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Original Research Article

Comparative evaluation of bone density (in Hounsfield units) of potential implant sites in the edentulous mandibular first molar region in young adults and elderly male patients using cone beam computed tomography: A cross-sectional study

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A B S T R A C T

Background: Previous literature has highlighted a significant difference in bone density between male and female patients; however, comparative data are scarce regarding bone density among younger and elderly male patients.
Aim: To measure the difference in bone density at the center and periphery of potential implant sites in the edentulous mandibular first molar region in young and elderly adult male patients.
Materials and Methods: Scans fulfilling the inclusion criteria will be divided into Group A (30–40 years) and Group B (50–60 years). The customized software measured and compared bone density at the potential implant site's center and periphery.
Results: A total of 90 CBCT scans were equally divided into two groups. The mean density of both groups was compared on center (P 0.787), on the lingual aspect at 2mm (P 0.310), 4mm (P 0.291), and buccal aspect at 2mm (P 0.223) and 4mm (P 0.291). The difference in bone density in both groups at different positions of potential implant sites was statistically insignificant.
Conclusion: In males, age was not associated with bone density for the edentulous mandibular bone of the mandibular first molar site.

1. Introduction

Cone beam computed tomography (CBCT) offers the potential for better diagnosis and treatment planning for a wide range of clinical applications in implant dentistry.[1] The density of the available bone at an edentulous site is a determining factor in treatment planning and prognosis of implants. Hounsfield units (HU), which are directly related to tissue attenuation coefficients, evaluate bone density.[2]

In past years, traditional panoramic and periapical radiographs were considered adequate to plan oral and maxilla-facial surgery, despite having disadvantages such as a two-dimensional view, magnification, and no quantitative and qualitative information about bone density.[3] With the advancement in dental and maxillofacial radiology, cone beam computed tomography (CBCT) was introduced, which generates three-dimensional (3D) information.[1] Bone quality is a collective term referring to mechanical properties, architecture, degree of mineralization of matrix, and chemistry and structure of bone mineral crystals, which are the remodeling properties of bone.[4]

RATIONALE-Bone density is an important factor determining the initial stability and long-term implant success. Previous literature has highlighted that there is a significant difference in bone density in male and female patients; however, comparative data are scarce regarding bone density among younger and elderly male patients. Hence, the study was undertaken.

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This study evaluated and compared the quality of edentulous mandibular bone in the 1st molar region in male patients of different age groups.

2. Materials and Methods

The cross-sectional study was conducted in our dental institution's Department of Oral Medicine and Radiology after obtaining approval from the institutional ethical committee (MGVRESEARCH/14/2022). The study was conducted from November 2022 to February 2023. The study included elected scans of patients referred for various other purposes for mandibular arch and were selected from the departments of oral medicine and radiology.

The inclusion criteria of the study were CBCT scans depicting missing mandibular first molars in otherwise healthy male patients aged 30–40 and 50–60 years. After menopause, estrogen synthesis decreases, which can cause an abrupt drop in bone density, especially in females. Men have higher bone mineral content than women. It's also well known that as people age, their bone density declines. CBCT scans showing evidence of bony pathologies, fractures, the presence of implants or bony plates, screws, or orthodontic appliances in the region of interest, poor image quality, artifacts, scans with an edentulous potential implant site with a height less than 8mm and a width less than 4 mm, and scans of patients with a history of tobacco consumption were excluded from the study.

The 3D X-ray data recorded using ORTHOPHOS XG 3D (SIRONA, Germany) was characterized by a flat-panel image detector, 0.1 mm pixel size, tube voltage of 77 kV, tube current of 14mA and exposure time of 0.9 sec with the field of view of 8cm x8cm. The data was converted into DICOM (Digital Imaging and Communications in Medicine) format. A third-party proprietary software 3 DIM Viewer (version 3.1.1) was used to determine the values at the center and periphery of the potential implant site in the Hounsfield unit.

For each potential implant site, five readings were taken. At the center of the selected implant site, the crestal level at the mid-point is marked on the cross-sectional view. From this central point, the imaginary long axis of the implant site is drawn to the superior edge of the inferior alveolar canal. A midpoint (m) of this long axis was selected as the center of the implant site.(Figure 1 A)

A midpoint was marked at the periphery on the lingual aspect from the center of the crest to the lingual edge of the selected implant site. From this midpoint, an imaginary line parallel to the long axis was drawn. On this line, two points were selected as follows: (a) point 2mm apical to crestal bone height; (b) point 4mm apical to crestal bone height. (Figure 1 B) Similarly, on the buccal aspect of the periphery, from the center of the crest to the buccal edge of the selected implant site, a midpoint was marked. From this midpoint, an imaginary line parallel to the long axis was drawn. On this line, two points were selected as follows: (c) point 2 mm apical to crestal bone height; (d) point 4 mm apical to crestal bone height. (Figure 1 C) These scanned images were evaluated by two oral and maxillofacial radiologists to eliminate bias. Both observers assessed CBCT scans individually at different times and were done in a quiet windowless room with dimmed lighting.

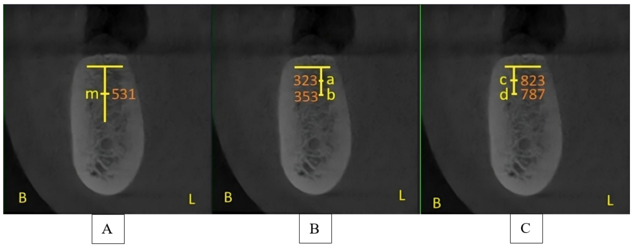

Figure 1: A): Bone density at the center of the implant site. A midpoint (m) was selected as the center of the implant site; **B**): Bone density on the lingual aspect of the implant site. A point (a) 2mm apical to crestal bone height. A point (b) 4mm apical to crestal bone height; **C**): Bone density on the buccal aspect. A point (c) 2 mm apical to crestal bone height. A point (d) 4 mm apical to crestal bone height

The formula for sample size is,

$$N=2\frac{S^2(Z1+Z2)^2}{(M1-M2)^2}$$

The sample size for this observational study was 90 significance level was 5%, the power was 80%, effect size of 0.6. A power analysis was established by G*Power version 3.0.1 (Franz Faul University, Kiel, Germany). The samples were divided according to the purposeful sampling technique. A total of 90 CBCT scans were equally divided into groups A and B. Group A was patients with an age range of 30–40 years and Group B was patients with an age range of 50–60 years.

Statistical analysis was performed using Statistical Product and Service Solution (SPSS) version 21 for Windows (SPSS Inc., Chicago, IL). Quantitative data was expressed as the mean and standard deviation, respectively. The confidence interval was 95%, and the alpha error (level of significance) probability was 5%. The power of the study was set at 80%. Data normality was checked by using the Shapiro-Wilk test. Intergroup comparison between groups for study parameters was done using the unpaired t-test.

3. Results

Among 90 (n) participants, group A was 45 patients had an age range of 30–40 years, and group B was 45 patients had an age range of 50–60 years. Based on the CBCT findings, a comparative evaluation of bone density (in Hounsfield units) at the center and the periphery of potential implant sites in the edentulous mandibular first molar region in young adults (group A) and elderly males (group B) was done.

The mean of bone density at the center of potential implant sites in the edentulous mandibular first molar region in group A was 412.4 and in elderly male patients was 406.1, (P 0.787). The difference in the bone density at the center of potential implant sites in groups A and B was not statistically significant.(Table 1)

The mean bone density at the lingual periphery of potential implant sites in the edentulous mandibular first molar region in group A at 2mm was 649.4 and in group B at 2mm was 561.55 (P 0.310). Similarly, the mean bone density at the lingual periphery of potential implant sites in the edentulous mandibular first molar region in group A at 4 mm was 618.5, and in group B at 4 mm was 537.55 (P 0.291). The difference in bone density between groups A and group B on the lingual site at 2 mm and 4 mm was not statistically significant.(Table 2)

The mean bone density at the buccal periphery of potential implant sites in the edentulous mandibular first molar region in group A at 2mm was 638.8 and in group B at 2mm was 535.35 (P 0.223). Similarly, the mean bone density at the buccal periphery of potential implant sites in the edentulous mandibular first molar region in group A at 4 mm was 560.25, and in group B at 4mm was 479.9 (P 0.344). The difference in bone density between both groups A and group B on the buccal site at 2mm and 4 mm was not statistically significant (Table 3).

4. Discussion

Our cross-sectional study used CBCT to evaluate and compare the bone density in male patients. We found that the bone density of the edentulous mandibular bone in the 1st molar region in male patients of various age groups is different but the difference in the bone density is not statistically significant.

In our study, we measured the bond density in HU units. CT (computed tomography) has been used to evaluate the dimension and density of bone, as it provides quantitative and qualitative data on medullary and cortical bone. With CT, bone density measurements are given in Hounsfield units (HU) based on density values for air (-1,000 HU) and pure water (0 HU). The cortical bone ranges from +1,000 to +1,600 HU values.[3] Chaturvedi A. et al. used a bone profile tool to assess the bone quality of potential implant sites using interactive computed tomography (CT) software in his trabecular bone density was evaluated using Hounsfield unit (HU) values.[4] In CBCT, the X-ray attenuation degree is indicated by grayscale (voxel value). Pauwels R et al. concluded that although there can be limited use of quantitative grey values in CBCT in some cases, it should be generally avoided owing to its unreliability. Grey values, measured on CBCT images may shift owing to the use of different CBCT devices, exposure parameters, the position of the measurement in the field of view FOV (centrally vs peripherally), and the amount of mass inside and outside the FOV.[5] A study by Gaur et al. concluded that the accuracy of the CBCT grayscale in measuring bone density, in contrast to CT HU, is questionable and needs to be standardized before clinical application.[6]

Our study used CBCT scans with third-party software to measure the bone density of potential implant sites**.** The efficacy of CBCT for bone density evaluation was validated by Mah et al., who found a strong linear relationship between HU in CT scan and grayscale in CBCT, suggesting that the voxel value in CBCT can be used for bone density assessment.[7] Alfawazan AA et al. and Haghanifar, et al. concluded the voxel value and primary stability had a normal distribution and strong correlation.[1–8] A review by Bhoosreddy AR et al stated that a CBCT scan, in combination with software modeling, can be used as a virtual planning environment to achieve the ideal placement of the prosthetics, occlusion, and associated supporting implants, in a virtual environment.[9] Morar L et al. conducted a study on a group of forty partly edentulous patients who underwent radiological examination by scanning the areas of interest using cone beam computed tomography (CBCT). Hounsfield units (HU) were analyzed using dedicated software.[10]

In our study all participants were males of different age groups to avoid gender bias we excluded female participants. The difference in the mean bone density value among genders might be associated with hormonal peculiarities in females and generally greater bone mass in males with the additional possible effects of the distribution of the interest sites and the age of the patients.[11] Loss of bone density occurs with advancing age and rates of fracture increase with age, giving rise to significant morbidity and mortality. Osteoporosis is three times more common in women than in men because women have a lower peak bone mass and hormonal changes occur at menopause.[12] Estrogens have an important function in preserving bone mass during adulthood, and bone loss occurs as levels decline, usually around the age of 50 years. In addition, women live longer than men and therefore have greater reductions in bone mass.[13]

Hasegawa Y. et al. studied bone density in older adults and found a significant relationship not only with clinical characteristics or physical performance but also with occlusal force, in male participants, Occlusal force and masticatory performance showed a significant association with the state of bone.[14] Cortical bone content, area, and density of the tibia were similar between age groups, but the trabecular analysis showed greater area and lower density in older men compared to younger men.[15] In a study by Suvarna PV et al., the statistical analysis did not show any significant relationships between HU values and demographic data like gender, age, jaw, side, or zone in the arch[16] which is per our study which shows insignificant difference of bone density with various age groups in males.

Table 1: Comparative evaluation of bone density (in Hounsfield units) at the center of potential implant sites in the edentulous mandibular first molar region in young adults and elderly male patients using cone beam computerized tomography

Centre	Mean	SD	Mean Difference ± SE	Unpaired t-test	P value, Significance
Group A (30-40 years)	412.4	252.48	6.3 ± 70.86	U = 190.0	p = 0.787 (No statistically significant difference)
Group (50-60 years)	406.1	190.17			

Table 2: Comparative evaluation of bone density (in Hounsfield units) at the lingual periphery of potential implant sites in the edentulous mandibular first molar region in young adults and elderly male patients using cone beam computerized tomography

Lingual Side - 2 mm	Mean	SD	Mean Difference ± SE	Unpaired t-test	P value, Significance
Group A (30-40 years)	649.4	207.39	87.85 ± 62.7	U = 162.5	p = 0.310 (No statistically significant difference)
Group B (50-60 years)	561.55	188.71			
Lingual Side 4 mm	Mean	SD	Mean Difference ± SE	Unpaired t-test	P value, Significance
Group A (30-40 years)	618.5	250.57	80.95 ± 70.24	U = 161.0	p = 0.291 (No statistically significant difference)
Group B (50-60 years)	537.55	189.49			

Table 3: Comparative evaluation of bone density (in Hounsfield units) at the buccal periphery of potential implant sites in the edentulous mandibular first molar region in young adults and elderly male patients using cone beam computerized tomography

Buccal side -2 Mm	Mean	Sd	Mean Difference ± Se	Unpaired t Test	P value, Significance
Group A (30-40 years)	638.8	295.75	103.45 ± 78.65	U = 155.0	p = 0.223 (No statistically significant difference)
Group B (50-60 years)	535.35	190.43			
Buccal Side -4 mm	Mean	SD	Mean Difference ± SE	Unpaired t test	P value, Significance
Group A (30-40 years)	560.25	314.98	80.35 ± 87.96	U = 165.0	p = 0.344 (No statistically significant difference)
Group B (50-60 years)	479.9	235.64			

We found that the mean bone at the center is less as compared to the density at the periphery for both groups. Al-Attas MA et al., in the study, found that site-specific differences in density were seen with both partial and completely edentulous mandible, which is per our study.[14]

Good stability favors implant osseointegration.[11] For patients unable to keep their natural teeth, implants fix acute problems and improve the quality of life. Also, it gives patients the benefit of restorative improvements for a modern lifestyle. They have gained immense popularity as they permanently restore the lost tooth structure without interfering with oral function or speech or compromising the self-esteem of the patient.[9]

To the best of our search, we did not find any research on the comparative bone density in edentulous mandibular bone in the mandibular 1st molar region of males. The strength of this study is we measure the bony density by using CBCT scans in HU.

5. Conclusion

Our study concluded that CBCT scans with 3 DIM viewer software can be used to accurately determine bone density. In males, age was not associated with bone density for the edentulous mandibular bone of the mandibular 1^{st} molar site. We encourage proper presurgical dental implant planning and an accurate assessment of bone structure before implant placement.

6. Limitation

The limitation of the present study is that the sample size is small and short duration. Since this study was retrospective, we did not know how long had passed since the extraction/loss of the first molars. Therefore, these factors might have affected the results obtained in this study.

7. Future Prospects

We recommend further studies with a larger sample size and long duration with an adequate history of edentulous span.

8. Sources of Funding

Nil.

9. Conflicts of Interest

There are no conflicts of interest.

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