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Radiographic Analysis of the Location and Bilateral Symmetry of the Mental Foramen on Digital Panorax

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Abstract

Introduction: The mental foramen (MF) is situated at the end of the inferior alveolar canal on the mandible's lateral surface and plays a crucial role in all dental procedures, including orthodontics. This research evaluate the digital panoramic based assessment of the locale and bilateral symmetry of mental foramina.

Methodology: The study is a cross-sectional descriptive analysis utilizing hospital records from March 1, 2022, to January 29, 2024, at a Dental Hospital in Rawalpindi, Pakistan. Panoramic radiographs were collected from patients aged 18 to 60 who visited the Dental OPD for their dental concerns. The mental foramen was examined bilaterally, noting its location and symmetry in relation to the patient's age and gender. The locale was assessed by aligning horizontal planes with the long axes of the bicuspids and a vertical plane extending from the apex of the 1st to the 2nd bicuspid. To locate the precise position of the foramen two horizontal reference planes were drawn along the axis between the 2nd premolar and the mesial root of the 1st molar. In cases where the mental foramen was notably large or situated within the region spanning both premolars and molars, the side demonstrating greater radiolucency was systematically evaluated for further analysis.

Results: This study's results show that on the right side, the most common horizontal position is between bicuspids (43.5%) and below the second premolar on the left side (37.1%) in both males and females, respectively. The vertical position is primarily inferior to the a premolar`s apical area, with 62.5% possessing a bilateral symmetrical vertical position.

Conclusion: In both males and females, the mental foramen is most commonly located between the apices of the first and second premolars on the right side, and inferior to the second premolar on the left side

Keywords: Mental nerve, Panoramic radiograph, Mandible, Orthodontics, Mandibular Foramina

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Introduction

The mental foramen is situated at the end of the inferior alveolar canal, placed on mandible's outer surface. It is typically found between the bicuspids or > 2mm apical to the apex of the mandibular 2nd premolar.[1] This foramen provides a pathway for the mental nerve, a branch of the inferior alveolar nerve, as well as the mental artery and vein.[2] These structures provide vascular and neural supply to the front of the chin, the corners of the mouth, the lower lip, the oral mucosa, and the buccal gingiva associated with the lower anterior and bicuspids on that side.[3]

According to the findings of D. Nanayakkara, the MF exhibits an average vertical dimension (R=2.38 ±0.41 mm; L= 2.41 ±0.46 mm). The

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transverse width measures (R=3.19±0.72 mm; L=3.10±0.65 mm). Additionally, the distance from the mental foramen to the midline of the mandible is recorded (R=25.65±1.75 mm; L=25.50±1.57 mm). The foramen's placement relative to the posterior border of the mandibular ramus is reported at (R=65.01±5.05 mm; L= 64.58±4.38 mm). Regarding its spatial orientation to the alveolar margin, the estimated measurements range from (R=13.23 ±2.69 mm; L=13.47 ±3.06 mm). Similarly, the distance to the inferior border of the mandible is noted as (R=13.34±1.79 mm; L=12.89±1.56 mm) on the left. These anatomical dimensions provide essential reference points for clinical and radiographic assessment.[4]

The MF locale changes throughout the life. In children before dental eruption, it is situated close to the alveolar margin. It shifts downward with advancing age, and lies midway between the superior and inferior mandibular border In adults, the foramen generally remains relatively close to the mandible's lower margin when teeth are present. With aging and subsequent tooth loss, the foramen shifts back toward the alveolar margin due to mandibular resorption.[5] Care must be exercised when performing a mental nerve block on an edentulous patient with significant bone loss, as the mental nerve may lie beneath the gums.

Numerous studies confirm a bilateral existence of the mental foramen, while cases of unilateral and bilateral absence have also been noted.[6,7] Congenital agenesis of the mental foramen though uncommon, do exists. Reports have indicated ineffective mental nerve blocks and neural sensory disturbances in the supplied region, while others note no sensory interruptions, possibly due to compensatory input from adjacent nerve fibers. In such instances, the mental nerve block may be enhanced with local infiltration anesthesia and mandibular block.[7]

Accurate localization is essential for administering regional anesthesia, managing mandibular fractures, diagnosing periapical lesions in the premolar area, performing endodontic procedures, executing periapical surgery, conducting pre-prosthetic interventions and placing orthodontic implants. Modern advancements have increased the necessity for invasive surgeries in the mental region focused on osteotomy preparation and implant placement, with a notable rise in the prevalence of orthognathic surgeries, raising the risk of damaging the mental nerve and its blood vessels. The mental foramen can also contribute to the missed diagnosis of radiographic lucent lesions located in the periapical region of mandibular bicuspid teeth. Its precise point is crucial for diagnostic evaluation and clinical intervention, including administering mental nerve blocks for inferior lip and chin injuries, extracting foreign objects, debriding lacerations, and providing analgesia for dental issues.[8-10]

Mental foramen location may vary radiographically based upon ethnicity and age, and even within a single individual, positions can differ on each side. It is most often found between both mandibular bicuspids; however, due to variability, researchers have classified its positions (Table I)

Position 1	Located anterior to mandibular first bicuspid tooth
Position 2	In relation to the long axis of mandibular first bicuspid
Position 3	In between the apices of mandibular first and second bicuspid
Position 4	In relation to the long axis of mandibular second bicuspid
Position 5	In between the apices of mandibular second bicuspid and first molar
Position 6	Aligned with the long axis of the mesial root of mandibular first molar

Table I: Classification of Mental Foramen Position[11]

The rationale for this research arises from the pivotal position of the MF in dental procedures, especially in orthodontics, the

administration of nerve blocks, and implant planning. Accurate determination of its location is crucial for preventing neurovascular complications in clinical and surgical procedures. Anatomical variations in the MF locale is, determined by age, gender, and hereditary factors, necessitate further studies to enable accurate localization in heterogeneous groups.

This research will fill the knowledge gap by assessing the digital panorax based location and symmetry of the MF. Through a systematic examination of its location over a wide age spectrum (18–60 years) and accounting for gender- related differences, the results will provide a more detailed insight into the anatomy of the mental foramen. This will increase diagnostic accuracy and enhance treatment outcomes, particularly in orthodontics and oral surgery. The study' s emphasis on a Pakistani population will also yield region- specific information, which is essential for customizing clinical methodologies to local anatomical patterns.

Methodology

This research, which was approved by the Ethical Research Committee (ERC) of the Foundation University College of Dentistry & Hospital, Pakistan, on February 28, 2022, was done in the Oral Radiology Department at FUCD&H, Rawalpindi, from March 1, 2022, to January 29, 2024. Panoramic radiographs were obtained from patients between the ages of 18 and 60 years who attended the Oral Medicine OPD for dental treatment. The radiographs were taken with the FONA Art Plus C (tube voltage: 61–85 kV; tube current: 4–10 mA; exposure time: 8–14.2 sec; focal spot: 0.5 IEC 60336) according to the manufacturer's instructions and by a skilled radiology technician. WHO sample size calculator was used to calculate the sample size, which gave 246 images at a 95% confidence level and 50% proportion size.

To maintain consistency, all the radiographs were read by one investigator with standard radiographic settings, and the radiographic brightness, opacity levels, and image magnification were refined for better clarity. The evaluator was previously prepared and skilled in the form of hands-on exercises with x-rays that were not part of the study sample. The inclusion criteria called for panoramic radiographs of patients who were between 18 and 60 years, precisely with fully erupted lower premolars and molars, and radiographs with clearly defined bilaterally distinguishable mental foramina. On the other hand, the exclusion criteria excluded poor-quality radiographs, radiographs with pathological lesions, and missing or with unerupted permanent lower teeth (36–46). Moreover, cases with supernumerary teeth in the lower arch, lack of canines (which could affect mesial premolar positions), or unclear mental foramina were excluded. Radiographs of lower teeth with wide caries, restorations, or endodontic procedures were excluded because of potential periapical radiolucency. In addition, mixed dentition cases, patients receiving or having received orthodontic treatment, and cases of crowding or spacing in the lower arch were also excluded from the study Radiographs were processed with the OrisWin DG Suite software of FONA ART PLUS C (Assago, Italy) to identify the horizontal and vertical position of the mental foramen.

Horizontal planes were outlined along the long axes of the 1st and 2nd bicuspids if they were positioned close, between, or opposite the apices of the 1st and 2nd bicuspids, and a vertical plane was identified from the first to second bicuspid’s apex. When positioned between or along the axis of the 2nd bicuspid and mesial root of the 1st molar, two horizontal planes gets positioned along their longitudinal axes, and a vertical plane was sketched between their apices to identify the foramen's exact position. When the mental foramen was enlarged or wedged between teeth, the radiolucent side was chosen for examination. According to the classification

technique of Yosue and Brooks, if there were more than one MF, then the upper most foramina closest to the mental nerve canal were taken as the primary radiographic mental foramen, leaving room for possibility of secondary or tertiary foramina.[12]

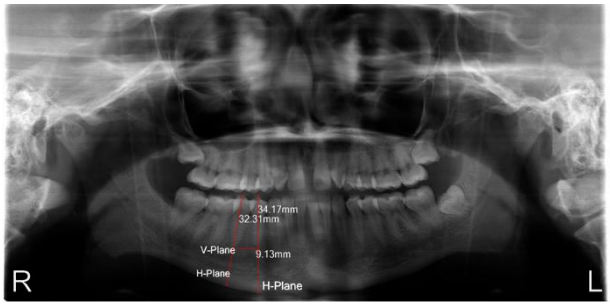

Fig:1 The Horizontal position of the mental foramen was determined through six different classes.

It was noted to be:
(1) anterior to the mandibular first bicuspid, (2) on long axis of the mandibular1st bicuspid, (3) between the apices of mandibular 1st and 2nd bicuspid, (4) on long axis of mandibular 2nd bicuspid, (5) between the apices of mandibular 2nd bicuspid and 1st molar, or (6) in line with the long axis of mesial root of mandibular 1st molar. In the same manner, the vertical location of mental foramen was classified into three categories: (1) above the vertical plane level, (2) at the vertical plane level, or (3) below the vertical plane level. The frequency counts and percentage distribution of these variables were computed. For determining the statistical significance, data were analyzed using the Chi-square test through IBM SPSS V 21.0.[13]

Result

This study included 1100 radiographs from participants aged 18 to 60 years, with a mean age of 30.99. Sample size was calculated through calculator Raosoft® Amongst these, 288 (26.2%) were males and 812 (73.8%) were females. 478 exhibited position 3 as the most frequent position on the right side, accounting for 43.5%. Position 4 was the predominant position on the left side, appearing in 408 radiographs with a frequency of 37.1%, followed by position 3 at 34.7%. Position 1 was the least common (right side = 8, left side = 6), with frequencies of 0.7% and 0.5%, respectively. There were 660 cases (60.0%) with symmetrical horizontal positions and 440 cases (40.0%) with asymmetrical horizontal positions. (Fig. I & II)

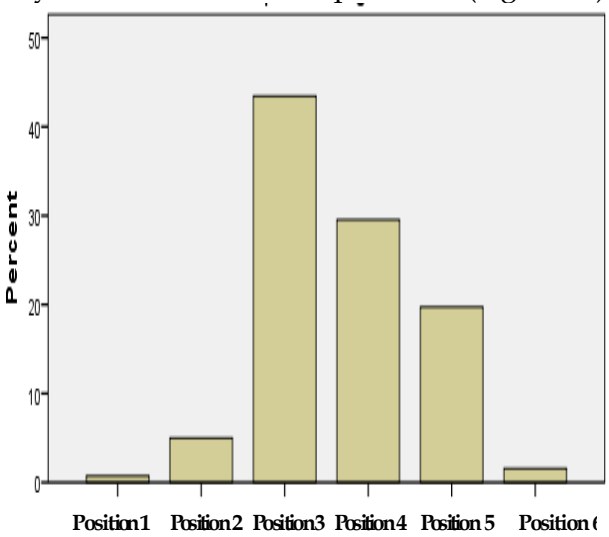

Fig. I: Horizontal position right side

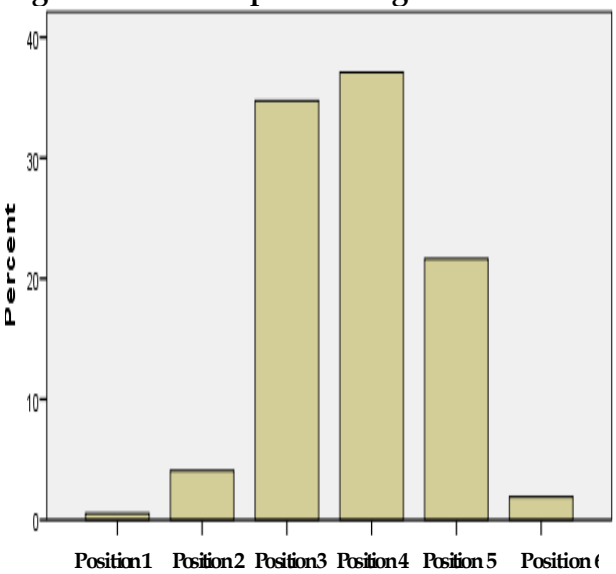

Fig. II: Horizontal position left side

For the vertical axis, position 3 was the prevalent position (RS=706 individuals; LS= 677), with frequencies of 64.2% and 61.5%, respectively. Position 1 was infrequently seen (RS=42 radiographs, frequency 3.8% and LS=48 radiographs, frequency 4.4%). The

symmetry for the vertical position was 62.5%, with 37.5% exhibiting asymmetrical configurations. (Fig. III & IV)

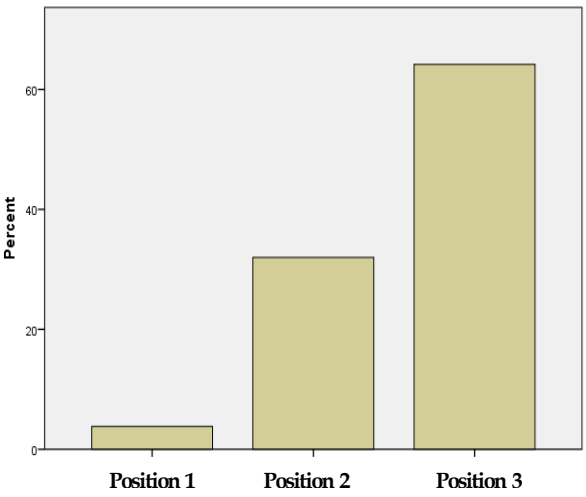

Fig. III: Vertical position right side

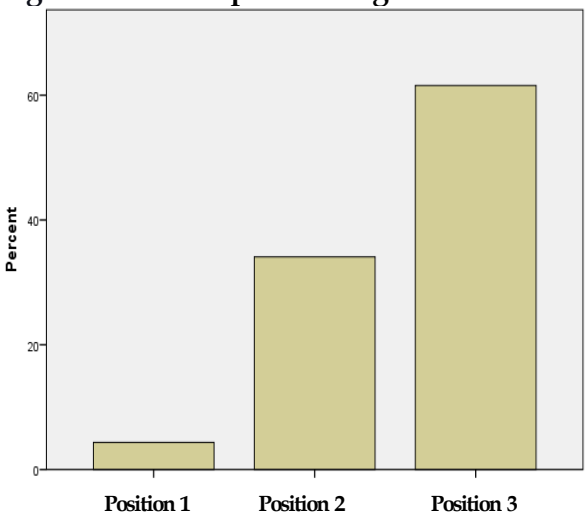

Fig. IV: Vertical position left side

Discussion

Meticulous assessment of the mental foramen's proximity to the apices of mandibular premolars is essential.[14] Mental foramen plays a vital role in various maxillofacial, Orthodontic and dental procedures, particularly in local anesthesia administration, implant placement, and orthognathic surgery.[15] Accurate localization is essential to avoid neurovascular complications. Surgical interventions, incl. uding midcrestal incisions, flap elevations, osteotomy procedures, and nerve blocks, require a precise understanding of MF positioning to ensure patient safety.[16]

These observations are consistent with those carried out in Pakistan, which noted Position 4 as the commonest horizontal position and position no 3 as the most common vertical position.[5,6] In the same manner, research in Indian populations by N Srinivas showed regional differences, where North Indians primarily presented with Position 4, whereas South Indians had a greater rate of Position 3—very close to our own observation on left-sided horizontal positioning.[17,18] Conversely, research by Chandramohan RV on 300 dry South Indian mandibles identified Position 4 to be the most common site, which is in accordance with our left-side results.[18]

Ngeow WC, Yuzawati Y. found Position 4 to be the most frequent MF site, with Position 3 being the second most frequently found, a finding similar to ours.[19] Korean research also found Position 4 to be the most frequent horizontal position, supporting the regional anatomical pattern across Asian populations.[20]

Among Middle Eastern populations, Saudi Arabian studies identified Position 3 as the most common site, in turn by Position 4—a trend slightly different from our data where Position 3 was more common on the right but not the left.[21] Iraqi and Egyptian studies found Position 4 to be the most commonly seen MF site, consistent with our left-sided data but with slight bilateral differences.[22-23]

A broader anthropometric study comparing Chinese, European, and Indian skulls established distinct MF positioning trends, where Chinese skulls favored Position 4, while European and Indian skulls exhibited more frequent Position 3 occurrences—reinforcing the genetic and skeletal influences on MF morphology.[8] Studies in Turkey confirmed that Position 3 remains a prevalent horizontal placement, further supporting our results.[24]

Clinical Implications; Given the high prevalence of Position 3 and Position 4, clinicians should prioritize these locations for nerve block techniques and implant planning, especially in South Asian and Middle Eastern populations. The bilateral symmetry in 60–62.5% of cases suggests that standardized surgical approaches may be applicable in most cases, but 40% of individuals displaying asymmetry require more tailored surgical techniques to prevent iatrogenic nerve injury.

Conclusion

In both males and females, the mental foramen is most commonly located between the apices of the first and second premolars on the right side, and inferior to the second premolar on the left side.

Limitations

This study was cross-sectional, limiting longitudinal assessment of MF positional shifts over time. Additionally, race-specific variations were not fully explored, requiring further investigations across broader demographics.

Future Recommendations

Future studies should incorporate advanced 3D imaging techniques such as CBCT, enabling more precise anatomical mapping of MF. Additionally, exploring correlations with edentulism, skeletal patterns, and genetic markers could enrich understanding of MF positional variability, improving surgical planning and nerve protection strategies

Ethical Approval

The study was approved by the Institutional Ethical Review committee of Foundation University College of Dentistry & Hospital, Islamabad. (FF/FUCD/632/ERC/29)

Funding Declaration

This study received no grant from any funding agency, commercial, or not-for-profit sectors.

Conflict of Interest

It is declared that the authors don't have any conflict of interest.

Authors' Contribution

IS: Research idea & proposal, Sample size calculation, fabrication and validation of a questionnaire, Data Collection, Data Analysis/formulation of results, Writing- Original draft of the manuscript.

NSM: Research idea & proposal, Sample size calculation, fabrication and validation of a questionnaire, Data Collection, Data Analysis/formulation of results, Writing- Original draft of the manuscript.

MU: Data Collection, Data Analysis/ formulation of results, Writing- Original draft of the manuscript.

ISM: Data Collection, Data Analysis/ formulation of results, Writing- Original draft of the manuscript.

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