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Original Article

Location and Shape of Mental Foramen in Patients Reporting to Saidu College of Dentistry- A Cone Beam Computed Tomography Based Study

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Abstract

Background: The mental foramen (MF) is a critical anatomical landmark in dentistry and maxillofacial surgery due to its role in transmitting the mental nerve, which provides sensory innervation to the lower lip, chin, and adjacent structures. Precise identification of its location and morphology is essential for procedures such as implant placement, nerve block anesthesia, and surgical interventions.

Objective: To determine the location and shape of mental foramen in patients reporting to Saidu College of Dentistry- A Cone Beam Computed Tomography Based Study.

Methodology: This cross-sectional study was conducted at the Radiology Department of Saidu College of Dentistry, Swat, from May to September 2024. A total of 164 CBCT scans (83 males, 81 females) were analyzed. The horizontal and vertical diameters of MF were measured, and its morphology was classified according to the horizontal-to-vertical (H:V) ratio. Horizontal and vertical positions of the MF were recorded relative to adjacent teeth and premolar apices. Data were analyzed using SPSS version 20, applying Mann-Whitney U, Kruskal-Wallis, and Fisher's exact tests with a significance level of $p < 0.05$.

Results: The mean horizontal and vertical diameters of MF were 2.57 ± 0.57 mm and 2.94 ± 0.83 mm, respectively, with an average H:V ratio of 0.90 ± 0.23. Significant age-related differences were observed in horizontal diameters ($p < 0.001$) and H:V ratio on the left side ($p = 0.014$). Males demonstrated significantly greater vertical diameters ($p = 0.026$) and H:V ratios ($p < 0.001$) compared to females. Type II (oval-vertical) was the least frequent MF morphology, while Type I (oval-horizontal) and Type III (round) were more common. The MF was most often located horizontally between the first and second premolars and vertically below the apices of mandibular premolars.

Conclusion: CBCT imaging revealed significant variations in MF morphology based on age and gender in patient reporting to SCD, while positional patterns remained largely consistent. These findings highlight the importance of preoperative CBCT assessment to avoid neurosensory complications during dental and surgical procedures.

Keywords: Anatomical variation, Cone-beam computed tomography, Dental implantology, Mental foramen, Pakistani population.

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Introduction

The mental foramen (MF) is a small bilateral opening located in the buccal cortical plate of the mandible, most commonly between the first and second premolars or near the apex of the second premolar [1]. It transmits the mental nerve, a terminal branch of the inferior alveolar nerve, which provides sensory innervation to the lower lip, chin, and adjacent tissues [2]. Due to its clinical significance, precise knowledge of the MF's location, size, and morphology is essential to avoid iatrogenic injury during surgical and restorative dental procedures, such as implant placement, periapical surgery, and local anesthesia administration [3,4].

The anatomical variation of MF poses a challenge in clinical practice, as its location and morphology may differ with age, gender, and ethnicity [5]. Improper localization can result in neurosensory disturbances of the lower lip and chin, significantly affecting patient outcomes. Advanced imaging techniques, particularly cone-beam computed tomography (CBCT), provide high-resolution three-dimensional views of the MF, offering superior diagnostic accuracy compared to traditional two-dimensional radiographs [6]. Panoramic radiography, commonly used in earlier studies, is limited by magnification errors, distortion, and superimposition of structures, thereby reducing accuracy [7].

Studies conducted in Pakistan and other regions have reported conflicting findings regarding MF location. For example, one study in a Pakistani population found the MF below the apex of the second premolar in 56.44% of cases, while others reported gender-specific variations [8]. However, several studies failed to demonstrate significant gender-related differences [9]. Moreover, most previous local studies have focused on two-dimensional imaging, leaving a gap in knowledge regarding CBCT-based analysis [10].

Given the inconsistencies in existing literature and the limited use of advanced imaging in Pakistani populations, this study aims to assess the location, shape, and dimensions of the MF using CBCT. By filling this gap, the study contributes to developing accurate anatomical guidelines for dental implantology and other oral surgical procedures requiring precise nerve localization.

Methodology

Study Design:

This was a cross-sectional observational study designed to assess the location and shape of the mental foramen (MF) using cone-beam computed tomography (CBCT) in a Pakistani population. The study was conducted between May 2024 and September 2024, focusing on patients undergoing CBCT scans for diagnostic and treatment planning purposes.

Ethics:

The study protocol (No: 85-ERB\027) was reviewed and approved by the Bioethics Committee of Saidu Medical College, Swat. Written informed consent was obtained from all patients and radiologists participating in the study prior to data collection, ensuring confidentiality and ethical compliance in accordance with the Declaration of Helsinki.

Setting:

The research was carried out at the Radiology Department of Saidu College of Dentistry, Saidu Sharif, Swat, Pakistan. The CBCT scans were acquired using AXEOS (Dentsply Sirona, Germany), a high-resolution imaging unit capable of small anatomical landmark assessment.

Participants:

A total of 164 patients above 18 years of age, comprising 83 males and 81 females, were included through non-probability consecutive sampling. Patients were stratified into three age groups: 20–45 years, 46–60 years, and >60 years. Inclusion criteria consisted of individuals with permanent dentition from canine to first molar, undergoing CBCT during routine dental care, and having a clearly visible MF. Patients were excluded if their CBCT images showed large pathological lesions, mandibular fractures, poor-quality scans, or image artifacts caused by implants, osteosynthesis plates, or patient movement.

Variables:

The primary outcome variables included the horizontal and vertical diameters of the MF, its shape based on the horizontal-to-vertical (H:V) ratio, and its location relative to adjacent mandibular teeth and premolar apices. Demographic variables such as age and gender were considered as independent factors for subgroup analysis.

Data sources/measurement:

CBCT scans were performed with standardized imaging parameters: 90 kVp, 12 mA, voxel size of 0.04 mm, and exposure time of 14 seconds. The images were analyzed using SIDEXIS 4 (Dentsply Sirona) software. Horizontal and vertical diameters were measured twice, and the mean values were taken for analysis. Morphological classification of MF was based on Ngeow and Yuzawati's H:V ratio method, categorizing into Type I (oval-horizontal, H:V > 1.24), Type II (oval-vertical, H:V < 0.76), and Type III (round,

0.76 ≤ H:V ≤ 1.24). Horizontal and vertical positions of MF were categorized into established anatomical groups for standardization.

Bias:

To minimize observer bias, all CBCT images were independently reviewed and measured twice, with mean values used for analysis. Patients were consecutively recruited to reduce selection bias. However, the use of a single-center sampling method may have introduced limited representativeness across ethnic groups.

Study size:

The sample size of 164 was determined using the OpenEpi sample size calculator at a 95% confidence interval and 3% margin of error, based on a previously reported 3.98% frequency of MF located between the second premolar and first molar in patients reporting to SCD.

Quantitative variables:

Quantitative variables included the horizontal and vertical diameters of MF, expressed in millimeters, and the H:V ratio for morphological categorization. Categorical variables included the MF's horizontal and vertical locations relative to dentition, as well as its morphological type.

Statistical methods:

Data were initially entered into Microsoft Excel and analyzed using SPSS version 20. Descriptive statistics were calculated as means, medians, interquartile ranges (IQR), and percentages where appropriate. The normality of data distribution was assessed prior to inferential analysis. Mann-Whitney U test was applied to assess differences between genders, while the Kruskal-Wallis test was used to examine age group differences in MF diameters. Fisher's exact test was employed to evaluate associations between MF type and demographic variables. A p-value < 0.05 was considered statistically significant.



Figure 1: Location of Mental Foramen



Figure 2: Horizontal size of MF in axial section

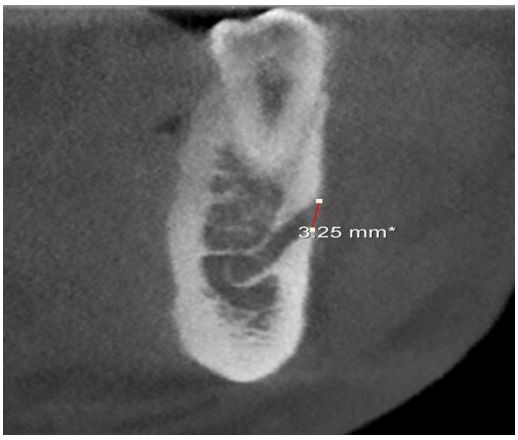


Figure 3: Vertical size of MF in cross sectional image

Results

Participants

A total of 164 patients were included in the study, comprising 83 males (50.6%) and 81 females (49.4%). The participants were stratified into three age groups: 20–45 years (n = 59), 46–60 years (n = 62), and above 60 years (n = 43). The mean age of the study sample was 50.65 ± 16.37 years, representing a wide age distribution across adulthood.

Descriptive data:

Overall, the CBCT scans demonstrated consistent visibility of the mental foramen (MF) on both sides of the mandible. The mean horizontal diameter measured 2.57 ± 0.57 mm, whereas the mean vertical diameter was 2.94 ± 0.83 mm, resulting in an average H:V ratio of 0.90 ± 0.23. Males tended to show larger vertical diameters compared to females, while horizontal diameters were generally similar across genders. Age-related variations were evident, with older participants exhibiting narrower horizontal diameters and altered H:V ratios.

Outcome data:

Comparative analysis revealed no significant difference between genders in terms of horizontal diameters on either side ($p = 0.084$, $p = 0.238$) or in the gender- and age-independent distribution of MF types ($p > 0.05$). However, males had significantly greater vertical diameters on the left side ($p = 0.026$) and higher H:V ratios ($p < 0.001$), indicating a gender-specific morphometric difference. With respect to age, the horizontal diameter varied significantly across groups ($p < 0.001$), and the H:V ratio on the left side also showed a significant association with age ($p = 0.014$).

Main results:

Type II MF (oval-vertical) was the least frequent morphological type in both genders and across all age groups, while Type I (oval-horizontal) and Type III (round) were more common. Horizontally, the MF was most frequently located between the first and second premolars, followed by beneath the second premolar root. Vertically, the most common location was below the apices of the premolar roots. No significant differences were observed in MF position between males and females on either side ($p > 0.05$). These findings indicate that although MF size and shape vary with age and gender, its position relative to dentition remains largely consistent across the studied in patients reporting to SCD.

Table 1: Demographic characteristics of the study group.

Age of patients (years)	Gender				Total N
	Male		Female		
	N	%	N	%	
20-45	30	36.14%	29	35.80%	59
46-60	28	33.73%	34	41.98%	62
>60	25	30.12%	18	22.22%	43
Total	83	100	81	100	164

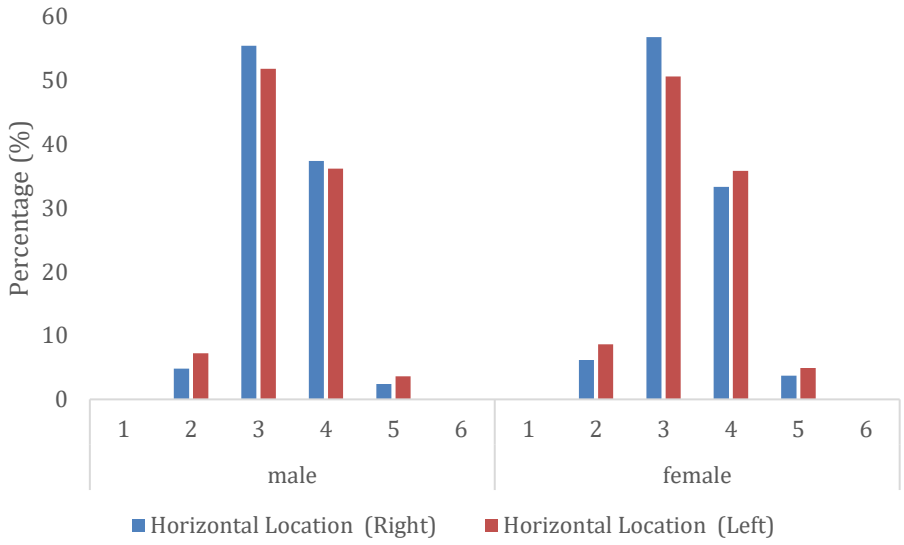
Table 2: Comparative measurements of mental foramen size in different age groups and genders.

Variables	Categories	Right side			Left side		
		Horizontal diameter (mm) Median (IQR) (min-max)	Vertical diameter (mm) Median (IQR) (min-max)	H:V ratio Median (IQR)	Horizontal diameter (mm) Median (IQR) (min-max)	Vertical diameter (mm) Median (IQR) (min-max)	H:V ratio Median (IQR)
Age (years)	**20-45**	4.23 (1.14) (2.52-6.32)	3.22 (1.5) (1.68-6.37)	1.39 (0.7)	4.23 (1.1) (2.31-6.11)	3.21 (1.26) (1.67-5.34)	1.39 (0.7)
	46-60	2.88 (1.2) (1.75-5.89)	2.94 (1.1) (6.78-1.65)	1.67 (0.6)	2.72 (1.2) (1.05-5.22)	2.99 (1.1) (1.24-6.22)	0.95 (0.6)
	>60	4.21 (1.0) (2.34-7.84)	2.88 (1.6) (1.24-5.99)	1.09 (0.6)	3.56 (0.9) (2.17-6.43)	1.06 (0.5) (2.03-6.03)	1.06 (0.5)
	p – value	< .001	.050	.095	< .001	.058	.014
Gender	**Male**	3.78 (1.5) (1.97-7.84)	3.22 (1.8) (1.24-6.78)	1.09 (0.9)	3.55 (1.8) (1.05-6.43)	3.22 (1.7) (1.24-6.22)	1.06 (0.7)
	Female	3.74 (1.1) (1.75-5.89)	3.22 (1.2) (1.24-6.37	1.16 (0.6)	3.68 ± 1.0 (1.57-5.67)	3.11 (1.0) (1.67-6.03	1.27 (0.6)
	p - value	.084	.074	< .001	.238	.026	.056

Where, SD: standard deviation; p values < 0.05 are indicated in bold.

Table 3: Comparison of mental foramen types in different age groups and genders.

Variables	Categories	MF type- right side			MF type- left side		
		I N (%)	II N (%)	III N (%)	I N (%)	II N (%)	III N (%)
Age (years)	20-45	41 (69.49)	2 (3.39)	16 (27.12)	37 (62.71)	2 (3.39)	20 (33.90)
	46-60	34 (54.84)	3 (4.84)	25 (40.32)	31 (50)	2 (3.23)	29 (46.77)
	>60	24 (55.81)	1 (2.33)	18 (41.86)	26 (60.47)	1 (2.33)	16 (37.21)
	p - value		.492			.994	
Gender	Male	52 (62.65)	4 (4.82)	27 (32.53)	44 (53.01)	3 (3.61)	36 (43.37)
	Female	47 (58.02)	2 (2.47)	32 (39.51)	50 (61.73)	2 (2.47)	29 (35.80)
	p - value		.517			.519	



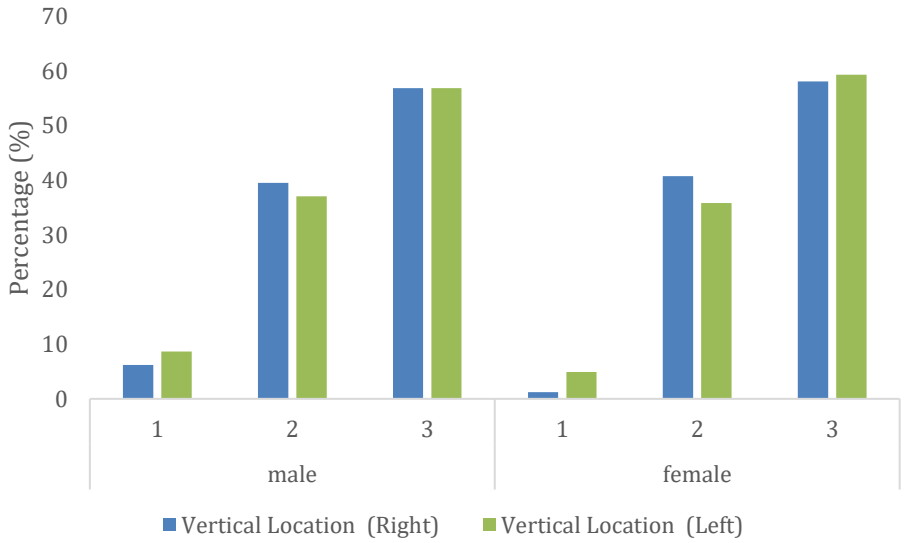


Figure 4(a&b): Comparison of horizontal and vertical location of mental foramen based on gender

Discussion

This study investigated the morphometric parameters and positional variations of the mental foramen (MF) in patients reporting in SCD using cone-beam computed tomography (CBCT). The mean horizontal MF diameter was found to be 2.57 ± 0.57 mm, the vertical diameter was 2.94 ± 0.83 mm, and the H:V ratio was 0.90 ± 0.23. The most frequent horizontal position was between the first and second premolars (Type IV, 56.5%), followed by the second premolar position (Type V, 25.9%). Vertically, the MF was most commonly located below the apices of the mandibular premolars (Type II, 68.5%), whereas placement at the apices (Type III, 10.2%) was least common.

The significantly smaller horizontal diameter and H:V ratio observed in younger subjects ($p = 0.012$ and $p = 0.009$, respectively) indicate a more vertically elongated MF in this group. This morphology may present clinical challenges in surgical procedures such as implant placement or nerve block anesthesia, as the foramen may be located more inferiorly relative to osseous landmarks. Gender-specific differences were also notable, with males exhibiting larger vertical diameters ($p = 0.026$) and higher H:V ratios ($p = 0.018$), suggesting that the MF tends toward a more oval-horizontal or rounded configuration in males. These findings align with the recognized sexual dimorphism of mandibular structures and emphasize the importance of gender-specific planning in oral and maxillofacial surgery to minimize neurovascular injury risks.

The predominance of Type II positioning (below apices) in this study underscores the importance of pre-surgical imaging, as the MF may be positioned closer to the lower cortical margin in dentate subjects, increasing the risk of intraoperative complications. Our findings both support and diverge from earlier literature. For example, one study in a similar target population reported the horizontal position between the first and second premolars (62.4%) and vertical position below the apices (65.1%) as predominant [11], results comparable to ours (56.5% and 68.5%, respectively). However, their mean MF diameters (horizontal 2.81 mm, vertical 3.12 mm) were slightly larger, which may reflect differences in sample composition or observer methodology.

Consistent with our findings, studies in Middle Eastern populations reported significantly larger MF dimensions in males, with mean vertical diameters of 3.15 mm compared to 2.74 mm in females, reinforcing gender-based variation. Their reported H:V index for males (1.02) was higher than that of our male subgroup (0.95 ± 0.21), suggesting more horizontal elongation in that cohort [12]. Another study highlighted age-related variations, reporting smaller MF dimensions in younger patients [13], supporting our observation of reduced diameters in this group.

Contrasting results were reported in an Indian population, where Type I (above apices) was the most frequent vertical position (54.2%) [14], whereas a Turkish cohort demonstrated a higher prevalence of Type III (at apices) positioning [15]. Conversely, a Pakistani study observed MF between premolars in 55% of cases and below the apices in 66% [16], figures closely aligned with our results (56.5% and 68.5%). Studies in Korean elderly populations reported smaller MF diameters (horizontal 2.34 ± 0.59 mm, vertical 2.70 ± 0.61 mm) [17], which may be attributed to age-related alveolar bone remodeling and reduction in MF size. Similarly, an Indian dry mandible study documented mean diameters of 2.58 mm (horizontal) and 2.85 mm (vertical), values nearly identical to our findings [18]. Another Pakistani subpopulation study also noted Type IV (between premolars) as the predominant horizontal position (53.4%) [19], consistent with our 56.5%. A systematic review further confirmed wide population variability, reporting Type IV prevalence between 41–62% and Type V between 28–36%, with Type II most common vertically [20]. Our frequencies (56.5% for Type IV and 25.9% for Type V; 68.5% for Type II) fall well within these ranges. In contrast, studies in Saudi populations reported that MF more frequently occupied Types I and III in edentulous patients [21]. Our findings in dentate individuals support this observation, highlighting that tooth loss may displace the MF upwards due to alveolar ridge resorption.

Limitations

This study provides valuable morphometric and positional data on the MF in patients reporting to SCD, with clinical implications for surgical planning and anesthesia safety. However, certain limitations must be acknowledged. The sample size, while adequate for statistical analysis, may not represent the full diversity of Pakistan's ethnic groups and geographic regions. Additionally, confounders such as oral health status, bone density, or systemic conditions were not considered, which could influence MF morphology. Future research using larger, multi-ethnic samples and high-resolution imaging is recommended to validate and expand these findings.

Conclusion

This study provides clinically relevant morphometric and positional data of the MF in patients reporting to SCD based on CBCT imaging. The mean horizontal and vertical

diameters were 2.57 ± 0.57 mm and 2.94 ± 0.83 mm, respectively, with significant differences across age and gender. The MF was most frequently located horizontally between the first and second premolars (56.5%) and vertically below the premolar apices (68.5%). These findings emphasize the importance of population-specific imaging in pre-surgical assessment to minimize neurovascular complications and support safe, precise surgical interventions.

Authors' Contributions

All authors meet the ICMJE criteria for authorship. They have reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Author 1: Substantial contribution to conception and design, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 2: Substantial contribution to conception and design, data acquisition, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 3: Analysis and interpretation of data, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 4: Analysis and interpretation of data, critical revision, final approval, agreed to be accountable for all the work.
Author 5: Substantial contribution to conception and design, drafting the manuscript, final approval, agreed to be accountable for all the work.
Author 6: Substantial contribution to conception and design, data acquisition, drafting the manuscript, final approval, agreed to be accountable for all the work.

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