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Role of Mandibular Morphologic Parameter in Identification of Gender: A CBCT Study

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Abstract

Introduction: Accurate sex identification from skeletal remains is critical in forensic anthropology and dentistry. This study explored sexual dimorphism in mandibular morphological parameters, focusing on the positions of the mental foramen and genial tubercles.

Materials and Methods: Conducted at the Department of Oral Pathology, JMF ACPM Dental College, this study analyzed cone beam computed tomography (CBCT) records of 52 patients (26 males, 26 females) collected during 2020-2024. Ethical clearance was obtained, and informed consent was obtained. Measurements included the vertical position and angle of the mental foramen, and the position of the genial tubercles. Reliability was ensured through repeated measurements by two independent observers.

Results: Significant differences were observed between males and females. Males had a greater distance from the lower margin to the center of the mental foramen (mean 7.84 ± 1.84 mm vs. 6.51 ± 1.21 mm, p = 0.003) and a larger angle of the mental foramen (mean 55.00° ± 12.50° vs. 46.00° ± 8.90°, p = 0.004). The position of the genial tubercles was more inferior in males, with a significant difference in the distance from the upper margin (mean 12.34 ± 3.45 mm vs. 10.81 ± 1.45 mm, p = 0.042).

Discussion: The results demonstrated significant sexual dimorphism in mandibular parameters. Males exhibited larger and more robust mandibular features, likely influenced by hormonal and muscular differences.

Conclusion: This study confirms that mandibular morphological characteristics exhibit significant sexual dimorphism, aiding forensic gender determination within the Indian population. Future studies should expand the sample size and include diverse populations for broader applicability.

Keywords: Mental foramen; Genial tubercle; Cone beam computed tomography; Gender; Forensic.

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INTRODUCTION

In forensic anthropology and dentistry, the accurate identification of gender based on skeletal remains is critical, especially in scenarios involving mass disasters, criminal investigations, and archaeological excavations. The mandible, one of the most robust bones in the human body, often survives post-mortem processes and thus becomes a focal point in gender determination studies.[1] Several morphological parameters of the mandible, such

as the position of the mental foramen, bicondylar width, and position of the genial tubercle, have been explored for their potential in distinguishing between male and female skeletal remains.[2]

The mental foramen, an opening on the anterolateral surface of the mandible, allows the passage of the mental nerve and vessels. Its position has been extensively studied, revealing significant sexual dimorphism.[3] Studies suggest that the mental foramen tends to be positioned more inferiorly in males than in females, possibly because of the generally larger mandibles and greater muscle attachment areas in males. Moreover, the horizontal position of the mental foramen varies between sexes, with implications for forensic investigations.[4]

The genial tubercles and small bony projections on the inner surface of the mandible served as attachment points for the geniohyoid and genioglossus muscles. The position and prominence of the genial tubercles can vary between sexes, influenced by differing muscular attachments and functional demands in males and females.[5] This parameter, though less commonly studied compared to the mental foramen and bicondylar width, holds potential in the multifactorial approach to sex determination.

Understanding these mandibular morphological parameters provides a comprehensive approach for sex identification. The integration of these parameters into a combined analysis can enhance the accuracy and reliability of forensic assessment. Previous research has highlighted the importance of utilizing multiple indicators rather than relying on a single morphological feature, thereby minimizing the risk of misidentification.[6,7]

This study aimed to explore the significance of the position of the mental foramen and genial tubercle in sex determination. By analyzing these parameters in a contemporary population sample, this study sought to validate their effectiveness and contribute to the growing body of forensic anthropological knowledge.

MATERIAL AND METHODS

Study Setting and Ethical Clearance

This study was conducted in the Department of Orthodontics, on Cone-beam computed tomography (CBCT) records of patients. Ethical clearance for the study was obtained from the institutional ethics committee to utilize the CBCT records of patients for research purposes. This study adhered to the ethical guidelines for research involving human subjects and followed the guidelines of the Declaration of Helsinki. As a protocol of our institution, written informed consent is always obtained from patients to use their records for study purposes, maintaining confidentiality.

Sample Size Calculation

The sample size was determined using the G*Power software version 3.2.9. For this study, an alpha error of 5% (95% confidence level) and power of 80% were set. Based on a minimally acceptable effect size of 0.75 for the mean comparison of bicondylar width between males and females, as referenced from previous studies[8], the total estimated sample size required was 52 patients, with 26 individuals in each sex group.

Sample Selection

The sample consisted of CBCT records from the departmental archives collected over a specified period of 2020-2024. The inclusion criteria were set to ensure the selection of adult patients aged 18-50 years with no history of craniofacial anomalies, trauma, or surgery that could affect mandibular morphology. Records with incomplete or poor-quality images were excluded. After applying these criteria, a total of 52 suitable records were selected, with 26 male and 26 female participants, and CBCT scans were obtained using Planmica Pro Max (Helsinki, Finland, USA). The scans were taken at 100 kVp, 5-10 mA, exposure time of 18 s, and a field of view (FOV) of 11 × 8 cm. The slice thickness was 0.3 mm, and the voxel size was 0.1µm.

Data Collection

Data were collected from selected CBCT records, focusing on the following mandibular morphological parameters:

1. **Position of the opening of mental foramen:** The vertical position of the mental foramen was measured using linear measurements on CBCT images. The vertical position was recorded as the distance from the lower border of the mandible to the center of the mental foramen, and from the upper border of the alveolar crest to the foramen center (Fig. 1A).
2. **Angle of foramen opening:** Angle of foramen opening measured between the sagittal axis and the path of foramen

opening (Fig. 1B).

3. **Position of genial tubercle:** The position of the genial tubercles was measured in terms of the vertical distance from the lower border of the mandible to the upper border of the alveolar crest (Fig. 1C).

Measurement Reliability

To ensure measurement reliability, two independent observers performed all the measurements. The observers were calibrated before the study to minimize inter-observer variability. Intra and inter-observer reliability were assessed by repeating the measurements on 10 randomly selected CBCT records after a two weeks interval. The intraclass correlation coefficient (ICC) was used to evaluate measurement consistency.

Statistical Analysis

Data were entered into a spreadsheet and analyzed using SPSS software version 25.0. Descriptive statistics, including mean and standard deviation, were calculated for each parameter. Independent t-tests were conducted to compare the mean values of mandibular parameters between the male and female groups. Statistical significance was set at P <0.05.

RESULTS

The ICC for intra-observer reliability and inter-observer reliability were 96% and 92%, respectively, showing excellent reproducibility and reliability.

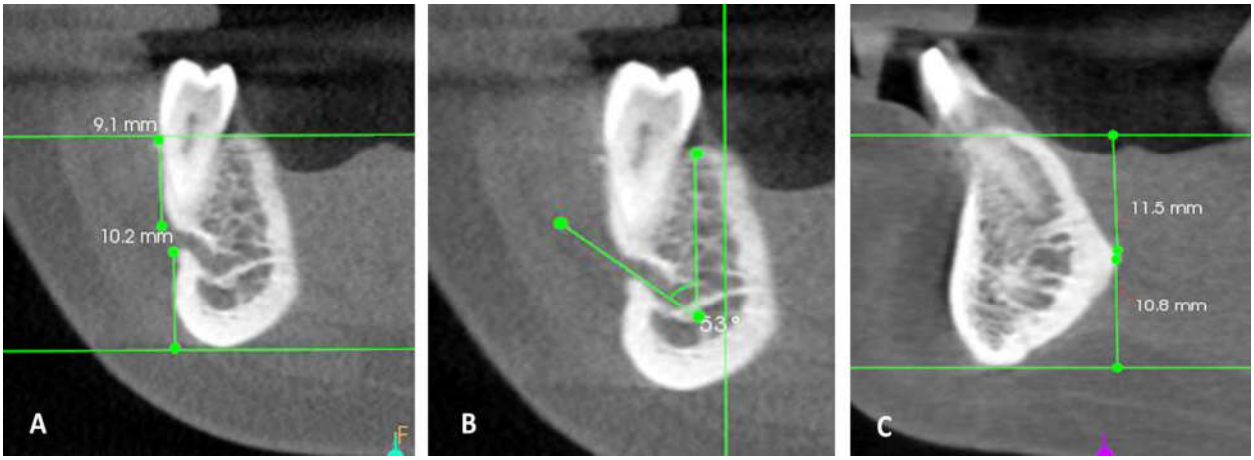

Fig. 1: Mandibular parameters on CBCT, **A:** Position of mental foramen, **B:** Angle of mental foramen opening, **C:** Position of genial tubercles.

The study analyzed various parameters between male and female subjects, providing insight into sex-based differences.

The mean age for males was 32.50 ± 5.43 years, while for females, it was 29.34 ± 4.67 years. The confidence interval (CI) for age differences ranged from 0.33 to 5.98, with a p-value of 0.021, indicating a statistically significant difference (Table 1). Regarding the mental foramen, the distance from the lower margin (DLM) showed that males had a mean DLM of 7.84 ± 1.84 mm, whereas females had 6.51 ± 1.21 mm. The CI for this difference was 0.46 to 2.19, with a p-value of 0.003, indicating statistical significance. For the distance from the upper margin (DUM), males had a mean DUM of 10.21 ± 2.53 mm, and females had 9.42 ± 1.80 mm. The CI ranged from -0.43 to 2.01, with a p-value of 0.200, indicating no significant difference. The angle of the mental foramen showed a significant difference, with males having a mean angle of 55.00 ± 12.50^0 compared to 46.00 ± 8.90^0 in females. The CI ranged from 2.95 to 15.04, and the p-value was 0.004, confirming statistical significance.

Table 1: Comparison of parameters by independent T test in males and females

Parameter		Male	Female	CI at 95%		P-value
		Mean±SD	Mean±SD	Upper	Lower	
Age	Years	32.50±5.43	29.34±4.67	5.98	0.33	0.021*

Table Cont...

Mental Foramen	DUM	10.21±2.53	9.42±1.80	2.01	-0.43	0.200
	DLM	7.84±1.84	6.51±1.21	2.19	0.46	0.003*
	Angle	55.00±12.50	46.00±8.90	15.04	2.95	0.004*
Genial tubercle	DUM	12.34±3.45	10.81±1.45	3.00	0.05	0.042*
	DLM	9.56±1.78	8.72±1.56	01.77	-0.09	0.07

DUM distance from upper margin, DLM distance from lower margin *p<0.05.

For the genial tubercle, the distance from the upper margin (DUM) revealed that males had a mean DUM of 12.34 ± 3.45 mm, while females had 10.81 ± 1.45 mm. The CI ranged from 0.05 to 3.00, with a p-value of 0.042, indicating a statistically significant difference. However, for the distance from the lower margin (DLM), males had a mean DLM of 9.56 ± 1.78 mm, compared to 8.72 ± 1.56 mm for females. The CI ranged from -0.09 to 1.77, and the p-value was 0.070, showing no significant difference.

DISCUSSION

Sex determination plays a crucial role in biological and forensic anthropology, as well as in various fields, such as population genetics, archaeological studies, and forensic inquiries. It involves identifying the biological sex of an individual based on their skeletal remains, with the mandible being a key skeletal element commonly examined because of its sexually dimorphic characteristics and notable preservation in forensic and archaeological settings.[10] The mandible, known as the jawbone, is the largest and most robust facial bone, responsible for providing structural support to the lower face and teeth. The accuracy of sex determination based on bone morphology relies on the reliability of these characteristics, which are relatively unaffected by environmental and genetic factors. Sexual dimorphism, which refers to the morphological distinctions between males and females of the same species, is most evident in the human mandible.[11]

Most studies have used orthopantomograms (OPG) for sex determination of mandibular parameters; however, according to Tassoker *et al.*, significant differences in mandibular morphometric measurements were noticed between OPG and CBCT, and therefore advised CBCT to be used for forensics.[12] Therefore, to increase the accuracy of linear and angular measurements, CBCT was employed in this study. To the best of our knowledge, no study to date has assessed sex differences in mental foramen angle.

The majority of studies have assessed the vertical and horizontal location of the mental foramen on OPG, and concrete data on CBCT measurements are lacking in this area.[2,10] The results of the present study indicated that the distance of the mental foramen from the lower border of the mandible was 10.21 ± 2.53 mm in males and 9.42 ± 1.80 mm in females, indicating that males had longer distance than females. This finding is in agreement with those of previous studies.[3,4,13] The reason for sex differences in the position of the mental foramen could be due to the fact that males exhibit greater and sturdier mandibles than females. Such variations in both the size and structure of the mandible can impact the positioning of the mental foramen, and hormones such as estrogen and testosterone are involved in the process of bone growth and development. Specifically, testosterone has been linked to the formation of more prominent bone structures in males, which could impact the positioning of the mental foramen.

It was also noticed from the results of this study that the vertical position of the mental foramen was more inferior in males than females as the DUM distance was greater than the DLM distance. This could be due to substantial restructuring of the mandible during the growth process. The positioning of the mental foramen undergoes alterations in conjunction with the growth of the mandible, exhibiting variations in growth trajectories between males and females. In general, males tend to undergo more pronounced mandibular growth, resulting in a posterior and inferior shift in the position of the mental foramen.[14]

The results of the present study also indicated that the angle of the mental foramen was greater in males, compared than in females. Because this angle was not measured in any study, it could not be compared. Growth changes due to remodeling and hormonal changes may have led to sexual dimorphism in the mental foramen angle. The masseter muscle, along with other muscles connected to the mandible, is commonly more developed and robust in males than in females. This discrepancy in muscular size and strength between sexes can lead to varying degrees of force applied to the bone structure, which

in turn has the potential to modify the positioning and trajectory of the mental foramen. It has been noted that heightened muscular exertion in males can give rise to a more prominent and enlarged exit angle of the mental foramen, thereby highlighting the intricate interplay between muscular anatomy and skeletal morphology in the human body. The anatomical variations resulting from the differential muscular forces exerted by the masseter and other mandibular muscles in males underscore the complex nature of biomechanical interactions within the craniofacial region.[15]

Similarly, this study revealed that the position of the genial tubercles was also more inferior in males than in females, and the results were statistically significant for the distance of the genial tubercles from the upper border, compared to the lower border. This could be due to differences in the remodeling process of the mandible in males and females, and the muscles connected to the genial tubercles, including the genioglossus and geniohyoid, are typically more extensive and robust in males because of their generally larger muscle mass. This disparity in muscle strength may have significant implications for the growth and alignment of genial tubercles. The enhanced force exerted by these muscles could influence the structural integrity and functional dynamics of the genial tubercles, ultimately shaping the anatomical features and physiological functions associated with this region.[16] Our findings are consistent with those of previous studies.[17, 18]

This study was specifically conducted on the Indian population. Consequently, these findings may not be applicable to other populations. Furthermore, variations in scanners and software applications could impact the outcomes, necessitating consideration when comparing the results with the existing literature. Furthermore, only the vertical positions of the mental foramen and genial tubercles were evaluated. Subsequent research endeavors could explore different populations with increased sample sizes to discern racial and ethnic distinctions via analysis of the mandible with more parameters.

CONCLUSION

Within the confines of the research conducted, the findings led to the determination that a significant degree of sexual dimorphism was observed in the positioning of the mental foramen and genial tubercles among individuals sampled from the Indian population. This finding suggests the presence of distinct anatomical variations based on sex within this specific demographic group.

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