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Radiographic Determination of the Mandibular Foramen Location

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Abstract: The mandibular foramen is an opening located on the medial surface of the mandible through which the inferior alveolar neurovascular bundle enters the mandibular canal. Accurate identification of the mandibular foramen has important diagnostic and therapeutic implications. The position of the mandibular foramen varies among individuals and is influenced by several factors, including age, sex, and anatomical characteristics of the mandible.

This retrospective study included 91 panoramic radiographs obtained between 2023 and 2025 at the Central Dental Hospital, Mongolian National University of Medical Sciences, using an HDX WILL panoramic device (DENTRI, Seoul, Korea). The images were selected according to predefined inclusion and exclusion criteria. Linear measurements were performed using ImageJ software with millimeter precision from the center of the mandibular foramen to anatomical landmarks of the mandibular ramus, including the anterior border, posterior border, mandibular notch, and inferior border of the mandible. This study was conducted with ethical approval (No. 2023/3-08), and statistical analysis was performed using SPSS version 27.0.

The center of the mandibular foramen was located at a mean distance of 18.25 ± 2.89 mm from the posterior border of the mandibular ramus, 23.93 ± 3.36 mm from the anterior border of the mandibular ramus, 24.55 ± 3.63 mm from the deepest point of the mandibular notch, and 40.75 ± 4.55 mm from the inferior border of the mandible. When the relationship between the location of the mandibular foramen and gender was evaluated, the distance from the center of the mandibular foramen to the inferior border of the mandible was 2.34 ± 0.93 mm greater in males than in females, significantly. No significant differences were observed between age groups.

The mandibular foramen is located in the posterior-superior region of the middle third of the mandibular ramus among Mongolian adults.

Keywords: Mandibular nerve; Anesthesia; Orthopantomography

Introduction

The mandibular foramen is an opening located on the medial surface of the mandible through which the inferior alveolar neurovascular bundle enters the mandibular canal. (Zelditch et al., 2026) The inferior alveolar nerve is the largest branch of the third division of the trigeminal nerve and is a mixed nerve located posterior and lateral to the lingual nerve along the internal surface of the lateral

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pterygoid muscle. After entering the mandibular canal through the mandibular foramen, the nerve gives off several branches that form a neural network. (Meuten, J. E. K et al, 2013) The inferior alveolar nerve provides sensory innervation to the mandibular teeth, surrounding mucosa, skin of the chin, and lower lip. (Nguyen JD et al, 2023)

Accurate identification of the mandibular foramen has important diagnostic and therapeutic implications. Proper localization helps prevent injury to the inferior alveolar nerve during clinical procedures such as mandibular anesthesia, tooth extraction, and implant placement. (Hillerup S et al, 2006; Yip Let al, 2001; Cade, T.A, 1992) Injury to this nerve may result in complications including pain, paresthesia, paralysis, and functional disturbances of the oral cavity. (Hillerup S et al, 2006; Haas, L. F et al, 2016) Therefore, precise anatomical knowledge is essential when performing mandibular anesthesia. The position of the mandibular foramen varies among individuals and is influenced by several factors, including age, sex, and anatomical characteristics of the mandible. (Haas, L. F et al, 2016) Consequently, consideration of individual anatomical variations is necessary in clinical practice. Preoperative evaluation using imaging techniques may improve treatment accuracy and safety. (Talib Jiboon, A et al, 2023)

Among the available imaging modalities, panoramic radiography is widely used because it allows comprehensive visualization of the mandible and the inferior alveolar anatomical structures. This technique offers several advantages, including relatively low radiation exposure, simplicity, cost-effectiveness, and broad accessibility. Previous studies have reported that panoramic radiographs provide valuable information for determining the location of the mandibular foramen and assist clinicians in establishing appropriate treatment plans. (Talib Jiboon, A et al, 2023) In addition, the relatively high image resolution of panoramic radiography makes it useful for clinical evaluation and treatment planning. (Angelopoulos C et al, 2004; Kalender A et al., 2012)

The present study aimed to determine the location of the mandibular foramen on panoramic radiographs and to investigate anatomical variations among Mongolian individuals. Due to the limited number of studies conducted in Mongolia on this topic, this research was undertaken to contribute to the existing knowledge.

Materials and Methods

This study was conducted using a retrospective study design using a panoramic radiograph. All panoramic radiographs were taken between 2023 and 2025 were retrieved from the archive of the Department of Oral and Maxillofacial Radiology, Central Dental Hospital, Mongolian National University of Medical Sciences (MNUMS). The all radiographs were obtained using a DENTRI panoramic imaging system (HDX WILL, Seoul, Korea).

A total of 91 radiographs were selected using a target sampling method according to inclusion and exclusion criteria. Inclusion criteria included individuals aged 19 years or older, with no evidence of mandibular trauma or deformity, and panoramic radiographs demonstrating adequate image clarity and resolution, clearly visible anatomical structures required for measurement, proper focal distance and patient positioning, and well-defined mandibular cortical outlines. Exclusion criteria included panoramic radiographs with poor image quality or unclear density, images obtained with incorrect patient positioning, foreign patients, and radiographs showing pathological lesions in the mandibular angle or mandibular ramus.

The individual's age of the radiographs was divided into five groups: 19–29, 30–39, 40–49, 50–59, and more the 60 years old. Each age group was planned to include 20 subjects10; males and 10 females.

For each radiograph, the location of the mandibular foramen (Figure 1) was measured using ImageJ software, and linear measurements were obtained with a digital caliper with millimeter precision. To eliminate operator error, the three examiners performing panoramic radiographs measured in 20 randomly selected cases, all measurements were made twice to assess intra-rater reliability, two week intervals using Cronbach's alpha ($\alpha = 0.98$). This study was conducted with the approval of the Research Ethics Committee of MNUMS (Approval No. 2023/3-08). Statistical analysis was performed using SPSS version 27.0.

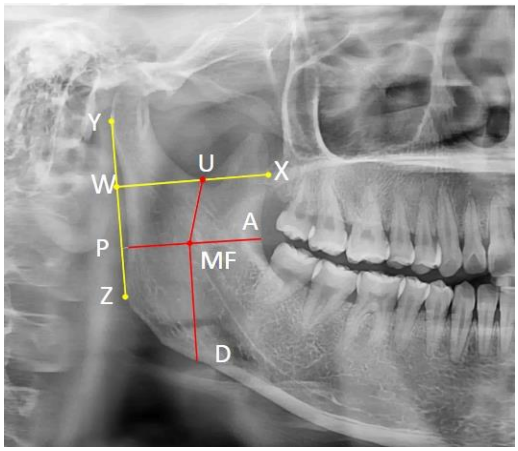

Figure 1. **Measurement landmarks** Linear measurements were taken from the center of the mandibular foramen to the borders of the mandibular ramus as follows: **YZ line**: a line connecting the most

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prominent posterior points of the mandibular ramus. **WX line**: a perpendicular line drawn from the YZ line passing through the deepest point of the mandibular notch. The following measurements were recorded: **P-MF**: distance from the center of the mandibular foramen to the posterior border of the mandibular ramus, measured perpendicular to the YZ line. **A-MF**: distance from the center of the mandibular foramen to the anterior border of the mandibular ramus, measured perpendicular to the WX line. **U-MF**: distance from the center of the mandibular foramen to the deepest point of the mandibular notch (superior border). **D-MF**: distance from the center of the mandibular foramen to the inferior border of the mandible, measured parallel to the YZ line.

Results

The mean distances of the center of mandibular foramen were 18.25 ± 2.89 mm from the posterior border of the mandibular ramus (P), 23.93 ± 3.36 mm from the anterior border of the mandibular ramus (A), 24.55 ± 3.63 mm from the deepest point of the mandibular notch (U), and 40.75 ± 4.55 mm from the inferior border of the mandible (D), significantly ($p < 0.001$).

When the location of the mandibular foramen was compared between genders, the D measurement (distance from the mandibular foramen to the inferior border of the mandible) was 2.34 mm greater in males than in females, which was statistically significant ($p < 0.001$) (Table 1, Figure 2).

Table 1. The comparison of mandibular foramen location according to sex

		N	Mean	SD	SE	p-value
P	male	44	18.58	3.07	0.46	NS
	female	47	17.93	2.70	0.39	
A	male	44	24.50	2.99	0.45	NS
	female	47	23.39	3.61	0.52	
U	male	44	25.10	3.58	0.54	NS
	female	47	24.02	3.63	0.53	
D	male	44	41.95	4.68	0.70	p<0.01
	female	47	39.61	4.15	0.60	

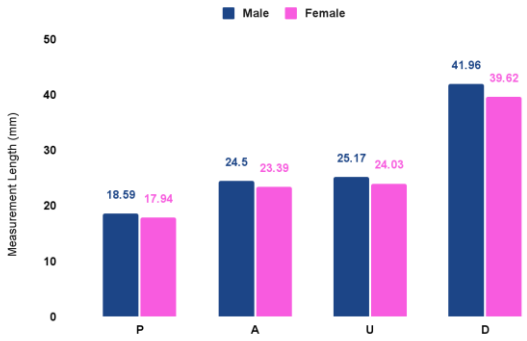

Figure 2. The comparison of location of mandibular foramen by gender.

Further analysis evaluating the relationship between the four measurements and age demonstrated that the D measurement showed a weak but statistically significant correlation with age ($p < 0.001$) (Table 2).

Table 2. The results of the regression analysis between mandibular foramen location and age

	Standardized β coefficient	T-value	p-value
P	0.200	1.927	0.057
A	0.064	0.605	0.547
U	-0.089	-0.844	0.401
D	0.341	3.423	0.001*

Discussion

In the present study, 91 panoramic radiographs were selected according to predefined inclusion criteria to determine the location of the mandibular foramen among Mongolians. The findings of this study contribute to the understanding of the anatomical position of the mandibular foramen in relation to surrounding mandibular landmarks.

A study conducted at King Saud University in Saudi Arabia reported that 85.7% of dental interns had experienced at least one unsuccessful mandibular anesthesia, which was attributed to anatomical variations. (Kanaa MD et al, 2006) This finding highlights the clinical importance of accurately identifying the location

of the mandibular foramen using radiographic imaging. Our study results were shown that the mandibular foramen was located in the posterior–superior region of the middle third of the mandibular ramus, which is consistent with the results of a study conducted in India in 2019. (Satyapal Johaley et al, 2019) Although, Haaz et al reported that the position of the mandibular foramen changes with increasing age in panoramic radiographic analysis (Haas, L. F et al, 2016), this study did not demonstrate a statistically significant age-related change in the location of the mandibular foramen. This discrepancy may be attributed to differences in population characteristics or study methodology.

Furthermore, the distance from the mandibular foramen to the inferior border of the mandible showed a statistically significant difference between males and females in this study. This finding is consistent with a computed tomography (CT) based study conducted in Cameroon in 2021, which also reported sexual dimorphism in the position of the mandibular foramen (Table 3). (Eboga M et al, 2021)

However, the absolute measurement values differed from those reported in the previous study. These differences may be related to ethnic variations in craniofacial morphology or to differences between CT-based and panoramic radiographic measurements. Future studies using cone-beam computed tomography (CBCT) are recommended to these variations with higher imaging accuracy.

Conclusion: The mandibular foramen was positioned in the posterior–superior region of the middle third of the mandibular ramus and there was a significantly difference between gender and no difference between age groups.

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Author's Contributions

N.M.: Conceptualization and study design, methodology, data collection, writing - original draft preparation, M.U., A.E.: Investigation, data curation, formal analysis, O.R: Investigation, data curation, formal analysis and validation, D.J.: Conceptualization and study design, writing - review and editing, supervision.

Conflict of Interest Statement

The authors declare that they have no conflicts of interest to disclose.

Data Availability Statement

The datasets generated and analyzed during the current study are not publicly available due to institutional and national regulations on patient data protection but are available from the corresponding author on reasonable request.

Ethics

This study received ethics approval from the Mongolian National University of Medical Sciences in Ulaanbaatar, Mongolia (Approval No. 2023/3-08).

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