Assessment of Hounsfield unit in the maxillary and mandibular ridges using CBCT

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Citation
Aryal D, Dhami B, Pokhrel S, Regmi S. Assessment of Hounsfield unit in the maxillary and mandibular ridges using CBCT. J Kantipur Dent Coll. 2022;3(2):10-3.

ABSTRACT

Introduction: The cone beam computed tomography (CBCT), was developed for the evaluation of dentomaxillofacial structures, and more frequently it is used in dentistry because it is a less complex device that produces images with satisfactory resolution, with little artifact incidence and lower dose of radiation. Multislice and cone beam CT images are frequently used to determine mineral density of craniofacial bone structures.

Objective: To examine the bone densities of edentulous in each sextant by CBCT.

Materials and Method: Based on CBCT images, the voxel values representing bone density in each sextant of 112 sites were calculated in the range from -20 to 2,000 Hounsfield units (HU). The bone densities of these regions were categorized according to Misch's classification and compared among individuals and between sexes and 2 different age groups.

Result: Our study also compared gender-based differences in Hounsfield unit in each sextant and showed no statistically significant difference between them. Similarly, no statistically difference in different age group. The maximum average mean HU in point A of mandibular A is 1059.

Conclusion: In total alveolar bone density after extraction shows decrease in bone density. Considering gray scale in CBCT is the criteria in measurement of bone density before implant placement, it is recommended because of the lower dose and cost of CBCT in comparison to CT scan.

Keywords: Bone density; CBCT value; dental implant; Misch's classification.

INTRODUCTION

Among various radiographic techniques used, Cone beam computed tomography (CBCT), provides the details on the anatomical structures, associated pathologies and also helps to determine the bone density. The density of a tissue is represented using the Hounsfield scale, with water having a value of zero Hounsfield units (HU), tissues denser than water having positive values, and tissues less dense than water having negative values. The Hounsfield unit was created by Sir Godfrey Hounsfield and was obtained from a linear transformation of the measured attenuation coefficient of water and air.

Low-density tissues are assigned darker (blacker) colors and high-density structures are assigned brighter (whiter) colors. HUs have been correlated with bone density and treatment planning for dental implant. Misch bone density classification may be evaluated on the CT images by correlation to a range of HUs. Many CBCT software programs are now available that allow for preoperative determination of bone density in the implant site. To every change in form and function of bone certain definitive change in internal and external architecture of bone occurs. With regards to the importance of the clinical application of gray scale, in determining the bone quality for dental implant placement and the increasing use of CBCT for dental application the present study was undertaken to use edentulous alveolar ridge after months of tooth extraction. But grey value is arbitrary and variable, so the derived density provides less than meaningful data and the ability to access the density or quality of bone is limited.

The first purpose of the study is to assess Hounsfield unit in the edentulous site using CBCT and compare the values with Misch bone density classification scheme in Nepalese population. The other aim of the study is to compare the Hounsfield unit with age of the patient, to compare the Hounsfield unit with sex of the patient and to compare the Hounsfield unit of alveolar crest of maxilla with alveolar crest of mandible.

MATERIALS AND METHOD

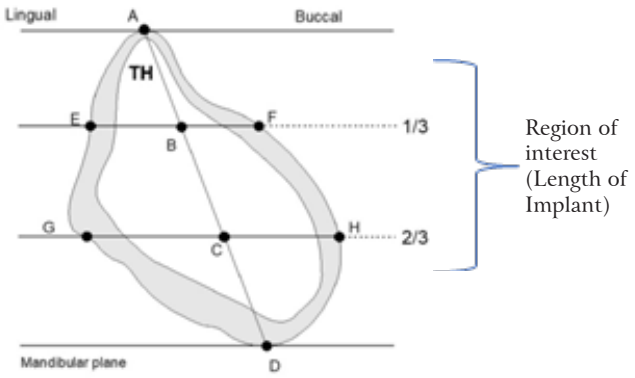
The study was conducted in 20th September 2021 to 20th April 2022 in the Department of Periodontology and Oral Implantology, Kantipur Dental College Teaching Hospital and Research Centre, Basundhara, Kathmandu after ethical approval taken from the Institutional Review Committee (KDC-IRC ref. no. 26/021).

Non-probability convenience sampling method was used and the sample size was calculated using the formula: n = z2 σ2/d2; where n = required sample size, z = 1.96 at 95% confidence interval. Hence, n = 112. Therefore, a total of 112 subjects were included in the study.

Both male and female patients with chronological age between 20-65 years, who were indicated to undergo dental implant placement as dictated by his/her treatment plan were considered in the study. The CBCT scans of the subjects fulfilling the inclusion and exclusion criteria were selected for the study. The inclusion criteria included patients in the age range of 20-65 years with missing teeth in the maxillary or mandibular arches with CBCT images obtained using the same machine and general adjustment settings. The exclusion criteria included insufficient bone for implant placement, and edentulous ridge before 6 months of extraction, diseases that alter the radiodensity of bone such as Osteoporosis, Paget's disease, Fibrous dysplasia etc. and the presence of CBCT artifacts such as beam hardening, ring artefact and motion artefact. The CBCT images were obtained from the subjects who had taken the scans, not particularly for the study but as per the indication for the diagnosis or treatment planning. All CBCT images were studied to allow measurement of HUs in the Posterior maxilla (PMx), Posterior mandible (PMn), Anterior maxilla (AMx) and Anterior mandible (AMn). The maximum values were recorded and measured. The increasing HU values denoted denser bone. CBCT values were recorded in Hounsfield units and the obtained values were compared between both sexes using the independent sample t-test and Pearson correlation coefficient was used to evaluate whether age was correlated with the HU values.

DICOM images were loaded in the Carestream software and virtual implant was positioned in each implantation site. Thereafter, the density measurement scale HU tool was used to measure the bone density. The bone density at the implantation site was determined by the mean of voxels grey values for the trabecular bone in the cervical (crest), body (1/3rd the length) and apical regions (2/3rd the length).

Fig. 1 Schematic representation of edentulous ridge with 3 different points



Point A to point D: line from crest to base of the alveolar ridge
Point A to point B: 1/3rd the length of implant
Point A to Point C: 2/3rd the length of implant

Data were entered and analyzed in SPSS version 20. Descriptive statistics were calculated. For qualitative variable like gender, frequency and percentage were calculated. For quantitative variables like bone density and age, mean ± standard deviation was calculated. Independent t-test was used to determine the differences in the bone density values (HU) between mandible and maxilla.

In edentulous patients or partially dentate patients with multiple sites, a mean value was taken to assign for that region. All the information was recorded in a specifically designed proforma. In order to address any bias, all readings were taken by one investigator and CBCT from only one system was included in the study.

RESULT

The majority of the bone in Posterior maxilla (PMx), Anterior maxilla (AMx), Posterior mandible (PMn) and Anterior mandible (AMn) was D3 falling in the range of 350-850 HUs with mean HU of 642, 816, 486 and 697 respectively.

Table 1. Descriptive analysis of Posterior Maxilla

HFU_TOTAL	N	Minimum	Maximum	Mean	Std. Deviation
Posterior maxilla (PMx)	22	153.67	1528.00	642.7879	339.44203
Anterior maxilla (AMx)	23	345.00	1753.00	816.0435	320.18598
Posterior mandible (PMn)	40	93.00	892.00	486.5000	214.16043
Anterior mandible (AMn)	26	271.67	1157.00	697.6923	236.46534

In our study, the highest mean value for the bone density of 816 HU was shown by the anterior maxillary sextant with the maximum value of 1753.00 HU and minimum value of 345.00 HU. Whereas, the minimum mean Hounsfield unit was shown by the posterior mandible as 486.5000 HU.

Table 2. Hounsfield unit in each point in maxilla

Maxilla	A point	B point	C point
Mean	1059.19	572.71	556.24
Std. Deviation	261.800	310.367	348.417
Minimum	580	255	15
Maximum	1559	1214	1216

Table 3. Hounsfield unit in each point in mandible

Mandible	A point	B point	C point
Mean	597.76	366.60	445.81
Std. Deviation	327.477	218.446	409.596
Minimum	10	-89	-219
Maximum	1247	921	1600

The mean HU of 1059.19 is present in point A of lower anterior and point A of posterior maxilla shows 597.76. Our study also compared gender-based differences in Hounsfield unit in each sextant and showed no statistically significant difference between them.

DISCUSSION

The highly satisfactory success rate obtained with dental implants in the treatment of various edentulous cases depends on the volume and quality of the bone. The initial stability of the implant is, in effect, one of the fundamental criteria for obtaining osseointegration. In our study, we proposed to modify Misch's classification to create subcategories within D3 as D3a (850-600) HU and D3b (601 to 150) HU as most of the sextant showed D3 bone as Sogo in 2012. Although HU has a potential role in bone quality assessment, its relevance has been questioned due to recent evolutions in implant dentistry which have gone beyond the evaluation of bone density.

Most grading scales are based on the characterization of cross-sectional trabecular morphology and cortical bone thickness. Yet, there is no single universally accepted system for classifying bone quality in the maxilla and mandible. The most traditional method applied during preoperative implant assessment is that of Lekholm and Zarb, categorizing bone quality into four groups according to the degree of cortication and the trabecular bone morphology.

In the present study, gender was not equally distributed for each sextant. In the assessment of anterior maxilla, number of males were 8 and number of females were 14 whereas in other sextants, the difference in numbers of male and female was not significant. Unequal distribution of sample in each sextant is the major limitation of study. In terms of bone density, no significant difference was seen between the two genders which is in contrary to the study by Khaled A. Alswat (2017) which has presented the tendency of males to have higher bone density than females. Moreover, the study showed that the difference in density could be influenced by gene difference, level of physical activities, nutrition level etc.

Though Misch classified anterior mandible as D1 bone and D4 bone in posterior, but our study shows D3 bone in lower anterior, which could be due to decrease in bone density after tooth loss. Acute disuse window loses mineral in bone which ultimately loses bone density. Studies shows 40% and 12% decrease in cortical and trabecular bone density repectively in disuse atrophy.

The advantage in using CBCT, decrease in radiation dose than the use of CT in implant dentistry and CBCT measure both the bone quality and quantity but measurement of bone density is higher in CBCT than CT in implant dentistry.

Various other issues are also associated with the use of Hounsfield unit values in CBCT. These issues relate to the limited-field CBCT geometry, variability in axial plane, variability between axial slices, high image noise.

In CT scan, Hounsfield unit is proportional to the degree of x-ray attenuation and it is allocated to each pixel to show the image that represents the density of the tissue. In CBCT, the degree of x-ray attenuation is shown by gray scale i.e., Voxel value (VV). But lower radiation dose and reduced costs of CBCT make this a useful substitute for CT. The influence of bone density on the crest of alveolar bone determines the speed and torque of first drill. This study measures the mean bone density in each point of each sextant. The result of study also helps to size, type and number of implants and its placement.

In addition, Hounsfield unit above 160 demonstrates normal bone mineral density which can be alternative to DEXA measurement. However, in order to be more accurately define the bone density with CBCT, a conversion ratio needs to be applied to the Volex Value (VV).

CONCLUSION

The study concluded that alveolar bone density after extraction shows decrease in bone density. Considering gray scale in CBCT is the criteria in measurement of bone density before implant treatments, it is recommended because of the lower dose and cost compared to CT scan.

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