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Maxilla and Mandible Bone Density in Sample of Normal Full Dentition Yemeni Adults: Cone Beam Computed Tomography (CBCT) Retrospective Study

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Abstract

Background and Objectives: The internal structure of bones is described in terms of their quality or density, which reflects a number of biomechanical properties such as strength and elastic modulus. Bone density refers to the concentration of minerals, particularly calcium and phosphorus, in a given volume of bone tissue. It plays a vital role in determining bone strength, contributing to approximately 60% of the overall structural integrity of the bones. This study aimed to obtain baseline data on bone density of the maxilla and mandible in normal Yemeni individuals across various anatomical regions, sexes, and age groups.
Materials and methods: We retrospectively analyzed Cone Beam Computed Tomography (CBCT) images of 150 mandibular and 150 maxillary jaws from adults with full dentition in Sana'a City, Yemen. Scans were acquired using the PaxFlex3DP2 system and analyzed using the Ez3Di and THEIA software.
Results: The mean bone density values in maxillary and mandibular jaw for normal Yemeni people aged between (18-64 y) ranged between (1036-1721 HU) for different maxillary areas and (1394.6-2099 HU) for different mandibular areas. The highest bone density was observed in both the mandible and maxilla between the central and lateral incisors, decreasing posteriorly in both jaws.
Conclusion: Yemeni populations showed one of the highest bone density values compared to other nations. Their lower jaw had higher bone density than the upper jaw,with peak values found in the anterior regions

Article Info

Keywords:
Bone density, jawbone, CBCT, maxilla, mandible, retrospective study, Yemeni population.

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1. INTRODUCTION

Bone density is a fundamental determinant of skeletal strength and structural integrity, and serves as a key factor in the assessment and management of both systemic and localized bone conditions [1]. In dentistry, evaluating bone density in the maxilla and mandible is especially important because of their critical roles in supporting dentition, facilitating mastication, and preserving facial morphology [2]. Accurate assessment of jawbone density enables clinicians to diagnose the underlying pathology, predict bone remodeling patterns, and plan interventions such as implants, orthodontic movement, extractions, and grafting procedures [2, 3]. The structural composition of the jawbones, consisting of cortical and cancellous bones, undergoes changes throughout an individual's life due to physiological and pathological influences. Age, sex, nutrition, and systemic diseases such as diabetes or osteoporosis significantly affect the bone mineral density (BMD), which in turn can affect dental treatment outcomes [4, 5]. Anatomical variations are also prominent, with studies showing that the mandible tends to have higher bone density than the maxilla and that anterior regions typically exhibit denser bone than posterior regions [6]. Advancements in imaging technologies have revolutionized the assessment of jawbone density. Traditional methods, such as panoramic radiography, provide limited precision and are unable to detect subtle changes in the bone quality [7]. However, Cone Beam Computed Tomography (CBCT) offers high-resolution three-dimensional imaging with minimal radiation exposure, making it an ideal tool for evaluating the maxillofacial skeleton [8]. CBCT allows clinicians to estimate relative bone density in Hounsfield Units (HU), which has been shown to correlate with bone quality and is crucial not only for dental implant planning, but also for predicting future bone loss and ensuring optimal osseointegration [9]. Different classification systems, such as those proposed by Lekholm [10] and adapted by Misch [11],remain widely used for preoperative bone evaluation and treatment planning. Since preoperative bone density values guide the clinician in planning the intervention and choosing the right dental implants and surgical protocols, there is important clinical value in the investigation of preoperative bone densities before dental implant placement. Several studies have explored bone density using CBCT in various global contexts [12, 13, 14]. Differences between populations are important for accurate diagnosis and treatment, as factors such as the environment, diet, and culture can affect jawbone density. In Yemen, habits such as chewing qat may play a role in different oral characteristics [15]. Several CBCT-based studies in Yemen have explored anatomical structuressuch as the anterior maxillary sinus canal [16], mandibular canal [17], and cervical vertebrae [18] to support clinical and surgical safety. Studies specifically examining maxillary6and mandibular bone densities are still limited; therefore, introducing bone density values of the jaws is crucial for refining treatment strategies and enhancing clinical outcomes. To date, no study has investigated the bone density of the maxilla and mandible in a sample of normal Yemeni adults with complete dentition using cone-beam computed tomography (CBCT). This retrospective study aimed to identify the bone density values of both jaws and to compare the findings with those of other populations.

2. MATERIALS AND METHODS

2.1. Study design

This was retrospective cross-section study.

2.2. Study population

This study analyzed a total of 500 maxillary and mandibular jaw CBCT images from adult patients with full dentition, conducted in private radiology centers in Sana'a City, Yemen.

2.3. Sample size

Of the 500 CBCT images reviewed,150 met the inclusion criteria comprising 70 men and 80 women.

2.4. Inclusion criteria

Patients with a full set of permanent teeth in both jaws, no radiographic evidence of systemic diseases, chronic medication use affecting bone density, dentofacial deformities, pathologic lesions, or facial trauma,were included.

2.5. Exclusion criteria

Patients under 18 years of age and those with radiographic evidence of trauma, orthodontic treatment, or pathological disorders,were excluded.

2.6. Data collection

Data were collected between June 2018 and November 2024, with 150 cases meeting the study criteria after excluding 350 images owing to cropping, fractures, orthodontic appliances, cystic lesions, or destructive conditions.

2.7. CBCT scans testing

CBCT scans were acquired using the PaxFlex3DP2 system (Vatech, Korea) with standardized settings, including a field of view (FOV) ranging from 5×5 cm to 9×12 cm, a tube voltage/current of 90 kVp and 4.0 mA, and a scan time of 24 s with isotropic voxel sizes of 0.160–0.200 mm for full-mouth scans and 0.060–0.020 mm for specific regions. The detector completed 2000 rotations within 14 s to ensure high-quality 3D imaging. Images were processed using Ez3Di from Vatech and THEIA software from Genoray, which is a comprehensive image processing software that offers extensive features for CBCT analysis, including 3D reconstruction, slice thickness adjustment, and distance/angle measurement. The data were processed on a high-performance laptop (HP Core™ i7-4710MQ CPU, 2.50 GHz, 800 GB RAM) to achieve accurate 3D visualization and multiplanar reconstruction (MPR). Bone density measurements were taken in specific regions of interest **(ROI) for maxillary jaw:**

Mx1-2 Maxillary region between the central and lateral incisors.

Mx 3-4 Maxillary region between the canine and the

first premolar.
Mx 4-5 Maxillary region between the first premolar and second premolar
Mx 5-6 Maxillary region between the second premolar and first molar.
Mx 6-7 Maxillary region between the first and second molars.
MxT: Maxillary tuberosity.
And **(ROI) for mandibular jaw:**
Md1-2 Mandibular region between the central and lateral incisors.
Md 3-4 Mandibular region between the canine and the first premolar.
Md 4-5 Mandibular region between the first premolar and second premolar
Md 5-6 Mandibular region between the second premolar and first molar
Md 6-7 Mandibular region between the first and second molars.
RM Retromolar area.

ROI areas were identified in three views: axial, sagittal, and coronal. To overcome the overlap between anatomical structures and teeth, parallelism was used in the following manner. On coronal and axial views, the vertical axis was positioned interdentally and aligned parallel to the roots of the teeth in the area of measurement. On the sagittal view, it was positioned parallel to the angulation of the alveolar bone. The horizontal axis was positioned approximately 4 mm from the crest of the bone in all the views [19]. The ROI was drawn freehand to encompass the cortical and trabecular bone, and three readings per view were averaged to determine the final density value for each area.

2.8. Statistical method

Data were described using descriptive statistics. Data analysis was performed using SPSS version 26. The data are presented as numbers and percentages. The quantitative non-parametric data were reported by described in terms of mean and standard deviation (after utilizing Mann-Whitney test). Statistical significance was set at $P < 0.01$.

2.9. Ethical approval

Ethical approval was obtained from the Medical Ethics Committee of the Faculty of Dentistry, Sana'a University.

3. RESULTS

This study revealed significant variations in bone density across the maxilla and mandible, with distinct patterns observed from the anterior to posterior regions. In the maxilla, the overall bone density ranged from 575.9 HU in the maxillary tuberosity (MXT) to 1721.1 HU in the 1-2 area (central and lateral incisors), the latter representing the highest density and indicating strong anterior bone support. Moderate bone density was observed in the 3-4 area (canine and first premolar) and 4-5 area (first and second premolars). The 5-6 area (second premolar and first molar) and 6-7 area (first and second molars) exhibited lower bone density, although a slight increase was noted in the 6-7 area. The MXT group had the lowest bone density, reflecting weak bone support in this region. In the mandible, bone density ranged from 1237.9 HU in the retromolar area (RM) to 2099.4 HU in the 1-2 area, which showed the highest density, consistent with strong anterior bone support. Moderate bone density was observed in the 3-4 area and 4-5 area. The 5-6 area and 6-7 area exhibited lower bone density, with the 6-7 area showing the lowest density among the interradicular regions. RM had the lowest bone density, indicating weak bone support in this area. Statistically significant differences ($P = 0.01$) were observed between all interradicular areas in both jaws. The mandible consistently exhibited a higher bone density than the maxilla across all measured sites, with the highest density in the anterior mandible and the lowest density in the posterior maxilla.

4. DISCUSSION

The accurate assessment of jawbone density plays a crucial role in surgical planning and implant selection in dental procedures. CBCT has emerged as a significant advancement in CT-scan technology and is widely adopted in dentistry because of its high-resolution imaging, lower radiation exposure, and cost-effectiveness compared to traditional CT scans. Its enhanced capabilities enable the accurate evaluation of bone density, optimal implant positioning, and improved treatment predictability [20]. This study provides the first CBCT-based evaluation of bone density in both the maxilla and mandible of an adult Yemeni population with full dentition. The results revealed significant regional variations in both the jaws. The anterior regions (incisor and canine areas) demonstrated the highest bone density values, likely reflecting their role in managing the occlusal forces from biting. In contrast, the posterior segments, particularly the premolar and molar zones, exhibited lower densities. This study revealed significant regional variations in bone density across the maxilla and mandible. The anterior regions (1-2 area: central and lateral incisors) exhibited the highest bone density in both jaws, reflecting the strong bone support required for biting and chewing. In contrast, the bone density gradually decreased in the posterior regions, with the lowest values observed in the 5-6 (second premolar and first molar) and 6-7 (first and second molars) areas. These findings align with those of previous studies, such as those conducted by Felicori et al. [21] and Poedjiastoeti et al. [12] which also reported a higher density in the anterior regions compared to the posterior region, with the mandible being denser overall. Similarly, Ahmed, Ikram, et al.[14] noted the highest mean bone density in the anterior mandible and maxilla, followed by the posterior mandible, and the lowest density in the posterior maxilla, highlighting the relationship between the bone density distribution and functional loading patterns in the jaw. The mandible consistently demonstrated a higher bone density than the maxilla across all measured sites, with the anterior mandible exhibiting the highest density (mean = 2099.4) and the maxillary tuberosity showing the lowest (mean = 575.9). These findings are consistent with those of previous studies, such as Felicori et al.[21], who reported higher bone density in the mandible than in the maxilla, and Morar et al.[13], who found that the mandibular central incisor area had a greater density than the maxillary central incisor area, and that the mandibular first molar area was denser than the maxillary first molar area. These results underscore the inherent structural differences between the maxilla and mandible, which must be considered in clinical decision making for implant placement and other restorative procedures. The current study aimed to evaluate jawbone density among a Yemeni population and compare it with other populations from different regions worldwide, namely, the USA, China, Turkey, Saudi Arabia, Pakistan, Myanmar, and the UK. Bone density was assessed in different oral regions (anterior mandible, anterior maxilla, posterior mandible, and posterior maxilla) using Hounsfield Units (HU) as a standardized measure. The results, when compared with other populations, showed clear differences in jawbone density distribution, especially in the anterior regions of the maxilla and mandible; the Yemeni population demonstrated exceptional density in anterior regions (anterior mandible: 2099.4±279.6 HU; anterior maxilla: 1721.1±301.5 HU), nearly doubling values seen in other groups. Similar anterior dominance was observed in Pakistan (anterior mandible: 1093.34±109.42 HU; anterior maxilla: 709.75±122.63 HU) [22] and Turkey (944.9±207 HU and 715.8±190 HU respectively) [6]. Western populations showed more moderate anterior densities (USA: 559±208 HU mandible/517±177 HU maxilla [23]; UK: 970.0 HU/696.1 HU) [24], while China presented the lowest anterior values among Asian groups (530±161 HU/516±132 HU) [25]. The Saudi population showed unique cortical- cancellous disparities, with extremely high buccal cortical density (937.56±176.92 HU), in contrast to porous posterior maxillary cancellous bone (247.12±46.75 HU) [26]. The posterior regions universally exhibited lower densities, although with significant population variation. The posterior mandible ranged from exceptionally high in Yemen (1452.3±233.1 HU) to moderate in Turkey (674.3±227 HU) [6] and Pakistan (599.45±135.55 HU) [22], and notably lower in the USA (321±132 HU) [23]. Posterior maxillary densities showed even greater variability, from Yemen's remarkably high 1036.0±261.9 HU to critically low values in Saudi Arabia (247.12±46.75 HU) [26] and Pakistan (299.66±73.09 HU)[22]. Myanmar's data revealed significant maxillary trabecular differences (anterior: 439±271 HU vs. posterior: 271±143 HU, $p < 0.01$) [27], with progressive age-related decline. These findings demonstrate that, while the anterior > posterior density gradient is universal, its steepness varies dramatically by population. The Yemeni population may differ in jawbone density from other populations due to a combination of genetic predispositions and environmental influences. Genetic variations in key bone-regulating genes, such as the vitamin D receptor), COL1A1 (collagen type I alpha 1), and LRP5, affect calcium absorption, bone strength, and remodeling, and these variants can differ by ethnicity and region [28]. In Yemen, environmental and cultural factors may further affect the bone health. Limited sun exposure due to traditional clothing, along with dietary insufficiencies in calcium and vitamin D, is common and contributes to suboptimal bone mineralization [29]. Together, these genetic and nutritional factors may explain the observed differences in bone density between the Yemenis and other global populations.

5. LIMITATION OF THE STUDY

One of the primary shortcomings of the current study is that it is retrospective in nature and medical records occasionally fail to accurately document factors, even in cases that may be characterized. Because it is impossible to determine with certainty whether the patients being diagnosed are representative of all (apparently) comparable individuals, it is challenging to evaluate conclusions using historical data. Although retrospective studies still have several serious problems, including poor recording, missing data, and missing or insufficient documentation, they are still useful tools.

6. CONCLUSION

This study underscores the importance of CBCT in assessing jawbone density; the mandible exhibited a higher density than the maxilla, with the anterior regions showing the greatest density, consistent with functional loading patterns. These findings highlight the need for longitudinal studies to track bone density changes over time, better understand the impact of aging on jawbone density, and use additional variables, such as hormonal status, bite force, and systemic health conditions that could influence bone density outcomes.

DATA AVAILABILITY

The accompanying author can provide empirical data that were utilized to support the study's conclusions upon request.

Table 1. Mean bone density values in maxilla and mandible among Yemeni selected individuals.

	Bone density											
Site	1-2	P	3-4	P	4-5	P	5-6	p	6-7	P	MXT / RM	p
Maxilla												
mean	1721.1	***	1344.4	***	1108.2	***	1036.0	***	1095.2	***	575.9	***
SD	301.5	***	266.1	***	234.5	***	261.9		299.4	***	251.2	***
Mandible												
mean	2099.4	***	1822.2	***	1558.0	***	1452.3	***	1394.6	***	1237.9	***
SD	279.6	***	271.2	***	234.6	***	233.1	***	241.1	***	310.1	***

P-value Mann-Whitney test, ***P value= significant at 0.01 level. 1-2, interradicular area between the central and lateral incisors, 3-4, interradicular area between the canine and first premolar;4-5, interradicular area between the first and second premolars 5-6, interradicular area between the second premolar and first molar;6-7, interradicular area between the first and second molars MXT, maxillary tuberosity; RM, retro molar area in the mandible; SD, standard deviation. Anterior maxilla include 1-2,3-4, Posterior maxilla include 4-5,5-6,6-7 and MxT. Anterior mandible include 1-2,3-4 , posterior mandible include 4-5,5-6,6-7 and RM .

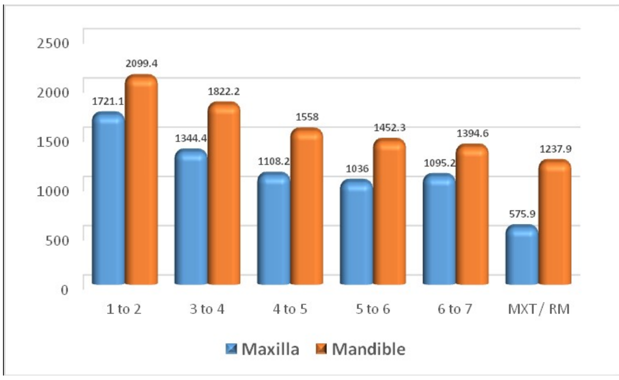

Figure 1. Mean bone density for maxillary and mandible bones for Yemeni individuals

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A DISPUTE OF INTEREST

The authors declare no conflict of interest regarding this project.

REFERENCES

[1] Juliet Compston. "Bone quality: what is it and how is it measured?" In: *Arquivos brasileiros de endocrinologia & metabologia* 50 (2006), pp. 579–585.

[2] A Gulsahi et al. "Assessment of bone mineral density in the jaws and its relationship to radiomorphometric indices". In: *Dentomaxillofacial Radiol.* 39.5 (2010), pp. 284–289.

[3] Tina Chugh et al. "Bone density and its importance in orthodontics". In: *J. oral biology craniofacial research* 3.2 (2013), pp. 92–97.

[4] Patricia J Kribbs. "Comparison of mandibular bone in normal and osteoporotic women". In: *The J. prosthetic dentistry* 63.2 (1990), pp. 218–222.

[5] A Gulsahi et al. "Assessment of panoramic radiomorphometric indices in Turkish patients of different age groups, gender and dental status". In: *Dentomaxillofacial radiology* 37.5 (2008), pp. 288–292.

[6] I Turkyilmaz, TF Tözüm, and C Tumer. "Bone density assessments of oral implant sites using computerized tomography". In: *J. oral rehabilitation* 34.4 (2007), pp. 267–272.

[7] Mateus Azevedo Kinalski, Noeli Boscato, and Melissa Feres Damian. "The accuracy of panoramic radiography as a screening of bone mineral density in women: a systematic review". In: *Dentomaxillofacial radiology* 49.2 (2020), p. 20190149.

[8] Robert Weiss and Andrew Read-Fuller. "Cone beam computed tomography in oral and maxillofacial surgery: an evidence-based review". In: *Dent. journal* 7.2 (2019), p. 52. DOI: 10.3390/dj7020052.

[9] Yan Hua et al. "Bone quality assessment based on cone beam computed tomography imaging". In: *Clin. oral implants research* 20.8 (2009), pp. 767–771. DOI: 10.1111/j.1600-0501.2008.01677.x.

[10] U. Lekholm. "Patient selection and preparation". In: *Tissue-integrated protheses: Osseointegration in clinical dentistry*. 1985, pp. 199–209.

[11] C.E. Misch. "Density of bone: effect on treatment plans, surgical approach, healing, and progressive boen loading". In: *Int. J. Oral Implantol. Implantol.* 6.2 (1990), pp. 23–31.

[12] Wiwiek Poedjiastoeti et al. "Alveolar bones density assessment of dental implant sites using cone-beam computed tomography". In: *Padjadjaran J. Dent.* 34.3 (2022), pp. 264–270. DOI: 10.24198/pjd.vol34no3.42383.

[13] Leonard Morar et al. "Analysis of CBCT bone density using the Hounsfield scale". In: *Prosthesis* 4.3 (2022), pp. 414–423. DOI: 10.3390/prosthesis4030033.

[14] Myra Ahmed et al. "ASSESSMENT OF JAW BONE DENSITY IN TERMS OF HOUNSFIELD UNITS USING CONE BEAM COMPUTED TOMOGRAPHY FOR DENTAL IMPLANT TREATMENT PLANNING". In: *Pak. Armed Forces Med. J.* 71.1 (2021).

[15] Ali Kaid Al-Sharabi et al. "Qat Chewing as an Independent Risk Factor for Periodontitis: A Cross-Sectional Study". In: *Int. journal dentistry* 2013.1 (2013), p. 317640. DOI: 10.1155/2013/317640.

[16] Saleem Taher Ali Ahmed et al. "ASSESSMENT OF THE ANATOMICAL STRUCTURE OF CANALIS SINUOSUS IN THE ANTERIOR MAXILLA TO AVOID SURGICAL COMPLICATIONS". In: *Univers. J. Pharm. Res.* (2024). DOI: 10.22270/ujpr.v9i4.1153.

[17] Fahim Haza'a Ali Abdo Saif et al. "ANATOMICAL PATTERN COURSE OF MANDIBULAR CANAL AND ITS FORAMINA LOCATION ON SAMPLE OF YEMENI PATIENTS USING CONE BEAM COMPUTED TOMOGRAPHY". In: *Univers. J. Pharm. Res.* (2023). DOI: 10.22270/ujpr.v8i1.895.

[18] Etehad Al-Ghola, Ghamdan Al-Harazi, and Hassan Abdulwahab Al-Shamahy. "THREE-DIMENSIONAL EVALUATION OF THE FIRST CERVICAL VERTEBRAL MORPHOLOGY IN SKELETAL CLASS I AND III MALOCCLUSIONS IN YEMENI PATIENTS". In: *Univers. J. Pharm. Res.* (2025). DOI: 10.22270/ujpr.v10i1.1269.

[19] Intan Fariska et al. "Normal Value of Cortical and Mandibular Trabecular Bone Density using Cone Beam Computed Tomography (CBCT)". In: *J. Int. Dent. & Med. Res.* 12.1 (2019).

[20] Reinhilde Jacobs et al. "Cone beam computed tomography in implant dentistry: recommendations for clinical use". In: *BMC oral health* 18 (2018), pp. 1–16. DOI: 10.1186/s12903-018-0523-5.

[21] Silvana Maria Felicori et al. "Assessment of maxillary bone density by the tomodensitometric scale in Cone-Beam Computed Tomography (CBCT)". In: *J. Health Sci. Inst* (2015), pp. 319–322.

[22] M. Ahmed et al. "ASSESSMENT OF JAW BONE DENSITY IN TERMS OF HOUNSFIELD UNITS USING CONE BEAM COMPUTED TOMOGRAPHY FOR DENTAL IMPLANT TREATMENT PLANNING". In: *PAFMJ* 71 (2021), pp. 221–227.

[23] Tannaz Shapurian et al. "Quantitative evaluation of bone density using the Hounsfield index". In: *Int. J. Oral & Maxillofac. Implant.* 21.2 (2006).

[24] Michael R Norton and Carole Gamble. "Bone classification: an objective scale of bone density using the computerized tomography scan". In: *Clin. oral implants research* 12.1 (2001), pp. 79–84.

[25] L-J Fuh et al. "Variations in bone density at dental implant sites in different regions of the jawbone". In: *J. oral rehabilitation* 37.5 (2010), pp. 346–351. DOI: 10.1111/j.1365-2842.2010.02061.x.

[26] Naif N Almasoud, Nagaraju Tanneru, and Hesham F Marei. "Alveolar bone density and its clinical implication in the placement of dental implants and orthodontic mini-implants". In: *Saudi medical journal* 37.6 (2016), p. 684. DOI: 10.15537/smj.2016.6.14274.

[27] Yin Min Soe Kyi, Myat Nyan, and Shwe Hlaing. "A study on evaluation of trabecular bone density in partially edentulous maxilla". In: *J. Clin. Dent. Relat. Res.* 1.1 (2020), pp. 11–18. DOI: 10.2020/vol1iss1pp11-18.

[28] S. H. Ralston and A. G. Uitterlinden. "Genetics of osteoporosis". In: *Endocr Rev* 31.5 (2010), pp. 629–662.

[29] Madhusmita Misra et al. "Vitamin D deficiency in children and its management: review of current knowledge and recommendations". In: *Pediatrics* 122.2 (2008), pp. 398–417.