

Preoperative Bone Assessment Using Cone Beam Computed Tomography (CBCT)

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ABSTRACT

Objective: The purpose of this study was to evaluate the bone quality and quantity of jaws of mandible and maxilla by using Cone Beam Computer Tomography (CBCT).

Design: Ten patients were scanned using (Promax 3-D, Planmeca, Finland) CBCT. These CBCT data which are recorded on DICOM format are transferred into MIMICS software for density and cortical thickness measurement. Density and cortical thickness evaluations are performed on CEJ, 6 mm, 9 mm and 12 mm from CEJ level in the anterior and posterior position of mandibular and maxilla. Densities of bone are measured as average of Hounsfield Unit (HU) in the region of interest of bone target and cortical thickness is measured using distance measurement facility on MIMICS software.

Result: in all level measurement (CEJ, 6 mm, 9 mm and 12 mm) shown that cortical thickness from anterior to posterior increased; however the bone density decreased. Along sagittal direction, the cortical thickness increased from CEJ to 12 mm from CEJ level either on mandible and maxilla, oppositely the bone density decreased. The cortical thickness in mandible is thicker than maxilla. Meanwhile the bone density in mandible is higher than maxilla, the density difference is significant statistically ($p < 0.05$). comparison between inside and outside part, the density difference either on maxilla or mandibular is statistically not significant ($p > 0.05$).

Conclusion: Evaluation of site implant based on CBCT data give the valuable information about bone quality and quantity of jaw bone. The obtained results demonstrate that the space for implant placement of mandible is more adequate than maxilla, not only bone quantity, the bone quality of mandible also higher than maxilla.

KEY WORDS

cortical thickness, bone density, implants, cone beam computed tomography

INTRODUCTION

Accurate information on implant site prior to surgery is required for a surgeon. Not only to support the stability, this information is required to determine the type of implant, technique and aesthetic placement of the implant hence the implant success are realised satisfactory.

Bone quality and quantity together with other factors such as technique of implant placement determine the success of implant, primary implant stability and osseointegration process (Meredith, 1998). Clinical studies show greater implant survival in the mandible than in the upper maxilla, due to the area's characteristics (Farré-pagés, *et al.*, 2011). This survival is limited by bone quality, i.e. bone density. Bone quality and quantity of site implant has been examined using various methods including destructive and non-destructive method. Turkeyilmaz and Mcglumphy (2008) evaluated bone density using CT at hundred and eleven of patient involving 300 implants. They showed that local bone density has a prevailing influence on primary implant stability.

Gulsahi (2009) used conventional CT through the panoramic image. This method has ability to describe the anatomy of the jawbone in two dimensions precisely. However, the conventional CT still using high doses of x-ray as it was reported by Benson *et. al.* (1991); and also Chan

et.al. (2010).

Recently, Cone Beam Computer Tomography (CBCT) technique is more popular to be used as tools to evaluate site implant (ALamri *et al.*, 2012). The advantages of CBCT are its high resolution, potentially lower radiation dose and reduced costs compared with CT. Some workers have applied this method into dental implant technology to estimate bone quality and quantity (Isoda *et al.*, 2011); (Kaya *et al.*, 2012); (Hsu *et al.*, 2011). This study was conducted to evaluate density and cortical bone of site implant based on CBCT measurement.

MATERIALS AND METHODS

Patient Selection

Ten patients (seven males and three females, aged from 19 to 59 years) were included in this study. They were all healthy and none of them was receiving any medication.

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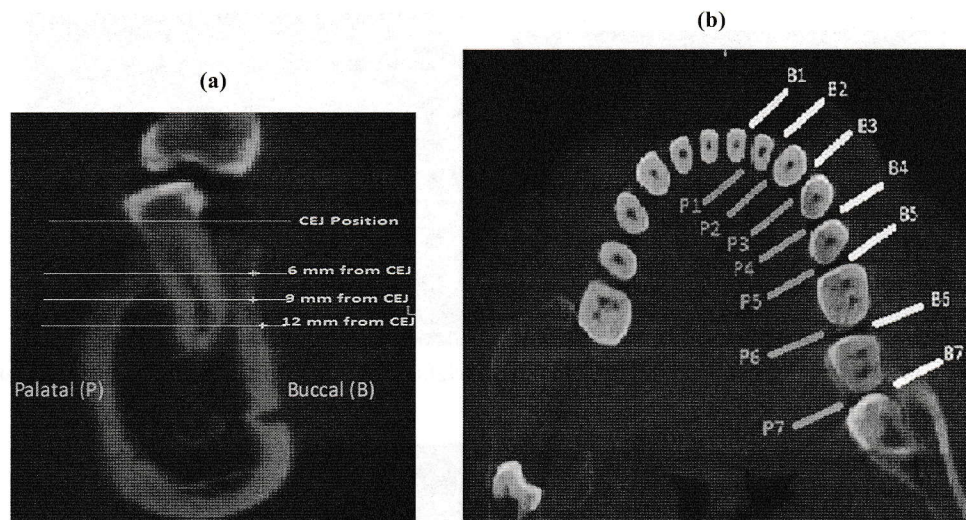


Figure 1. Schematic of the three level at which the root of incisor 1 from Cemento Enamel Junction (CEJ) (a). The location of cortical and bone density in maxilla at buccal (B1, B2, B3, B4, B5, B6, B7) and palatal (P1, P2, P3, P4, P5, P6, P7) (b)

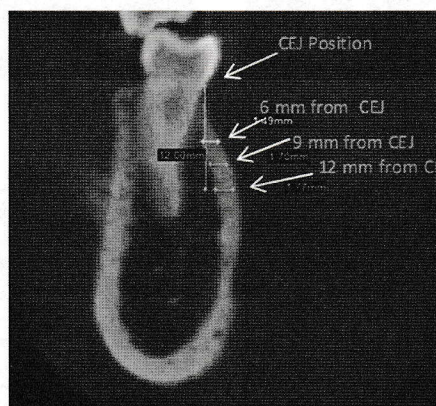


Figure 2. Measurement of cortical bone thickness

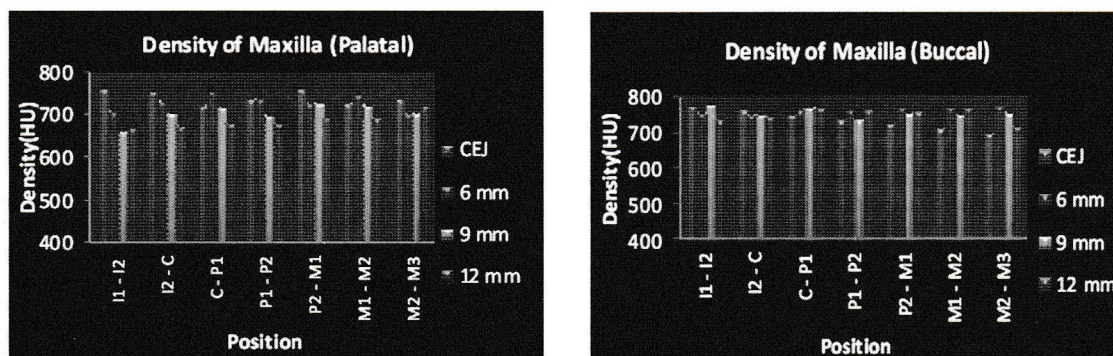


Figure 3. Bone density of palatal (left) and buccal (right) of maxilla from anterior to posterior position

CBCT Scan Set Up

Ten patients are scanned using CBCT before implant treatment using the Promax 3-D, Planmeca, Finland. To ensure that the voltage, current, resolution, field of view (FOV), and patient's position did not affect measurements of bone density and cortical thickness obtained from the CBCT images, the CBCT parameters and patient's position were identical in all of the CBCT scans. Before CBCT scanning, the patient was placed in a standing position with the head upright and positioned so that the intersection lines were straight horizontally and vertically through the centre of the region of interest. CBCT images were taken with the following parameters; 84 kVp, 192.53 mAs, 320- μ m voxel resolution, and FOV 16 cm.

Bone Density Measurement

The CBCT data that are stored in data base of CBCT machine are exported into DICOM format for bone evaluation purposes on MIMICS software.

For every patient, 56 points which are located on maxilla and mandibular are used to estimate bone density based on this CBCT data. Evaluation started from cemento enamel junction (CEJ) level as reference point and continued into 6 mm, 9 mm, and 12 mm from CEJ for maxilla and mandible, see Figure 1(a). On horizontal position, evaluations are performed from anterior to posterior position as shown in the Figure 1(b). The ROI is determined as area around that position with 1 mm of thickness and width area 6 mm². The density is defined as mean

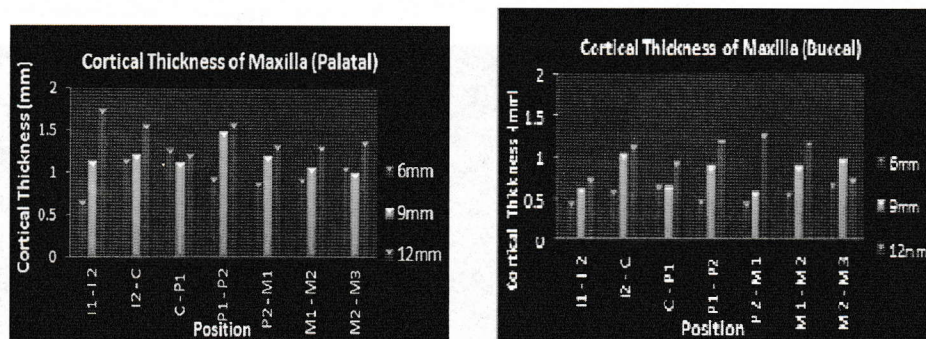


Figure 4. Cortical thickness of palatal (left) and buccal (right) of maxilla from anterior to posterior position

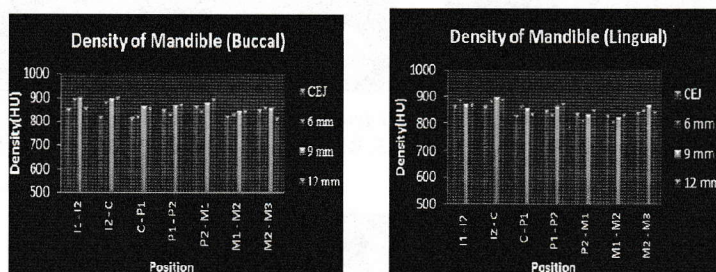


Figure 5. Bone density of buccal (left) and lingual (right) of mandible from anterior to posterior position

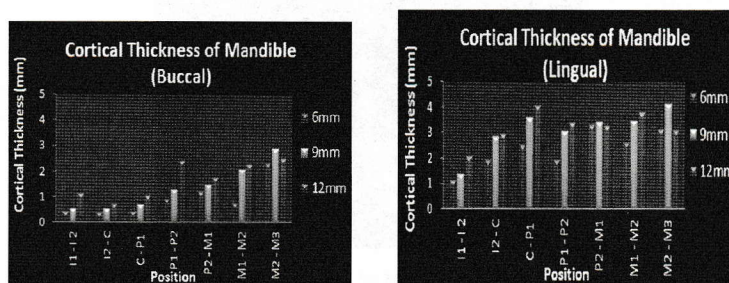


Figure 6. Cortical thickness of buccal (left) and lingual (right) of mandible from anterior to posterior position

value of HU in that 6 mm³ of volume.

Before bone densities are measured, the 3-Dimension model was re-sliced to obtain new CBCT slices of the teeth that were perpendicular to their longitudinal axes by using the "re-slice" function in MIMICS. The process are continued to generate masking for bone plus enamel and enamel only. Boolean operation is performed on both of masking to get the masking of bone only.

Cortical Bone Measurement

Cortical thicknesses are evaluated at the same location as well as bone density measurement, except at CEJ level. In this level the cortical thickness is not measured. Measurements are performed on bone enamel masking. Image was being enlarged using zoom facility till 200% to make the boundary of cortical bone identified clearly. The first location for measurement is at 6 mm and then continued for 9 mm and 12 mm from CEJ. The thickness of cortical was measured using distance measurement tools on MIMICS software on sagittal view as shown in the figure 2.

RESULTS

The data measurement was analyzed statistically using SPSS 18 software (SPSS Inc., Tokyo, Japan). The confidence level was set to 95% for all analysis.

Buccal and Palatal of Maxilla

In 10 patients the bone density of buccal are denser than palatal but the differences is not significant ($p = 0.151$). On buccal the mean of bone density is 730 HU meanwhile on palatal is 718 HU. Along sagittal direction, bone density on maxilla from CEJ level to 12 mm from CEJ is decrease either on buccal nor palatal. Bone density distribution from anterior to posterior for all level measurement is described in the Figure 3, the bone density increase from posterior to anterior.

The overall bone density was approximately between 663 and 779 HU for the maxillary bone. These numbers decreased progressively from incisor area to the premolar area at CEJ level of buccal. In the area between incisors and premolar 1, bone density relatively constant. Oppositely from premolar 1 to molar 3 bone density increases with the level measurement. In palatal of maxilla, the bone density of cortical at CEJ area is denser than alveolar bone.

The mean cortical thickness for three levels measurements (6 mm, 9 mm and 12 mm from CEJ) is 1.21 mm on palatal and 0.84 mm on buccal. Meanwhile the prerequisite site implant for cortical thickness at least 1.0 mm (Motoyoshi, Yoshida, Ono, & Shimizu, 2007). The cortical thickness difference between palatal and buccal is significant statistically ($p < 0.05$). Along vertical direction, cortical thickness increases from level 6 mm to level 12 mm from CEJ either on palatal nor buccal. From anterior to posterior, the pattern of cortical thickness either on palatal nor buccal is not linear. The highest cortical thickness occurs among canine and premolar. In the incisor area, the cortical thickness of palatal is thicker than molar, oppositely on buccal, the cortical thickness is less than molar. The detail of cortical thickness distribution along axial view is described in the Figure 4.

Buccal and Lingual of Mandible

In the mandible, the mean of bone density is 860 HU on buccal and 857 HU on lingual. This difference is not significant statistically ($p = 0.606$). In sagittal direction, bone density increase from CEJ level to 12 mm from CEJ. Along vertical section, bone density increase from CEJ level to 12 mm, highest density occurs at level 9 mm from CEJ. In this level the mean value is 873 HU on buccal, meanwhile in lingual density is increase more linear.

Along axial direction, from anterior to posterior, the bone density is decreasing. Density in anterior is relatively denser than posterior either on lingual or buccal, see Figure 5.

The cortical thickness on lingual generally is thicker than buccal, mean of cortical thickness is about 1.34 mm on buccal and 2.92 mm on lingual. This difference is significant statistically ($p = 0.001$). In sagittal view, cortical thickness was increase from level 6 mm to level 12 mm. In this direction, the increasing is almost linear either on buccal nor lingual.

In axial direction, cortical thickness on buccal increase exponentially from anterior to posterior, meanwhile in lingual the cortical thickness increase logarithmically. The data showing that cortical thickness of anterior on buccal and lingual is thinner than posterior. Cortical thickness of posterior is twice more thicker than anterior. Detail of this distribution is shown in the Figure 6.

DISCUSSION

The results of this study showed that adequate amounts of bone were identified in the posterior maxilla and mandible, adequate cortical bone thickness is described as 1 mm (Gonzalez, 2008). The maxilla provided adequate bone thickness at the level 9 mm except at second molar however for level 12 mm all posterior and anterior is adequate for implant placement. In the level 6 mm available space only on second incisor, canine and third molar, however in this location the cortical thickness of buccal is still not adequate. The cortical thickness on palatal is thicker than buccal it is showing that drilling should be placed close to palatal side rather than to buccal side. At this level, consideration should be taken into account when implants are placed. This level was of concern as the location of the maxillary sinus. Mini implant is more quite suitable for this location.

Evaluation on site implant on this location using cone beam computer tomography is useful to determine the dimension of site implant precisely. Surgeons able to use this information to decide the implant type and implant placement technique. Such as in area which is near to maxillaries sinus, proper angle of implant placement on high density of bone not only can support implant stability but also can prevent the maxillaries sinus disruption due to incorrect surgery process.

In the mandible, adequate cortical bone thickness is available for all levels and all position on lingual, however the adequate cortical thickness on buccal side only available on second premolar and first molar at level 6 mm and first premolar to third molar at 9 mm. adequate cortical thickness on buccal for all position occur at level 12 mm. Our measurement also showed that cortical thickness on lingual are thicker than buccal. It is mean that drilling process on implant placement on mandible also should be directed into lingual side. Comparing with maxilla, cortical thickness of mandible is more adequate than maxilla. Implant placement on mandible simpler than maxilla, only root channels and movement of mucosa should be taken into consideration.

Evaluation on density of jaw using cone beam computer tomography can support to gain knowledge about osseointegration and implant stability in the future. Hence different patient with different class (race, age, gender, disease) is possible to need different treatment to support the implant stability based on bone density issues. Classification of bone density based on CBCT measurement and its correlation with implant stability and osseointegration process still need to be investigated intently.

Comparing with other researcher, evaluation of site implant based on CBCT data can be summarized as follows; the cortical thickness was comparing with other researcher (Fayeda, Pazerab, & Katsaros, 2010) the result showing that the cortical thickness are measured with this

technique are the similar with their measurement. Chang *et al.* (2012) evaluated the bone density of alveolar at apical, intermediate and cervical level using CBCT data also showed that the bone density increase from CEJ level to intermediate level and decrease again from intermediate to apical level. Obtained bone density also was compared with Turkiylmaz and Mcglumphy (2008), they evaluated 111 patient using CT, Our results are in their range measurement.

CONCLUSION

In general, evaluation of site implant based on CBCT gives valuable information about cortical thickness and bone density of jaw bone as minimum requirement for adequate space determination for implant placement.

Based on this study, it can be concluded that the density of buccal is denser than palatal on maxilla, however the difference between them is not significant statistically. In mandible also the density of buccal is higher than lingual but the difference is not significant statistically.

The cortical thickness of mandible is higher than maxilla. At anterior or the outside part is thicker than inside part, oppositely on posterior the inside cortical thickness is thicker than outside. These results showed that in general, there are available areas with adequate bone thickness and density for implant placement in mandible rather than in maxilla.

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REFERENCES

- ALamri HM, Sadrameli M, Alshalhoob MA, *et al.* (2012). Applications of CBCT in dental practice: a review of the literature applications in oral and maxillofacial surgery. Featured in General Dentistry, September/, 390-400.
- Benson BW, Prihoda TJ, Glass BJ. (1991). Variations in adult cortical bone mass as measured by a panoramic mandibular index. Oral surg, oral med, and oral pathol, 71(3), 349-56.
- Chan H-liang, Misch K, Wang H-lay. (2010). Dental imaging in implant treatment planning. Implant Dentistry, 19(4), 288-298.
- Chang H-W, Huang H-L, Yu J-H, *et al.* (2012). Effects of orthodontic tooth movement on alveolar bone density. Clinical Oral Investigations, 16(3), 679-88.
- Farré-pagès N, Aué-castro ML, Alaejos-algarra F, *et al.* (2011). Relation between bone density and primary implant stability. Med Oral Patol Oral Cir Bucal, 16(1), e62-e67.
- Fayeda MMS, Pazerab P, Katsaros C. (2010). Optimal sites for orthodontic mini-implant placement assessed by cone beam computed tomography. Angle Orthodontist, 80(5).
- Gonzalez SM. (2008). Cortical bone thickness in the maxilla and mandible for mini-implant placement.
- Gulsahi A. (2009). Bone quality assessment for dental implants. Implant Dentistry, (ISBN 978-953-307-481-8).
- Hsu J-T, Chang H-W, Huang H-L, *et al.* (2011). Bone density changes around teeth during orthodontic treatment. Clinical oral investigations, 15(4), 511-9.
- Isoda K, Ayukawa Y, Tsukiyama Y, *et al.* (2011). Relationship between the bone density estimated by cone-beam computed tomography and the primary stability of dental implants. Clinical Oral Implants Research, 1-5.
- Kaya S, Yavuz I, Uysal I, *et al.* (2012). Measuring bone density in healing periapical lesions by using cone beam computed tomography: a clinical investigation. Journal of Endodontics, 38(1), 28-31.
- Meredith N. (1998). Assessment of implant stability as a prognostic determinant. The International Journal of Prosthodontics, 11(5), 491-502.
- Motoyoshi M, Yoshida T, Ono A, *et al.* (2007). Effect of cortical bone thickness and implant placement torque on stability of. Int J oral Maxillofac Implants, 22(5), 779-84.
- Turkiylmaz I, McGlumphy E. (2008). Influence of bone density on implant stability parameters and implant success: a retrospective clinical study. BMC Oral Health, 8, 32.