, Takano-Yamamoto T. Root proximity is a major factor for screw failure in orthodontic anchorage. Am J Orthod Dentofacial Orthop 2007;131:S68-73.

11. Asscherickx K, Vande Vannet B, Wehrbein H, Sabzevar MM. Success rate of miniscrews relative to their position to adjacent roots. Eur J Orthod 2008;30:330-5.

12. Schnelle MA, Beck FM, Jaynes RM, Huja SS. A radiographic evaluation of the availability of bone for placement of miniscrews. Angle Orthod 2004;74:832-7.

13. Lee KJ, Joo E, Kim KD, Lee JS, Park YC, Yu HS. Computed tomographic analysis of tooth-bearing alveolar bone for orthodontic miniscrew placement. Am J Orthod Dentofacial Orthop 2009;135:486-94.

14. Hu SK, Kang KM, Kim WT, Kim HK, Kim JH. Relationship between dental roots and surrounding tissues for orthodontic miniscrew installation. Angle Orthod 2009;79:37-45.

15. Park J, Cho HJ. Three-dimensional evaluation of interradicular spaces and cortical bone thickness for the placement and initial stability of microimplants in adults. Am J Orthod Dentofacial Orthop 2009;136:314.e1-12; discussion 314-5.