IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 24, Issue 7 Ser.2 (July 2025), PP 05-11
www.iosrjournals.org

Radiographic Assessment of Mental Foramen Location and Morphological Variations of the Condylar Head and Sigmoid Notch in a Western Maharashtra Population: A Retrospective Study

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Abstract
Background: *Precise knowledge of mandibular anatomical landmarks is essential in clinical dentistry and forensic science. Variations in the mental foramen location, condylar head, and sigmoid notch morphology influence surgical safety, diagnostic accuracy, and identification reliability.*
Aim: *To assess the location of the mental foramen and morphological patterns of the condylar head and sigmoid notch in the Western Maharashtra population using orthopantomographs (OPGs).*
Materials and Methods: *A retrospective evaluation of 100 digital OPGs (50 males, 50 females) was conducted. The horizontal and vertical location of the mental foramen was documented. Morphological shapes of the condylar head (round, angled, flat) and sigmoid notch (sloping, wide, round) were analyzed bilaterally. Data were recorded and interpreted descriptively.*
Results: *The mental foramen was most frequently located in line with the second premolar (right: 52%, left: 50%) and vertically at the root apex (60% bilaterally). Round-shaped condylar heads predominated (right: 67%, left: 60%), while the sigmoid notch was most often sloping (right: 71%, left: 83%). Females exhibited more symmetrical and consistent anatomical features.*
Conclusion: *Findings indicate that the most common mandibular anatomical patterns in this population align with previous regional data. These results enhance clinical planning, improve surgical outcomes, and aid forensic evaluations through region-specific anatomical profiling.*
Keywords: *Mental foramen, Condylar head, Sigmoid notch, Mandibular morphology, Orthopantomograph, Western Maharashtra*

Date of Submission: 24-06-2025 Date of Acceptance: 04-07-2025

I. Introduction

The mental foramen is a key anatomical landmark located on the anterolateral surface of the mandible, transmitting the mental nerve and vessels. Its position varies horizontally and vertically in relation to the premolars, influenced by ethnicity, age, and gender. Accurate localization is essential in endodontics, implantology, and surgical procedures to avoid nerve injury [1,2].The condylar head forms part of the temporomandibular joint (TMJ) and is responsible for mandibular articulation. Its morphology can vary as oval, round, or flattened, often reflecting developmental, functional, or pathological changes. Assessing condylar shape is vital in diagnosing TMJ disorders and planning orthodontic or prosthodontic treatments [3,4].The sigmoid notch, located between the coronoid and condylar processes, also exhibits shape variations—commonly categorized as sloping, round, or wide. These morphological patterns can aid in forensic identification and population-specific anthropological assessments [5].Orthopantomograph (OPG) is a non-invasive radiographic technique that provides a panoramic view of the maxillofacial skeleton, enabling detailed analysis of bilateral structures such as the mental foramen, condyles, and sigmoid notch. It serves as a reliable tool for morphometric and prevalence studies in large populations [6].

This study aims to evaluate the prevalence of the mental foramen location, and the morphology of the condylar head and sigmoid notch using OPG in the Western Maharashtra population.

II. Aims and Objectives

Aim:

To assess the anatomical variations in the location of the mental foramen and the morphology of the condylar head and sigmoid notch using orthopantomographs (OPGs) in individuals from the Western Maharashtra population.

Objectives:

1. To determine the horizontal and vertical position of the mental foramen in relation to the premolars and root apex, respectively, using OPG.
2. To evaluate the shape of the condylar head (classified as round, angled, or flat) and analyze its distribution based on side and gender.
3. To analyze the shape of the sigmoid notch (classified as sloping, wide, or round) and its prevalence across the study population.
4. To assess side-wise and gender-wise variations in the mental foramen position, condylar head shape, and sigmoid notch morphology.
5. To identify the most common anatomical patterns of these mandibular structures to support clinical diagnosis, treatment planning, and forensic identification.

III. Materials and Methods

This was a retrospective radiographic study conducted to assess the location of the mental foramen and the morphological variations of the sigmoid notch and condylar head in the Western Maharashtra population. The study was carried out in the Department of Oral Medicine and Radiology after obtaining ethical clearance from the institutional review board.

Data Collection

A total of 100 digital orthopantomographs (OPGs) of patients (50 males and 50 females), aged between 18 and 60 years, were retrieved from the departmental archives. These radiographs were taken previously as part of routine diagnostic work-up and were anonymized before analysis.

Inclusion Criteria

- OPGs of individuals aged 18 years and above.
- Radiographs showing complete visibility of both mental foramina, sigmoid notches, and condylar heads.
- Good quality images without distortion or artifacts.

Exclusion Criteria

- OPGs showing pathologies, trauma, developmental disorders, or history of mandibular or TMJ surgeries.
- Poor quality or incomplete radiographs.

Radiographic Evaluation

Each OPG was evaluated bilaterally for the following anatomical features: **[Fig. 1 & 2]**

1. **Mental Foramen**
   - Horizontal position: Relative to 1st premolar, between 1st and 2nd premolars, or 2nd premolar.
   - Vertical position: Coronal to apex, at apex, or apical/below apex.
2. **Condylar Head Shape**
   - Categorized as round, angled, or flat.
3. **Sigmoid Notch Shape**
   - Classified as round, wide, or sloping.

The radiographs were assessed independently under standardized viewing conditions. Any disagreement was resolved by mutual consensus. The data were recorded, coded, and statistically analyzed using SPSS version XX. Descriptive statistics and the chi-square test were applied to assess gender and side-wise distribution.

IV. Results

This retrospective study evaluated 100 digital orthopantomographs (OPGs), including 50 males and 50 females, to determine the location of the mental foramen and the morphological variations of the condylar head and sigmoid notch in the Western Maharashtra population.

1. Location of Mental Foramen (Table 1, 2, 3 & Graph 1)

a. Horizontal Position The mental foramen was most commonly located at the level of the second premolar. It was observed in 52% of cases on the right side and 50% on the left. The location between the first and second

premolars was the second most common, seen in 42% of both sides. The least common location was in line with the first premolar, seen in 6% on the right and 8% on the left.

b. Vertical Position Vertically, the mental foramen was most frequently found at the apex of the root in 60% of cases bilaterally. An apical/below apex position was observed in 36% on both sides, while a coronal position was rare, recorded in only 4% on each side.

2. Morphology of the Condylar Head (Table 4 & Graph 2)

The round shape was the most prevalent, found in 67% on the right and 60% on the left. The angled shape occurred in 21% on the right and 20% on the left. The flat shape was least common, observed in 12% on the right and 20% on the left. Round condyles were more prevalent in females, whereas flat condyles appeared more commonly in males, particularly on the left side.

3. Shape of the Sigmoid Notch (Table 5 & Graph 3)

The sloping shape of the sigmoid notch was most frequent, seen in 71% on the right and 83% on the left. The wide shape was present in 21% on the right and 13% on the left, while the round shape was least common (8% right, 4% left). Females predominantly exhibited the sloping shape, especially on the left side (90%), while wider and rounder notches were more frequently noted in males.

Overall, the mental foramen was most commonly located in line with the second premolar and at the apex of the root. The round shape of the condylar head and the sloping shape of the sigmoid notch were the most frequently observed morphological patterns. Gender-wise analysis revealed greater anatomical consistency in females and more morphological variation in males, particularly in condylar form.

V. Discussion

The present study found that the most frequent horizontal location of the mental foramen was in line with the second premolar, consistent with findings reported by Ngeow and Yuzawati, who observed a similar position in 50.4% of the Malay population [1]. Likewise, Apinhasmit et al. noted a comparable trend in the Thai population, supporting the notion of population-based anatomical predictability [2].

Vertically, the mental foramen was predominantly located at the apex (60%), which aligns with studies by Al-Khateeb et al., who reported a peak frequency in the apical region in their Jordanian cohort [3]. The low prevalence of coronal positioning reflects similar patterns in prior literature and emphasizes the clinical significance in endodontic and surgical contexts.

Regarding the condylar head, the round shape was most common, particularly in females. This observation is in agreement with findings by Al-Koshab et al., who reported that round condylar morphology was associated with a more physiologic state of the temporomandibular joint [4]. The increased prevalence of flat and angled condyles in males may be attributed to functional loading and adaptive remodeling, as supported by Tadej et al. [5].

For the sigmoid notch, the sloping type was overwhelmingly predominant, especially in females. Shakya et al. also found sloping notches to be the most frequent type, particularly in South Asian populations [6]. This consistent pattern suggests a possible developmental or genetic basis, with muscle attachment forces potentially influencing shape.

Thus, the findings of this study are in agreement with regional and international literature, reinforcing the importance of radiographic evaluation in anatomical and forensic dentistry.

Significance

1. Clinical Significance

Mental Foramen Location

Accurate identification of mental foramen location is essential in local anesthesia administration (e.g., mental nerve block), dental implant placement, and endodontic surgeries to avoid nerve damage. Variation in its position among individuals may influence treatment planning in prosthodontics and oral surgery.

Condylar Shape

Condylar morphology is crucial in diagnosing and managing temporomandibular joint (TMJ) disorders, orthodontic planning, and surgical reconstruction. Helps assess age- and gender-related changes in mandibular development.

Sigmoid Notch Shape

Knowledge of sigmoid notch morphology assists in radiological interpretation, mandibular surgeries, and reconstructive procedures. Variations can serve as landmarks during maxillofacial surgeries and TMJ evaluations.

2. Forensic and Anthropological Significance

The combination of these anatomical landmarks is used in personal identification, age estimation, sex determination, and even ethnic classification. Since these structures show population-specific variations, may contribute to regional anthropometric databases, improving forensic accuracy.

3. Anatomical and Educational Relevance

Enhances anatomical understanding of mandibular landmarks, which is beneficial for dental students, clinicians, and anatomists.

4. Research Implications

Supports future studies comparing radiographic vs. anatomical observations. Can be used as baseline data for machine learning models in automated OPG analysis.

Limitations

1. The study was retrospective in nature, relying solely on archived OPGs, which may limit the diversity and completeness of data.
2. The sample size was limited to 100 subjects, which may not represent the full spectrum of anatomical variation in the entire Western Maharashtra population.
3. Only OPGs were used, and three-dimensional imaging such as CBCT could have provided more accurate anatomical insights.
4. Functional correlations such as mastication force or clinical TMJ symptoms were not evaluated.
   Future studies with larger and more diverse samples, including clinical correlation and advanced imaging modalities, are recommended for deeper anatomical and diagnostic understanding.

VI. Conclusion

This study highlights the predominant anatomical patterns of the mental foramen, condylar head, and sigmoid notch in the Western Maharashtra population. The mental foramen was most commonly located in line with the second premolar and at the root apex. The condylar head exhibited a round morphology in the majority of cases, while the sigmoid notch was predominantly sloping. These findings show consistency with regional and international studies and hold clinical value in improving surgical accuracy, diagnostic confidence, and forensic identification. Incorporating such population-specific anatomical data into routine radiographic interpretation can enhance patient care and support medico-legal applications.

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FIGURES, TABLES & GRAPHS

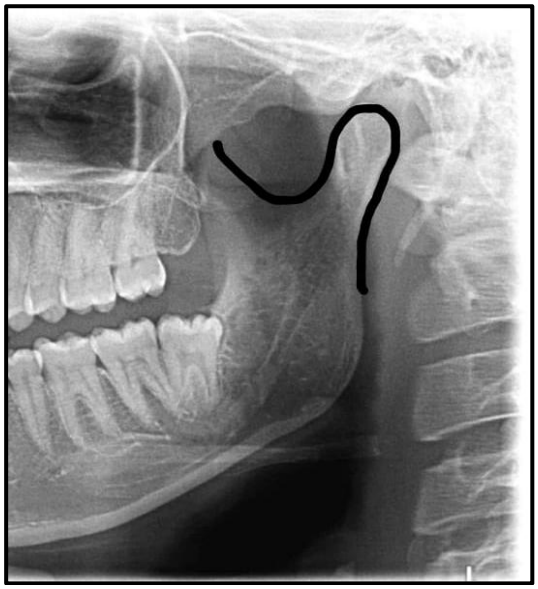


Fig 1. Left side showing location of mental foramen at 2nd premolar below apex , round condyle and round sigmoid notch

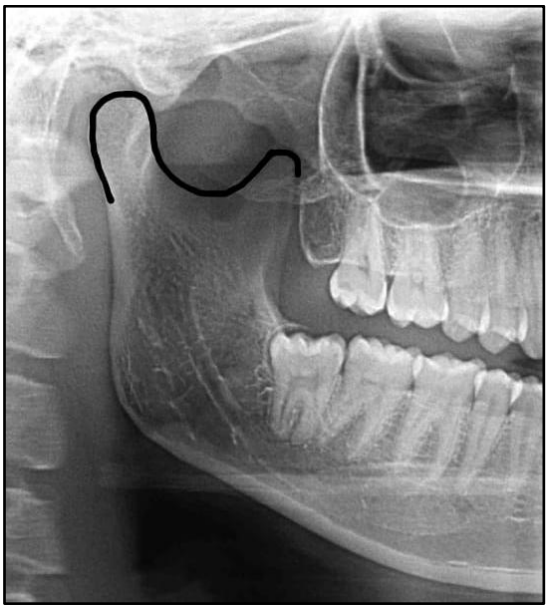


Fig 2. Right side of same patient showing location of mental foramen at 2nd premolar below apex , flat condyle and wide sigmoid notch

Gender	Side	Between 1st & 2nd PM	2nd PM	1st PM	Total
Male	Right	14 (28.0%)	31 (62.0%)	5 (10.0%)	50
Male	Left	15 (30.0%)	30 (60.0%)	5 (10.0%)	50
Female	Right	25 (50.0%)	23 (46.0%)	2 (4.0%)	50
Female	Left	24 (48.0%)	24 (48.0%)	2 (4.0%)	50

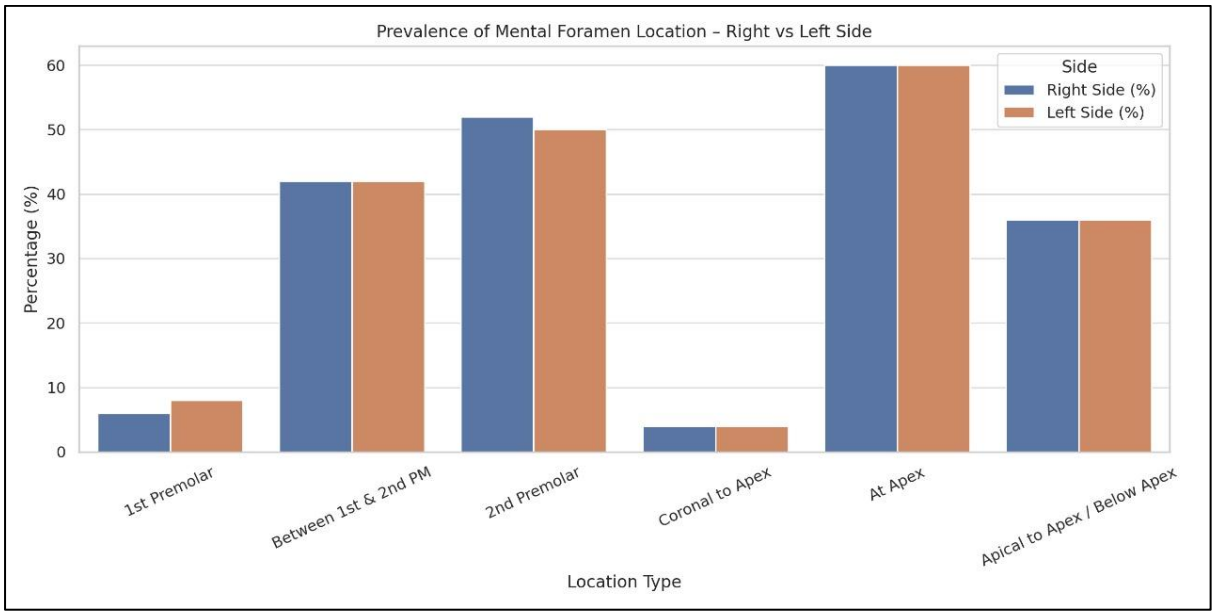
Table 1. Prevalance of horizontal location of mental foramen

Gender	Side	Coronal to Apex	At Apex	Apical/Below Apex	Total
Male	Right	2 (4.0%)	35 (70.0%)	13 (26.0%)	50
Male	Left	2 (4.0%)	34 (68.0%)	14 (28.0%)	50
Female	Right	0 (0.0%)	29 (58.0%)	21 (42.0%)	50
Female	Left	0 (0.0%)	28 (56.0%)	22 (44.0%)	50

Table 2. Prevalance of vertical location of mental foramen

Location Type	Right Side (%)	Left Side (%)
Horizontal Position		
1st Premolar	6%	8%
Between 1st & 2nd PM	42%	42%
2nd Premolar	52%	50%
Vertical Position		
Coronal to Apex	4%	4%
At Apex	60%	60%
Apical to Apex / Below Apex	36%	36%

Table 3. Prevalence Table (in %) for Mental Foramen Location – Right and Left Sides



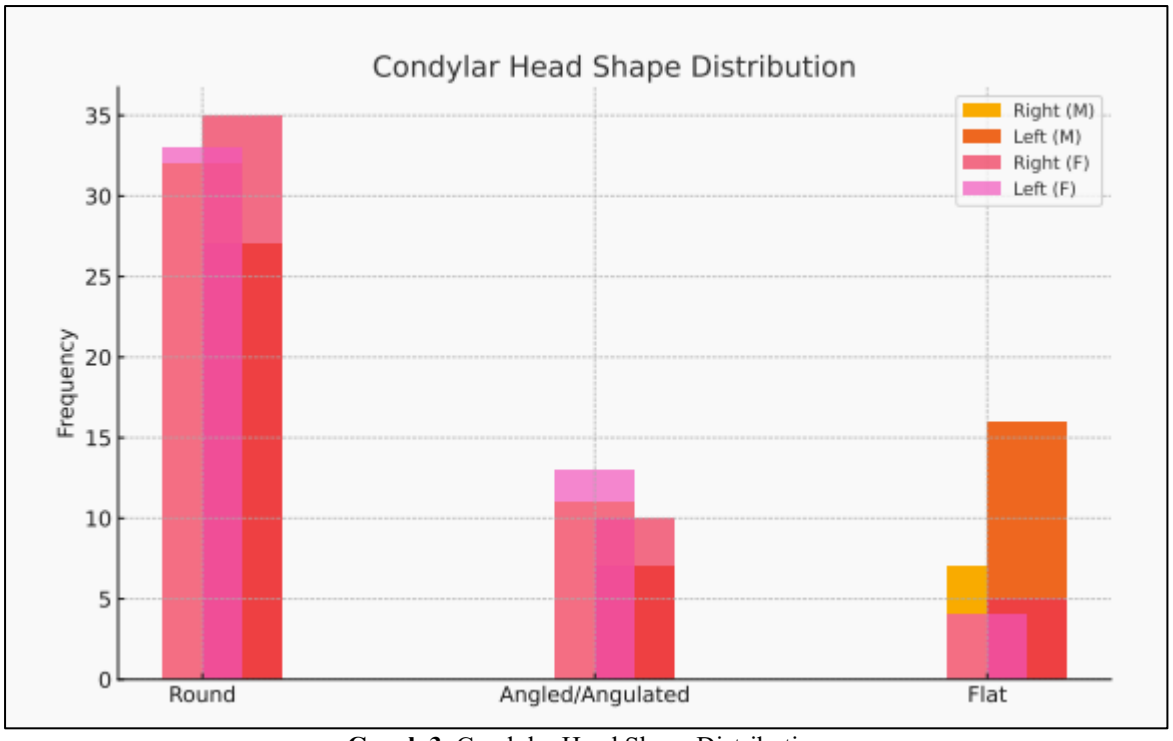
Graph 1. Prevalance of Mental foramen location- Right and Left sides

Table 4. Prevalance of shape of condylar head for right and left side in males and females

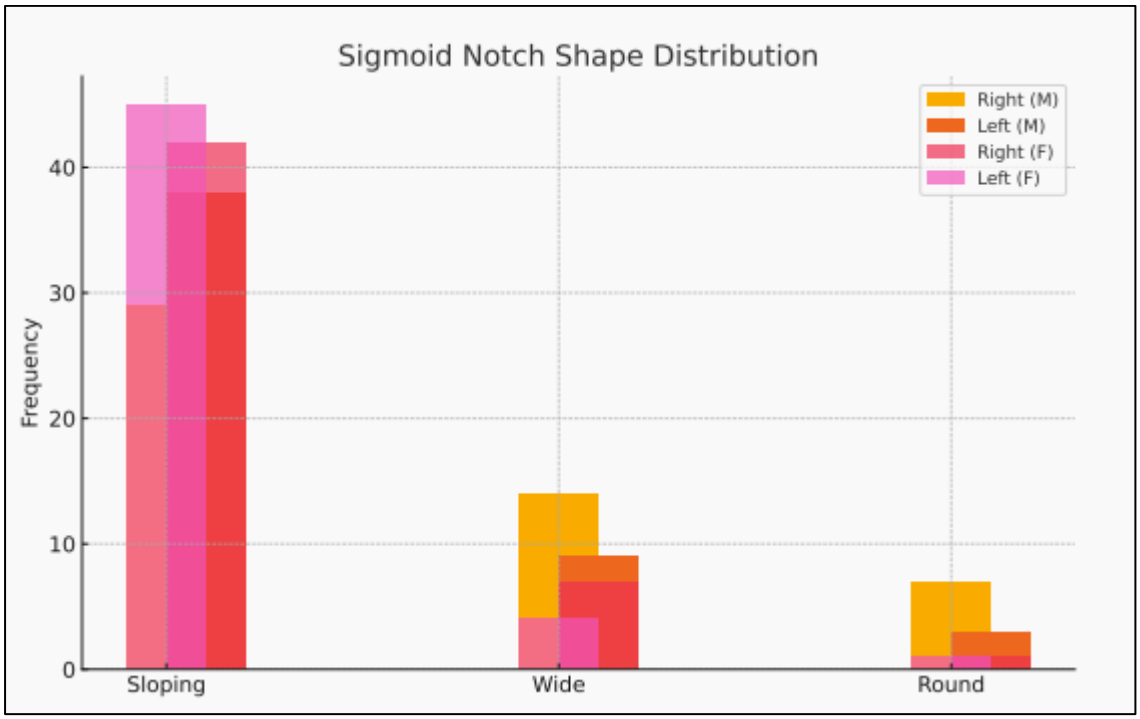
Condylar Head Shape	Right (M)	Left (M)	Right (F)	Left (F)	Right (Total)	Left (Total)
Round	32 (64%)	27 (54%)	35 (70%)	33 (66%)	**67 (67%)**	**60 (60%)**
Angulated	11 (22%)	7 (14%)	10 (20%)	13 (26%)	**21 (21%)**	**20 (20%)**
Flat	7 (14%)	16 (32%)	5 (10%)	4 (8%)	**12 (12%)**	**20 (20%)**

Sigmoid Notch Shape	Right (M)	Left (M)	Right (F)	Left (F)	Right (Total)	Left (Total)
Sloping	29 (58%)	38 (76%)	42 (84%)	45 (90%)	**71 (71%)**	**83 (83%)**
Wide	14 (28%)	9 (18%)	7 (14%)	4 (8%)	**21 (21%)**	**13 (13%)**
Round	7 (14%)	3 (6%)	1 (2%)	1 (2%)	**8 (8%)**	**4 (4%)**

Table 5. Prevalance of shape of Sigmoid notch for right and left side in males and females



Graph 3. Condylar Head Shape Distribution



Graph 4. Sigmoid Notch Shape Distribution