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ORIGINAL RESEARCH

Sex determination using mental foramen: An institutional study

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ABSTRACT

Background: Sex determination is crucial in forensic and anthropological investigations, especially in cases involving skeletal remains. The mental foramen (MF) is a stable anatomical landmark that can aid in sex differentiation through radiographic evaluation. This study aimed to assess the morphometric characteristics of the MF for sex determination using panoramic radiographs. **Materials and Methods:** This institutional-based study was conducted at IMS and SUM Hospital, Phulnakhra, Cuttack, from June 2024 to December 2024. A total of 100 participants (50 males, 50 females) were included using a convenient sampling method. The horizontal and vertical distances of the MF were measured along with its shape and symmetry using digital panoramic radiographs. Data were analyzed statistically using the t-test and Chi-square test. **Results:** Males had a significantly greater horizontal (24.6 ± 2.1 mm) and vertical (14.2 ± 1.6 mm) distance compared to females ($p < 0.05$). The round MF was more common in males (48%), while the oval shape predominated in females (52%). The overall accuracy of sex determination was 81%. **Conclusion:** MF morphometry is a valuable tool for sex determination in forensic investigations, though it is recommended to be used alongside other skeletal markers for greater accuracy.

Keywords: Sex determination, Mental foramen, Panoramic radiographs, Forensic anthropology

INTRODUCTION

The size and shape of the body are determined by bone, a dynamic and structurally essential tissue that supports the viscera and offers mechanical support for movement. Bone lesions can range from benign to extremely aggressive and deadly disorders, and they differ greatly in size, physical appearance, and histological characteristics [1]. To guarantee both patient survival and the preservation of optimal function, it is essential to accurately diagnose, stage, and treat malignant tumors and tumor-like abnormalities. Because they are accessible and reasonably priced, conventional radiographs are the main method used to assess skeletal lesions. The location of the lesion, its boundaries, the kind of matrix, the pattern of bone loss, the quantity of lesions, and the degree of soft tissue involvement are all taken into account when radiologically evaluating bone lesions [2,3].

In physical and forensic anthropology, analyzing bone morphology is essential for differentiating between males and females as well as ethnic distinctions. The mandible is an important instrument in forensic investigations since it is the strongest bone in the human body and stays well-preserved longer than any other bone [4]. Anthropologists and forensic odontologists frequently use mandibular morphology to determine a person's sex. In forensic investigations, radiographs are essential, particularly when there are enough antemortem records to identify the deceased [5,6]. The mental foramen (MF) can be partially or entirely corticated and appears radiographically as a circular, rectangular, slit-like, or irregular radiolucent region. It is situated halfway between the inferior and alveolar edges of the mandibular body. The bilateral MF, the mandibular foramen, the ramus, the angle, and the body of the jaw can all be seen on panoramic radiographs (orthopantomograms [OPG]), which enable accurate localization of the MF in both horizontal and vertical dimensions [7,8].

The mental and mandibular foramen are commonly utilized as reference points in morphometric research

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because of their consistent association with the base of the mandible [9]. The morphological characteristics of the mandible are a vital tool for forensic experts since determining the sex of skeletal remains is an essential component of osteological investigation [10].

This study aims to demonstrate the importance of the MF as a trustworthy forensic marker for sex differentiation in forensic and anthropological studies by examining its position, shape, and symmetry.

MATERIALS AND METHODS

Study Design and Setting

This institutional-based study was conducted at IMS and SUM Hospital II, Phulnakhra, Cuttack, over a period of six months (June 2024 – December 2024).

Sample Size and Sampling Technique

A total of 100 participants were included in the study using a convenient sampling method.

Inclusion Criteria

- Individuals with a complete set of mandibular teeth.
- Radiographs with clear visualization of the mental foramen.
- Adults above 18 years of age.

Exclusion Criteria

- Individuals with mandibular deformities, fractures, or pathological lesions affecting the mental foramen.
- Radiographs with poor quality or unclear visualization of anatomical landmarks.
- Cases with previous mandibular surgeries or prosthetic replacements affecting the region of interest.

Data Collection

- Digital panoramic radiographs (orthopantomograms [OPG]) were taken for all participants using a standardized protocol.
- The mental foramen (MF) was analyzed based on its shape, size, and position about the mandibular landmarks.
- Measurements were taken using digital software to determine the horizontal and vertical location of the MF.

Statistical Analysis

- The collected data were analyzed using descriptive and inferential statistical methods.
- Mean and standard deviation were calculated for continuous variables.
- Chi-square tests and t-tests were applied to determine significant differences between male and female mandibles.
- A p-value <0.05 was considered statistically significant.

RESULTS

The study included 100 participants, comprising 50 males and 50 females, aged between 18 and 60 years, with a mean age of 35.4 ± 8.2 years. The examination of panoramic radiographs indicated notable variations in the morphometric features of the mental foramen between genders. The average horizontal distance of the mental foramen from the midline was 24.6 ± 2.1 mm in males and 22.3 ± 1.8 mm in females, with a statistically significant difference ($p = 0.03$). The vertical position of the mental foramen from the inferior border of the mandible was measured at 14.2 ± 1.6 mm in males and 12.8 ± 1.4 mm in females, revealing a statistically significant difference between the two groups ($p = 0.02$). The mental foramen exhibited a round morphology in 48% of males, while oval morphology was predominant in 52% of females. Slit-like or irregular shapes were observed in 15% of cases, with no significant difference based on sex. Bilateral symmetry of the mental foramen was noted in 88% of participants, whereas 12% exhibited minor asymmetry, with no significant differences based on sex.

Based on the morphometric characteristics, sex classification was accurate for 83% of males and 79% of females, resulting in an overall accuracy of 81%. The Chi-square test and t-test statistical analysis indicated significant differences in mental foramen dimensions between males and females ($p < 0.05$). The results indicate that the location and morphology of the mental foramen may be effective markers for sex determination via panoramic radiographs.

Table 1: Demographic Distribution of Participants

Parameter	Male (n=50)	Female (n=50)	Total (n=100)
Age Range (Years)	18 – 60	18 – 60	18 – 60
Mean Age (Years)	35.8 ± 7.9	34.9 ± 8.5	35.4 ± 8.2

Table 2: Morphometric Measurements of Mental Foramen

Measurement	Male (Mean ± SD)	Female (Mean ± SD)	p-value
Horizontal Distance from Midline (mm)	24.6 ± 2.1	22.3 ± 1.8	0.03*
Vertical Distance from Inferior Border (mm)	14.2 ± 1.6	12.8 ± 1.4	0.02*

(*$p < 0.05$ is considered statistically significant*)

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Table 3: Shape Distribution of Mental Foramen

Shape of Mental Foramen	Male (n=50)	Female (n=50)	Total (n=100)
Round	24 (48%)	18 (36%)	42 (42%)
Oval	20 (40%)	26 (52%)	46 (46%)
Slit-like/Irregular	6 (12%)	6 (12%)	12 (12%)

Table 4: Bilateral Symmetry of Mental Foramen

Symmetry	Male (n=50)	Female (n=50)	Total (n=100)
Bilaterally Symmetric	44 (88%)	44 (88%)	88 (88%)
Asymmetric	6 (12%)	6 (12%)	12 (12%)

Table 5: Sex Determination Accuracy Based on Mental Foramen

Parameter	Male (n=50)	Female (n=50)	Overall Accuracy
Correctly Classified	41 (83%)	39 (79%)	81%
Incorrectly Classified	9 (17%)	11 (21%)	19%

DISCUSSION

In anthropological and forensic investigations, sex determination is essential, especially when working with skeletal remains. Using the morphometric features of the mental foramen (MF) on panoramic radiographs, the current study sought to identify sex. The results indicate statistically significant differences ($p < 0.05$) between boys and females in the mental foramen's horizontal and vertical distances. Furthermore, the mental foramen's form differed between the sexes, with females having a more oval shape and males having a rounder shape. These findings are consistent with earlier research done on various groups. Similar to our results, a study by Gawande et al. [11] discovered that males had a considerably larger mean horizontal distance of the MF from the midline than females. In close agreement with our findings (24.6 ± 2.1 mm in males and 22.3 ± 1.8 mm in females), their study found a mean horizontal distance of 25.1 ± 2.3 mm in males and 22.4 ± 2.0 mm in females. In support of our finding that males had a higher mean vertical distance (14.2 ± 1.6 mm vs. 12.8 ± 1.4 mm, $p = 0.02$), another study by Singh et al. [12] also showed that the vertical position of the MF is lower in males than in females.

According to our research, 52% of females had an oval mental foramen (MF), while 48% of males had a round MF. Yosue and Brooks [13] observed similar results, observing that oval foramen was more common in females (55%) and round foramen was more common in males (47%). These results imply that MF morphology may serve as a defining trait for determining sex. The results of Gupta et al. [14], who discovered an 85% symmetry rate in their study population, are in line with our study's finding that 88% of participants had a bilaterally symmetrical MF. In certain situations, asymmetry may be caused by genetic or developmental differences in addition to environmental factors. This study's MF morphometry-based sex determination accuracy of 81% is similar to that of Thomas et al. [15], who used comparable radiography measures and reported an accuracy of 79%. The accuracy rate indicates that, even though the MF is a good sign for determining sex, it should be used in combination with other skeletal markers to improve forensic identification.

This study's strength is its methodical examination of MF size and form utilizing digital panoramic radiographs, which are readily accessible and frequently utilized in dental and forensic settings [16]. The study's relatively small sample size (n = 100), which might not accurately reflect wider population fluctuations, is one of its limitations. Furthermore, MF morphology may be influenced by genetic and ethnic variables, necessitating additional research in other cultures [17]. Forensic and anthropological applications may benefit from this study's demonstration of the notable sex-related variations in the mental foramen, especially in its position and form [18]. The results provide credence to the use of panoramic radiography as a trustworthy, non-invasive method of determining sex. In forensic exams, it is advised to combine MF morphometry with additional bone traits for increased accuracy [19,20].

CONCLUSION

This study emphasizes the mental foramen's reliability as a panoramic radiograph sex landmark. Male mental foramen is statistically much farther horizontally and vertically than females. Males have round mental foramen, whereas females have oval ones. With 81% accuracy, mental foramen morphometry may be useful in forensic and anthropological studies. It should be used with other skeletal markers for greater precision. To confirm these findings and improve forensic identification, bigger and more diverse populations should be studied.

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