Original Article

A CBCT-based Study to Evaluate the Availability of Bone Quantity and Its Relative Density for the Placement of Implants in Mumbai-Navi Mumbai Population

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Abstract

Rationale: The quality and quantity of bone is important parameter for predictable success of implant prosthesis. Availability of bone might depend on many factors like time period after the extraction, trauma, patient's systemic condition, local pathological lesions, presence of adjacent teeth, sinus membrane thickening or racial and regional variations. There are differences in teeth size amongst different ethnic or regional groups. This might be true for the jaw bones as well. This study was carried out to evaluate the amount of bone and its relative density in Mumbai – Navi Mumbai population. **Material and Methods:** The CBCT data at different CBCT centers and total of 250 scans done as diagnostic imaging for the placement of implants were selected for this study. The selected implant sites were divided in to four regions - Mandibular anterior, Mandibular Posterior, Maxillary anterior and Maxillary Posterior and analyzed for height, width of the bone available, and its relative density. **Results:** Maximum mean height measured was in mandibular anterior region in both male, female followed by mandibular posterior, maxillary anterior and maxillary posterior. Maximum mean width measured was in maxillary posterior region, followed by mandibular posterior and mandibular anterior. Maximum relative density measured was 884.40 HU and 857.32 HU in mandibular anterior in male and female patients, respectively. Minimum relative density measured was 334.20 HU and 321.10 HU in maxillary posterior in male, female patients. **Clinical Significance:** This CBCT-based study has enabled us to visualize the bone dimensions and relative density of jaw bones in the Mumbai population in India.

Keywords: Relative density, CBCT, Mumbai – Navi Mumbai population, Bone availability.

Introduction and Rationale

Treatment planning for successful implants requires consideration of prosthetic factors- number/position of implants, crown-height space, loading protocol, occlusion, teeth in opposing arch, para-functional habits and surgical factors-size/angulation of implants, systemic conditions, proper surgical protocol, quality, and quantity of recipient bone.[1-4] Bone density is a vital parameter for treatment planning, implant design, surgical approach, healing time, and type of loading during prosthetic reconstruction.[2,3,5-7] Bone quality, quantity required for the size of implant may not be available due to post-extraction, trauma, systemic condition, local pathological lesions, and presence of adjacent teeth size racial and regional variations.[8-10] This CBCT based study is to evaluate the quality of bone available and its relative density for the placement of implants in Mumbai – Navi Mumbai population.

Access this article online

Website: www.jrad.co.in

DOI: https://doi.org/10.53064/jrad.2022.13.2.132

Materials and Methods

The current study was carried out in accordance to the STROBE guidelines. The Ethical committee approval was obtained from the Terna Dental College ethics committee (reference number: TDC EC/20/2020). A total of 250 patient's CBCT scans done as pre-operative diagnostic imaging for the placement of implants were selected from different CBCT centers. The centers using the same CBCT machines were selected to standardize the

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Received: Nov. 08, 2021; **Accepted:** Jan. 29, 2022; **Published:** Mar. 08, 2022

How to cite this article: Shah N, Dhokar A, Iyer J, Khanna T, Patil N, Bhatnagar S. A CBCT Based Study to Evaluate the Availability of Bone Quantity and Its Relative Density for the Placement of Implants in Mumbai-Navi Mumbai Population. J Res Adv Dent 2022;13(2):43-47.

exposures, voxel values, and grey matter corrections. The CBCT data from different CBCT centers in Mumbai and Navi Mumbai were used for this study. The participant's information and consent forms in English, Hindi and Marathi were sent to all centers and patient's consent was taken.

The implant sites from these scans were evaluated for inclusion and exclusion criteria.

The age group from 25 years and above was considered. Both male and female patient's scans whether partially dentulous or completely edentulous were selected for study. Implant site was selected as per the radiographic markers. Where there were no radiographic markers seen on the scans, one implant per missing tooth for partially edentulous arches and two implants per region (Mandibular anterior, Mandibular Posterior, Maxillary anterior, and Maxillary Posterior) for completely edentulous arches were considered.

The selected sites were divided in to four regions - Mandibular anterior, Mandibular Posterior, Maxillary anterior and Maxillary Posterior and analyzed for height, width of the bone available for implant placement, and its relative density. Height of the bone was measured from crest of the ridge to the nearest vital structures such as maxillary sinus floor and mandibular canal (Figure 1).

The width was measured at the crest of the recipient bone (Figure 2).

Relative density was measured by Hounsfield Units (HU) value. The area for HU value was selected in such a way that maximum area of proposed implant site can be included in the measurements (Figure 3). The highest and the lowest values in all three parameters were excluded. As additional information, we observed the scans for the radiographic markers as a diagnostic tool.

The parameters for evaluation were formulated on MS Excel. The dicom files were assessed on the iCAT Vision software by three operators at various CBCT centers with iCAT CBCT machines at Mumbai and data were analyzed. While taking measurements, all the three operators were present and consensus was taken for the final reading of each measurement.

Data thus collected were analyzed using SPSS 19.0 software. The data were presented using descriptive statistics such as frequency, percentage, mean, SD, and SEM. The data were presented using graphical techniques such as pie chart and bar chart.

The normality of data was tested using Kolmogorov–Smirnov test. Further analysis was done using one-way Analysis of Variance technique. The level of significance was set at 5%. All $P < 0.05$ were considered as significant.

Evaluation parameters:

A. Age
B. Sex:
    1. Male
    2. Female

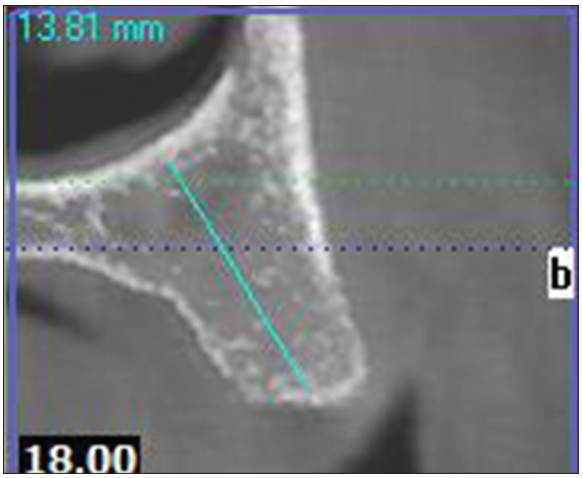


Figure 1: Measurement for the height of bone available

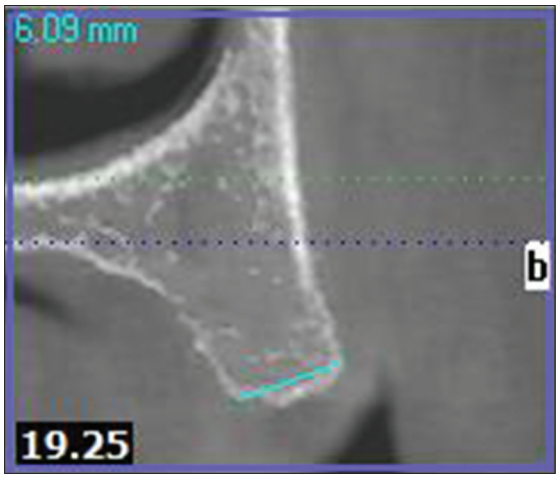


Figure 2: Measurement for the width of bone available relative density

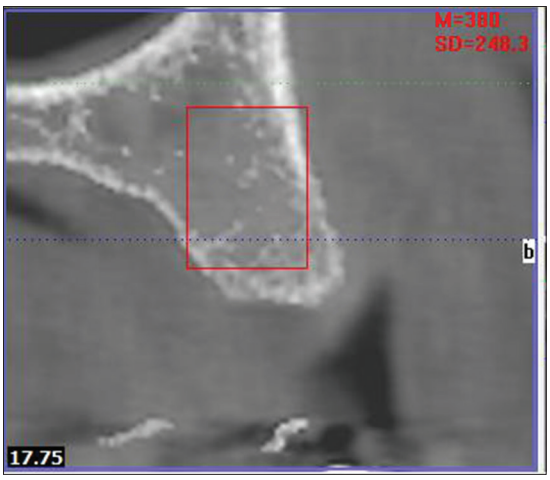


Figure 3: Measurement for the bone in the region of implant placement

C. Was the patient completely edentulous or partially edentulous?
    1. Completely edentulous
    2. Partially edentulous

D. What was the region for proposed implant placement?
   1. Mandibular anterior
   2. Mandibular posterior
   3. Maxillary anterior
   4. Maxillary posterior
E. What was the height available for implant placement from the crest to the nearest anatomical landmark?
F. What was the width available for implant placement?
G. What was the relative density of bone in region of implant planned?
H. Whether the radiographic stent provided by the dentist? (1) Yes (2) No

Results

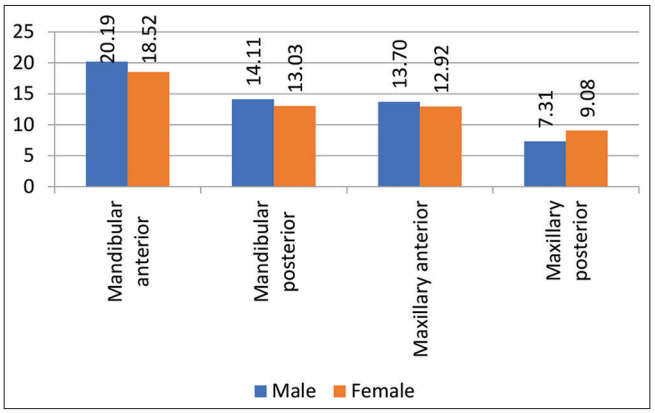
The total no. of implant sites evaluated were 1000 of 250 patient's CBCT records. Out of these, the sites with highest and lowest values for all three parameters were excluded from the study. The bone height of <3 mm also was excluded since that might represent only the cortical bone and give false reading for relative density. Remaining 240 patient's scans with 963 implant sites were evaluated statistically for height, width, and relative density.

Out of total no. of scans 46.10% were male and 53.90% were female patients. Total number of completely edentulous patients was 25 out of which 17 were male and 8 were female and total number of partially edentulous patients was 215 out of which 98 were male and 117 were female. The gender distribution of partially and completely edentulous patient's frequency is shown in Table 1.

The implant sites were divided in to four regions of mandibular anterior, mandibular posterior, maxillary anterior, and maxillary posterior. Region-wise distribution of implant sites is plotted in Table 1. Maximum implant sites were recorded in mandibular posterior region in which 109 sites were in male and 126 were in female. Second maximum implant sites were recorded in maxillary posteriors with 76 sites in male and 98 in female. The third site recorded was maxillary anterior with 21 in male and 29 in female. The least implant sites were recorded in mandibular anterior region with 25 in male and 22 in female patient's scans (Table 1).

Maximum mean height measured was in mandibular anterior region in both male and female patients, followed by mandibular posterior, maxillary anterior, and maxillary posterior region. These height differences within four regions were statistically significant but were not significant between male and female patients. Highest mean height of 20.18 mm was measured in male in mandibular anterior region and the lowest mean height measured was 7.31 in maxillary posterior region in male patients (Graph 1).

Maximum mean width of bone available for implant placement measured was in maxillary posterior region, followed by mandibular posterior and mandibular anterior. Least mean width was measured in maxillary anterior region in both male and female patients. Although the difference of available width was not statistically significant in male patients, in female patients this difference was found to be significant. In female patient's, maximum mean width recorded was 5.97mm in maxillary posterior region while minimum width recorded was only 3.71 mm. in male patients maximum mean width measured was 6.58 mm in maxillary posterior region and minimum mean width measured was 4.65 mm in maxillary anterior region (Graph 2).



Graph 1: Height available for implant placement

Table 1: Occurrence of edentulism and sex-wise distribution of selected implant sites

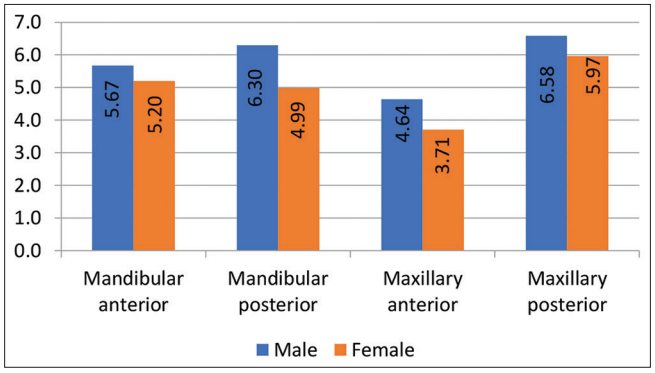
	EP1:Edentulism		Total		EP2: Region wise distribution				Total
	Completely Edentulous	Partially Edentulous			Mandibular anterior	Mandibular posterior	Maxillary anterior	Maxillary posterior	
Sex									
Male									
Count	17	98	115	Count	25	109	21	76	231
% within EP1	68.0%	45.6%	47.9%	% within EP2	53.2%	46.4%	42.0%	43.7%	45.7%
Female									
Count	8	117	125	Count	22	126	29	98	275
% within EP1	32.0%	54.4%	52.1%	% within EP2	46.8%	53.6%	58.0%	56.3%	54.3%
Total									
Count	25	215	240	Count	47	235	50	174	506
% within EP1	100.0%	100.0%	100.0%	% within EP2	100.0%	100.0%	100.0%	100.0%	100.0%

Relative density of bone was measured in Hounsfield Units in maximum rectangular area covered at implant site. Maximum relative density measured was in 884.40 HU and 857.32 HU in mandibular anterior region in male and female patient's implant sites, respectively. Minimum relative density measured was 334.20 HU and 321.10 HU in maxillary posterior region in male and female patient's implant sites. Difference in relative density of different region was statistically significant, although the difference between the male and female was not significant (Graph 3).

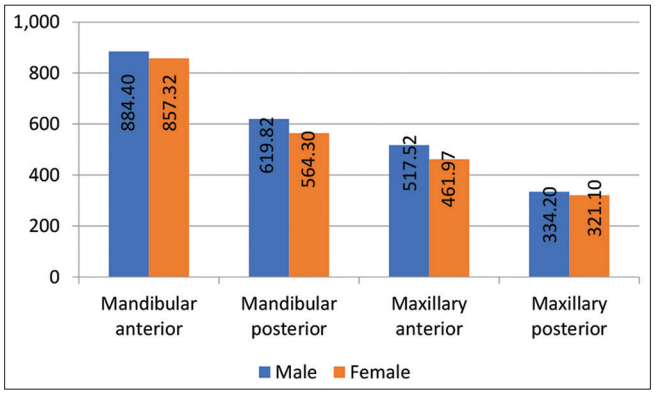
Radiographic stent provides the exact location of implant placement to guide the measurements and visualization of quantity and quantity of bone in the region of implant placement. The results of this study showed that only 8.10% CBCT scans were with the radiographic markers. About 91.90% patients sent by the clinician for the CBCT as diagnostic and planning tool were not having any radiographic stent (Graph 4).

Discussion

With the development of CT and CBCT, clinicians have tools to access bone quality and quantity at the site of implant placement.[3,4] Scarfe and Farman in 2008 compared accuracy of CT and CBCT in assessment of implant site dimensions and CBCT dimensions were found more accurate than CT. The resolution of CBCT is higher than conventional CT. Ekrish *et al.* in 2011 compared accuracy of CT and CBCT in the assessment of Implant site dimensions and CBCT dimensions were found more accurate than CT. Al Ekrish and Ekaram found that CBCT has got much lesser radiation exposure and is less expensive than conventional CT.[11,12]



Graph 2: Width of bone available for implant placement



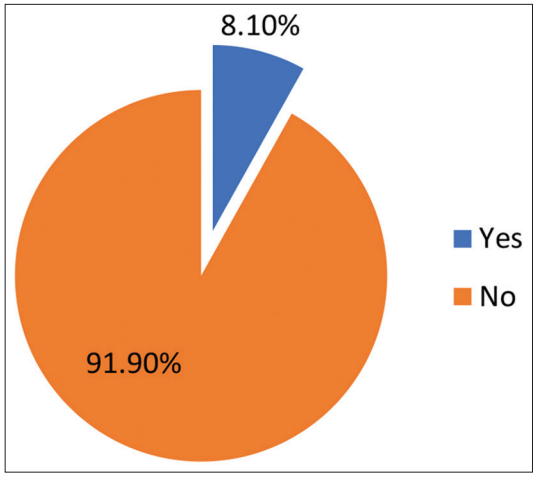
Graph 3: Relative density of bone in region of implant planned

Although there are various methods of imaging available for the treatment planning, in the present study, the CBCT was used to evaluate the type and amount of bone.[13-16]

In the present study, four regions for implant sites were selected. In anterior region, in both maxillary and mandibular arch showed more bone height than posterior region because of presence of maxillary sinus and inferior alveolar nerve respectively. Further, more height in canine region in anterior maxilla and premolars in posterior maxilla were observed. These results are in accordance with the study of Shapurian *et al*. and Naitoh *et al*. who observed that a site specific evaluation of height would be of more value for implant placement.[13-16] Furthermore, enough height was observed in maxillary anterior region but the width was found to be deficient.[14] This warrants bone augmentation procedures before placement of standard implants.

Our study found out that maximum width of bone was available in maxillary posterior region but it most often lacked in height. In such situations, clinician is always left with the option of sinus elevation procedures.[17, 18] The current study showed that the standard implants dimensions can be easily accommodated in the mandibular arch which showed adequate amount of bone in mandibular posterior region as compared to maxillary arch. The wider implants can compensate for the length. As per Winkler *et al*. implants with diameter of 3–3.9 mm showed lesser survival rate then 4–4.9 mm.[19]

Hanihara and Ishida in 2005 found the largest teeth among Australians followed by Melanesians, Micronesians, sub-Saharan Africans, and Native Americans. The Philippine Negritos, Jomon/Ainu, and Western Eurasians have small teeth, while East/Southeast Asians and Polynesians are intermediate in overall tooth size.[20]



Graph 4: Radiographic stent provided by dentist

This proves that Indians have significantly smaller size of teeth as compared to population in the west[21] hence the supporting bone may also be less. Today most of the implant systems are imported and the implant dimensions they manufacture are more pertaining to the western population. Using the same dimensions of implants always needs additional surgical procedures in Indian population.[10]

Some authors believe bone density is the most significant factor, while others suggest that the combination of volume and density is a better predictor of implant success.[18] D1 and D2 types of bone promise the most successful implants. Various studies report that the maxilla (where the bone is less dense) and mandibles that have suffered severe resorption, produce the most implant failures.[12,16,18] Low bone volume combined with soft bone quality (Type IV) increases the incidence of implant failure.[5,13]

The present study recorded the following relative bone density with no significant difference between male and female patients:

Mandibular anterior region : 884.4 HU–857.32 HU type D2 Bone

Mandibular posterior region : 619.8 HU–564.30 HU type D3 bone

Maxillary anterior region : 517.5 HU–461.97 HU type D3 bone

Maxillary posterior bone : 333.2 HU–321.10 HU type D4 bone

42 sites in Maxillary Posterior, five in mandibular Posterior, and three in maxillary anterior were having HU <100 which indicates their inability to provide primary stability. Norton and Gamble in 2001 recorded that the mean bone densities in the anterior mandible, the posterior mandible, the anterior maxilla, the posterior maxilla were 970, 669, 696, and 417 HU, respectively. Shapurian *et al*. in 2006 reported that the average bone density values in the anterior mandible, the anterior maxilla, the posterior maxilla, and the posterior mandible were 559, 517, 333, and 321 HU for 219 implant sites. HU values recorded in this study is in accordance to values found in other studies representing western population.[13,15,17]

Conclusion

This CBCT-based study has enabled us to visualize the bone dimensions and relative density of jaw bones in the Mumbai-Navi Mumbai population in India. The relative density of the bone observed is similar to those which are recorded in literature. The height of the available bone is observed to be sufficient but not the width recorded is deficient which alarm the availability of the size of implants. This, in turn, will guide the manufacturer in manufacturing and providing the size of the implants for the Indian population thereby easing the process for the clinicians in selecting the implants for predictable and successful implant prosthesis.

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