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Quantification of Bone in the Maxillomandibular Region, using Cone Beam Computed Tomography

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ABSTRACT

Background: Maxillary and mandibular bones are the primary bones of the face. Both the mandible and maxilla are subjected to the physiological and pathological changes. The success of dental implant largely depends on pre-operative preparation.
Objective: This study aimed to find the quantity of bone using CBCT among genders with different age groups and to generate a novel classification system for the amount/quantity of bone in the maxillo-mandibular region.
Materials and Methods: This cross-sectional study consisted of 417 subjects (age limit 18-80 years/both genders) visiting the Radiology Department of Sardar Begum Dental College and Khyber College of Dentistry. CBCT was used to generate the new classification system for the quantity of bone in the maxillomandibular region. The frequency/percentages and Mean ± SD for the numerical data were calculated using descriptive statistics. The numerical variables were graded from very high value to very low recordable value. The chi-square test was used for all the categorical variables. The level of significance was (P value≤0.05) for six categories of decade age sub-groups, between both genders.
Results: The mean age group was 48.95 with a standard deviation of 17.11 years. In the mandible, 69.78% of candidates had an abundant quantity of bone among which 33.34% (n=139) females and 36.78% (n=152) males showed sufficient dimensions. The inadequate and deficient dimensions were found in 8.63% (n=36) and 7.67% (n=32) females and 8.87% (n=37) and 5.03 % (n=21) males. In contrast, in the maxilla 63.07% (n=263) patients in which 31.18% (n=130) females and 31.89% (133) males, had deficient maxilla in all dimensions.
Conclusion: The novel classification system showed, that the mandible was abundant and sufficient in quantity and marked as Division A/ B. In contrast, the posterior maxilla was found to be deficient and insufficient in quantity and marked as division C/D. The quantity of the maxillary and mandibular bones was more deficient in the females than in males.
Keywords: Cortical bone, Density, Lingual undercut, Mandible, Maxilla, Quantity, Trabecula.

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INTRODUCTION

Bone is connective tissue. It is made up of cells and an extracellular matrix that is mineralized. It plays an important role in providing support and structure and enables mobility. It stores essential minerals and protects vital anatomical structures.[1]

Maxillary and mandibular bones are the primary bones of the face.[2] Mandible is the largest and strongest bone of the face and it forms the lower jaw. It plays a role in force absorption and is the only movable bone of the masticatory unit.[3] Maxilla is another important bone of the mid-face which acquires the central position on the face, supports the viscera-cranium and distributes the forces of mastication.[4]

Both the mandible and maxilla are subjected to the physiological (age changes) and pathological changes (extractions, atrophy, tumors, fractures etc.) that affect the quantity of these bones by causing loss of height, width and affecting normal architectural features.[5]

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In the field of Dentistry, the "Oral rehabilitation with dental implants" refers to a treatment method where missing teeth are replaced with surgically implanted titanium screws into the adequate quantity of jawbone that serves as an anchor for artificial teeth. The success of dental implant largely depends on pre-operative preparation, in terms of morphometric measurements of bone height and width objectively.[6]

Similar to this, gender variations in the amount of maxillary and mandibular bone are a crucial topic that must be discussed in the field of forensic odontology.[7]

This research paper was able to present a classification system for the quantity of maxillary and mandibular bone using 3-dimensional cone beam computed tomography (CBCT) or CBVT (Volumetric tomography)[9] instead of 2-dimensional radiographs, since all previous classification systems lack generalisation to the conditions mentioned above.[8]

Thus, the rationale of this study was to introduce a novel anatomical bone classification system using 3-dimensional view, that can be used objectively in all fields of clinical dentistry e.g. for successful implant installation, bone mineral density determination, age estimation/age changes, gender discrimination etc. This classification will also help post-graduate students to understand and learn the quantitative differences between maxillary and mandibular bones.

The objective of this study was to introduce a Novel classification system that will help to measure morphometric parameters related to the quantity of two facial bones using CBCT, among both genders and different age groups in population of KPK.

MATERIALS AND METHODS

This cross-sectional comparative study was done for a period of 9 months (from 27th April 2021 till 27th Jan 2022). The setting area for the study was the radiology department of Sardar Begum Dental College and Khyber College of Dentistry. Planmeca Romexi CBCT three-dimensional Viewer was used to obtain reformatted Dicom files. The irradiation pulse was 17sec with Voxel size (0.3x0.3x0.3mm) was sufficient to measure the height and width of buccal and lingual bone of maxilla and mandible on coronal plane. The posterior region of maxillary and mandibular bone on the coronal view of CBCT view was Defined Data Range (DDR) at 6.3mA and 80KVP. The field of View (FOV) selected was 10x13cm with a Greyscale depth of 12 Bits to obtain the reformatted images along sagittal, coronal and axial plane of maxilla and mandible for morphometric measurements. Non-probability/convenience sampling was used to collect the data. Written and informed consent was taken independently from every included subject. To avoid error, two Oral Biologists and three Radiologists validated the "CBCT Based New Classification "for future practical use in all relevant dental fields. The calculated sample size was 417 patients while using mean ± SD of 0.97±0.416mm,[9] 95% confidence interval and 5% margin of error. The inclusion criteria was patients with an age limit of 18-85 years, oral rehabilitation with implant placement, age related changes among both genders. The exclusion criteria was patients with traumatic dental injuries, extractions and ongoing orthodontic treatment, pregnant females. the ethical approvals were obtained from ethical review board KCD (26/ADR/KCD) and Sardar Begum Dental College (No/GU/2021/01).

After fulfilling the inclusion criteria, a specially designed proforma was used to record all details. Categorical variables like gender and quantitative variables (Age, Bone width, alveolar bone height, thickness of buccal and lingual cortex etc) were recorded on the performa. The age was arranged into six-decade age groups. The numeric variables were graded from highest to lowest recordable values. The height of the buccal and lingual/palatal bone in the maxillo-mandibular region was ranked from abundant (≥25mm) to atrophic (≤10mm).[9] The depth of the lingual undercut was grouped as Type I ≤2mm, Type II=2-3mm, and Type III≥3mm.[10]

The SPSS (version 16.01 BM. SPSS) was used for data analysis of both numerical and categorically entered data. The frequency/percentages and descriptive statistics (Mean ± SD) were calculated for quantitative variables like buccal, and lingual cortical height and width, lingual cortical width and depth etc. The chi-square test was used to determine the significant difference in quantity of bone among both genders with different age groups with P value≤0.05. Data was further elaborated via tables and graphs.

RESULTS

The mean age group was 48.95±17.11 years. In the mandible, 69.78% of candidates had abundant bone, among which 33.34% (n=139) females and 36.78% (n=152) males showed sufficient bone dimensions. The inadequate and deficient dimensions were found in 8.63% (n=36) and 7.67% (n=32) females and 8.87% (n=37) and 5.03 % (n=21) males. In the case of the maxilla, the calculations were opposite to the findings in the mandible. Sixty-three per cent (n=263) of patients 31.18% (n=130) females and 31.89% (133) males were having deficient maxilla in all the dimensions. Table No 01

Thus, overall, the quantitative parameter for the mandible is found to be abundant and sufficient in terms of height and thickness (n=291, 69.8%) and marked as division A / B when compared to the quantitative parameters of the maxilla found to be deficient (n=263, 63.1%) and marked as division C/D, is all shown in table 01. There was a statistically significant relationship between the maxilla and the mandible among both genders.

The descriptive statistics (mean, SD) for the height of buccal and lingual cortical bone of mandible along with depth of lingual undercut were shown in Table 02. The mean value recorded for both genders were statistically significant with the p value of less than 0.05.

In the maxilla, deficient bone height was recorded more among the females (n=19, 4.55%) than males (n=3, 0.71%) with a statistically significant p-value (p<0.05). Table No 03

According to the novel classification for maxilla and mandible, morphometric parameters were marked as abundant and adequate dimensions from 25-45 years. However, after 50 years, there was inadequate bone height and deficient bone dimensions in both genders. Table 04

The figure number I and II presented the CBCT views reformatted images to record the quantity of posterior bone in maxillary and mandibular regions.

Table 01. Quantitative parameters for the Mandible and Maxilla in both the Genders.

Gender	Quantitative Parameter for Mandible				Quantitative Parameter for Maxilla			
	Div A/B	Div C/D	Div C Only		Div A/B	Div C/D	Div C Only	
	Abuntant /Adequate	Inadequate	Deficient	Total	Abuntant /Adequate	Inadequate	Deficient	Total
Female	139,33.34%	36,8.63%	32,7.67%	207	50,11.99%	27,6.47%	130,31.18%	207
Male	152,36.78%	37,8.87%	2,5.03%	210	35,8.89%	42,10.07%	133,31.89%	210
Total	n=291/69.78%	n=73/17.50%	n=53/12.7%	417	85/20.38%	69/16.5%	263/63.06%	417

Table 02. Descriptive statistics for the Quantitative parameters in the Mandible among both genders.

Parameters for Mandible	Mean/SD	P value for genders with x^2 value
Height of Buccal Bone	Mean=22.13±4.703mm	0.01(53.481)
Height of Lingual Bone	Mean=21.63±5.885mm	0.05(1.865)
Lingual Undercut Depth	Mean=1.58±0.985mm	0.02 (16.122)
Width of Lingual Undercut	Mean =10.87±3.296mm	0.001(11.102)
Height of concavity from alveolar Crest	Mean =16.61±2.112mm	0.01(0.027)
Thickness of Buccal Cortex of Mandible	Mean= 1.47±0.625mm	0.05(61.964)
Thickness of Lingual Cortex	Mean=2.07±0894mm	0.05(343.96)

Note: Level of Significance P-Value. < 0.05,

Table 03. Descriptive statistics for the Quantitative parameters in the Maxilla among both genders.

Parameters for Maxilla	Mean/SD	P value for genders with x^2 value
Height of Buccal bone	Mean=14.18±3.082mm	0.001(1.750)
Height of Palatal bone	Mean=6.56±4.105mm	0.02(1.080)
Bucco-palatal width	Mean=11.00±3.366mm	0.001(1.080)
Buccal bone thickness of Maxilla	Mean= 1.006±0.400mm	0.01(1.190)

Note: Level of Significance P-Value. < 0.05, x^2 Chi-Square

Table 04. Quantitative parameters of maxillary and mandibular bone in both the Genders.

Quantitative. Parameters for Bone in Different Age Groups		Abundant Greater than 25mm (20-30 Years)	Adequate 20mm (31-40 Years)	Inadequate less than 15mm (41-50 Years)	Deficient less than 10mm (above 51 Years)		Asym-Sig (2 Sided)
Gender of the Patient	Female	135 (33.09%)	5 (1.19%)	48 (11.51%)	19 (4.55%)	207	0.01(0.038)
	Male	152 (36.45%)	4 (0.96%)	51 (12.23%)	3 (0.71%)	210	
Total		290 (69.54%)	9 (2.15%)	99 (23.74%)	19 (4.56%)	417(100%)	

Note: Level of Significance P-Value. < 0.05

DISCUSSION

The present study aimed to find out the bony architecture in terms of quantity/amount) using CBCT in the posterior maxillo-mandibular regions among both genders in different age groups.

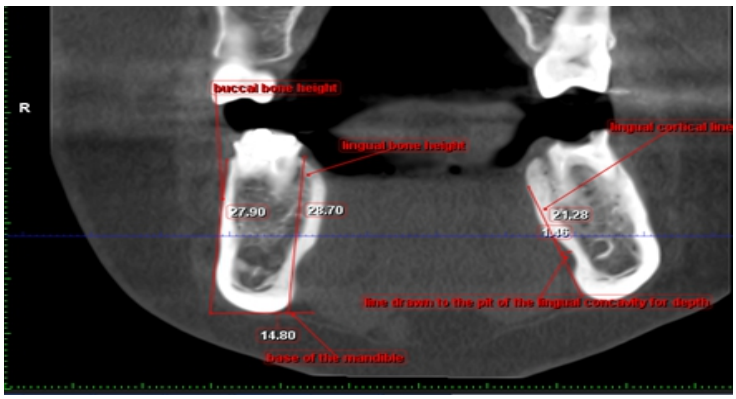
There was a marked bony difference between the maxillary and the mandibular bone composition, which was influenced by age and gender in our study. The study of Celenk[10] and showed that the mandible had dominant lamellar bone occupying 63% of the tissue in the mandible and the maxilla was 46% lamellar bone and 18% trabecular bone was similar to the present study. According to Botemans and his colleagues,[11] the mandible is considered sexually dimorphic in terms of morphological and morphometric indices was consistent to the present study findings. Their findings were also found to be statistically significant between genders just like our study. Sandeep et al.[12] alsoagreed with the above findings. Thus, overall, it was becoming a universally accepted fact that the facial bones carry sexual dimorphism and parameters in this study can be used even for gender identification in the field of forensic odontology.

This study showed the recorded dimensions of the maxilla were deficient or inadequate more in the man than the women and this correlates well with the findings of the Yeung.[13] According to another study conducted by Wang et al[14] buccal bone heights from the alveolar crest of the maxillary first molar region to the inferior margin of the sinus floor is 9.1 ± 3.8 mm, was also congruent to the findings in present study. A study of the Fauda[9] showed the height of buccal bone in the posterior mandible; with means was 20.08±4.77 in the men and 18.68±5.56 in the females, while in this present study, the findings carried small variation was consistent with them.

In this study, the buccal and lingual heights in the mandible were found to be abundant among the 24-45 years age groups. After the age of 45 years, the dimensions were recorded as either deficient or inadequate. These observations correlate well with the study of Ramanauskaite.[15] According to them, the decrease in bone strength in aging is a globally observed phenomenon among all human beings was congruent with present study. According to Malik[16] changes in the cortical and trabecular bone structure occurs with ageing, are useful for fracture prediction can also be defined with the findings in this study. This also showed the uniqueness of present research paper.

The study of the Wang et al.[14] has shown the buccal bone wall thickness for the posterior maxilla was 0.76±0.19mm in contrast to 1.006±0.400mm buccal bone wall thickness in our study.

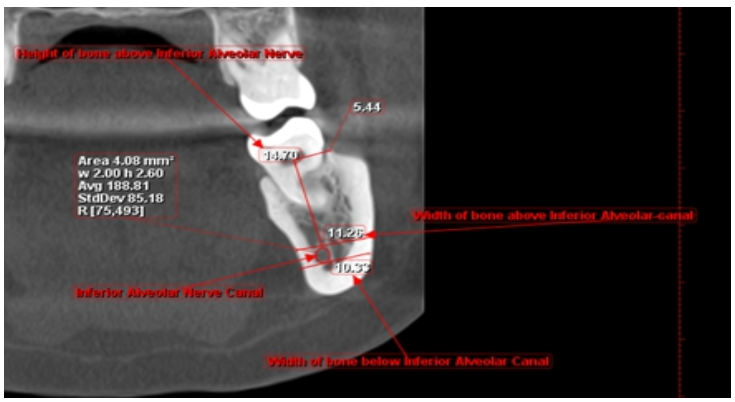
Botelho[17] illustrated that the majority (46.7%) of subjects presented with the lingual undercut was similar to the present study. However, he also showed no significant difference observed between the males and females was not congruent to our findings. Zhang[16] and Almahdi[18] on the other hand found the difference between the genders was similar to the study. All these findings demonstrate the importance of the pre-operative CBCT as a reliable tool, for the proper assessment of lingual concavity.



Quantitative bone measurements in Mandible:

1. Mandibular bone heights;
   a. Buccal bone height (Base of mandible to crest of bone on buccal side)
   b. Lingual bone height (Base of mandible to crest of bone on lingual side)
2. Lingual concavity depth (tangential line drawn to the lingual bone and perpendicular line dropped to the depth of concavity)

Figure 01. Coronal View on CBCT. Quantitative bone measurement in Mandible (15 bits, 120KV, 6mA, voxel size 400, FOV 20x10cm, DICOM file format)



Quantitative bone measurement:

1. Width of bone above Inferior Alveolar Nerve(IAN)
2. Width of bone below IAN
3. Height of alveolar bone from the center of the canal to the buccal alveolar crest

Figure 02. Coronal CBCT view: Quantitative bone measurement in Mandible concerning Inferior Alveolar Nerve Canal (IANC)

Ethical Consideration

This study was approved by Institutional Review Board of Sardar Begum Dental College and Khyber College of Dentistry, Peshawar, Pakistan.

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Conflict of Interest
Authors declared no conflict of interest.

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DATA SHARING STATEMENT: The data that support the findings of this study are available on request from the corresponding author. The data is not publicly available due to privacy or ethical restrictions.

AUTHORS' CONTRIBUTION
The following authors fulfill authorship criteria as per ICMJE guidelines;

Murad N, Asmaullah: Substantial contribution to conception and design, drafting the manuscript, final approval, agreed to be accountable for all the work.

Nausheen N: Substantial contribution to conception and design, data acquisition, drafting the manuscript, final approval, agreed to be accountable for all the work.

Nisar P: Analysis and interpretation of data, drafting the manuscript, final approval, agreed to be accountable for all the work.

Begum A: Analysis and interpretation of data, critical revision, final approval, agreed to be accountable for all the work.

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