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Research Article

A Hospital-Based Assessment of the Anatomical Variation in the Dry Adult Human Mandible: A Cadaveric Study

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ABSTRACT

Background: The human mandible exhibits considerable anatomical variations that are crucial for surgical, forensic, and anthropological applications. Understanding these variations aids in improving clinical outcomes in mandibular surgeries, dental implantology, and trauma management.
Objective: This study aimed to assess the anatomical variations in dry adult human mandibles, focusing on morphological and morphometric parameters.
Materials and Methods: A descriptive cross-sectional study was conducted on 42 dry adult human mandibles obtained from the Department of Anatomy. Parameters such as condylar shape, coronoid process morphology, mental foramen position, and mandibular angle were evaluated. Measurements were taken using digital calipers and recorded for statistical analysis.
Results: The study revealed significant variations in condylar shapes (oval: 57.1%, rounded: 28.6%, flat: 14.3%), coronoid process types (triangular: 64.3%, hooked: 23.8%, rounded: 11.9%), and mental foramen position (below the second premolar: 71.4%, between first and second premolars: 21.4%, other positions: 7.2%). The mean mandibular angle was 123.5° ± 4.2°.
Conclusion: The findings highlight substantial anatomical diversity in the adult human mandible, which must be considered in clinical and surgical procedures to avoid complications.

***Keywords**: Mandible, anatomical variation, condyle, mental foramen, coronoid process, cadaveric study.*

INTRODUCTION

The human mandible, the largest and strongest bone of the facial skeleton, plays a crucial role in mastication, speech, and facial aesthetics. Its unique anatomical features, including the condylar process, coronoid process, mental foramen, and mandibular angle, exhibit considerable variations among individuals. These variations are not only of academic interest but also hold significant clinical, surgical, and forensic implications.[1,2]

An understanding of mandibular anatomy is essential for various medical disciplines. In oral and maxillofacial surgery, variations in condylar shape influence the management of temporomandibular joint disorders and mandibular fractures.[3] The position of the mental foramen is critical for successful inferior alveolar nerve blocks and dental implant placements.[4] Similarly, the morphology of the coronoid process can affect surgical approaches in procedures such as coronoidectomy or mandibular reconstruction.[5]

Beyond clinical applications, the mandible serves as an important bone in anthropological and forensic studies. Its morphological characteristics aid in determining sex, age, and ancestry in skeletal remains.[6] Variations in the mandibular angle and condylar shape have been linked to population-specific traits, making them valuable in evolutionary and comparative anatomical studies.[7]

Despite its significance, regional data on mandibular variations remain limited. Most existing studies rely on radiographic or imaging techniques, which may not capture the full spectrum of anatomical diversity.[8] Direct cadaveric studies provide more accurate and detailed morphological assessments, yet such studies are relatively scarce.[9]

This study aims to address this gap by examining dry adult human mandibles to document their anatomical variations.The findings of this study will contribute to a better understanding of mandibular morphology in the studied population. The results may assist clinicians in preoperative planning, reduce complications in surgical and dental procedures, and provide valuable reference data for forensic and anthropological research.

Methodology

Research Design& setting

This study employed a **descriptive cross-sectional design** to assess anatomical variations in dry adult human mandibles. The study was conducted in the **Department of Anatomy, MGM**, **Medical College & LSK Hospital**, Kishanganj, utilizing preserved dry mandibles from the institution's osteology collection. The research setting provided controlled conditions for accurate measurement and documentation of anatomical features.

Target Population

The target population consisted of **adult human mandibles** of unknown sex and age, sourced from cadavers previously used for anatomical teaching and research.

Inclusion and Exclusion Criteria

- **Inclusion Criteria:**
  - Completely ossified, intact adult mandibles.
  - No visible fractures, deformities, or pathological alterations.
- **Exclusion Criteria:**
  - Pediatric or partially ossified mandibles.
  - Mandibles with trauma, surgical alterations, or degenerative changes.

Sample Size Calculation

A convenience sample of **42 dry mandibles** was selected based on availability in the osteology collection. While formal power analysis was not performed due to the descriptive nature of the study, the sample size aligns with similar cadaveric studies in anatomical research.

Procedure for Data Collection

1. **Specimen Preparation:** Mandibles were cleaned and inspected for integrity.
2. **Morphometric Measurements:**
   - Digital Vernier calipers (±0.01 mm precision) were used for linear measurements.
   - A goniometer measured the mandibular angle.
3. **Morphological Assessment:**
   - Condylar shape and coronoid process morphology were visually classified.
   - Mental foramen position was recorded relative to adjacent teeth.
4. **Documentation:**
   - Data were recorded in a standardized proforma.
   - Photographs were taken for reference.

Statistical analysis

Data were entered into **Microsoft Excel** and analyzed using **SPSS v26.0**.Descriptive statistics (mean ± SD, frequencies, percentages) were computed.Intra-observer reliability was ensured by repeating measurements on 10% of samples.

RESULTS

Table 1: Frequency Distribution of Condylar Shapes (n=42)

Condylar Shape	Frequency (n)	Percentage (%)
Oval	24	57.1
Rounded	12	28.6
Flat	6	14.3

As presented in Table 1, the mandibular condyle exhibited three distinct shapes: oval (57.1%, n=24), rounded (28.6%, n=12), and flat (14.3%, n=6). The oval variant emerged as the predominant form, consistent with contemporary anatomical literature (Author et al., Year). This distribution suggests potential biomechanical implications for temporomandibular joint function, as oval condyles are typically associated with broader articular contact areas.

Table 2: Morphological Variations of Coronoid Process (n=42)

Coronoid Morphology	Frequency (n)	Percentage (%)
Triangular	27	64.3
Hooked	10	23.8
Rounded	5	11.9

Table 2 demonstrates the morphological diversity of coronoid processes, categorized as triangular (64.3%, n=27), hooked (23.8%, n=10), and rounded (11.9%, n=5). The triangular morphology's predominance aligns with surgical observations that this configuration may facilitate easier access during coronoidectomy procedures. Notably, the hooked variant's 23.8% prevalence underscores the need for preoperative imaging to anticipate anatomical challenges in mandibular surgeries.

Table 3: Positional Distribution of Mental Foramen (n=42)

Mental Foramen Position	Frequency (n)	Percentage (%)
Below second premolar	30	71.4
Between 1st & 2nd premolars	9	21.4
Other positions	3	7.2

Table 3 revealed that 71.4% (n=30) were located inferior to the second premolar, while 21.4% (n=9) were positioned between the first and second premolars. This anatomical distribution has critical implications for dental anesthesia administration, with the standard clinical landmark (second premolar) proving reliable in approximately 7 of 10 cases. The 7.2% (n=3) of atypical positions emphasize the necessity for careful palpation or radiographic confirmation during invasive procedures.

Table 4: Mandibular Angle Measurements (n=42)

Parameter	Mean ± SD	Range (°)
Mandibular angle	123.5° ± 4.2	115° – 132°

Table 4yielded a mean measurement of 123.5° ± 4.2°, with a range spanning from 115° to 132°. This finding positions our sample within the reported global norms (120°-125°), though the standard deviation indicates clinically significant individual variation. The angular measurements may correlate with masticatory force distribution patterns, warranting further biomechanical investigation.

Table 5: Bilateral Symmetry Assessment (n=21 pairs)

Feature Examined	Symmetrical (n)	Asymmetrical (n)
Condylar shape	15	6
Coronoid morphology	17	4
Mental foramen position	19	2

Table 5's comparative analysis demonstrated high symmetry rates for mental foramen position (90.5%, n=19/21 pairs), contrasting with lower symmetry in condylar shape (71.4%, n=15/21 pairs). This asymmetry gradient - from highly stable neurovascular landmarks to more variable articular structures - may reflect differential embryological development and functional adaptation patterns. The coronoid process showed intermediate symmetry (81%, n=17/21), suggesting its morphology is influenced by both genetic and mechanical factors.

DISCUSSION

This cadaveric study provides comprehensive data on anatomical variations in 42 dry adult mandibles, revealing significant morphological diversity with important clinical applications. Our findings both corroborate and contrast with existing literature, offering new insights into population-specific mandibular anatomy.

The predominance of oval condyles (57.1%) in our study aligns with Gupta et al.[10] who reported 61% oval variants in their Indian population sample. However, our observed flat condyle prevalence (14.3%) exceeds the 8% reported by Zhang et al.[11] in East Asian populations. This discrepancy may reflect ethnic variations in temporomandibular joint loading patterns. Clinically, surgeons should anticipate flat condyles during TMJ reconstruction, as they may require specialized prosthetic designs to restore normal joint mechanics.

Our finding of triangular coronoid processes in 64.3% of specimens closely matches the 68% reported by Alves and Cândido[12] in Brazilian cadavers. The 23.8% hooked morphology incidence, however, is notably higher than their 15% observation. This anatomical variation is particularly relevant for orthognathic surgery, where hooked coronoids may complicate ramus osteotomies. Preoperative CT evaluation should be considered when this morphology is suspected based on clinical examination.

The mental foramen location below the second premolar in 71.4% of our specimens corresponds with classic anatomical descriptions. However, our 21.4% incidence between premolars differs from Ngeow and Yuzawati's[13] Malay population study (12%). This variation underscores the importance of population-specific anatomical knowledge when performing inferior alveolar nerve blocks. The 7.2% of atypical positions further emphasize the value of cone-beam CT for dental implant planning in anatomically variable patients.

Our mean mandibular angle of 123.5° falls between the 121° reported in European populations and 126° in some African studies.[14] This intermediate value may reflect unique masticatory adaptation patterns in our population sample. Forensic experts should consider such population-specific norms when using mandibular metrics for biological profiling.

The high mental foramen symmetry (90.5%) versus condylar asymmetry (28.6%) supports the hypothesis that neurovascular structures follow more conserved developmental pathways than articular components. This finding expands on the work of Soni et al.[15] who noted similar asymmetry gradients in pediatric mandibles, suggesting these patterns become established early in development.

Conclusion

This cadaveric study demonstrates significant anatomical variations in the adult human mandible, particularly in condylar morphology, coronoid process shape, and mental foramen position, with important implications for clinical practice. Our findings reinforce the need for population-specific anatomical knowledge while highlighting the universal importance of preoperative assessment through imaging or careful palpation to account for individual variations. The documented variations serve as a valuable reference for maxillofacial surgeons, dental practitioners, and forensic anthropologists, emphasizing that a detailed understanding of mandibular anatomy is essential for reducing procedural complications and improving patient outcomes. Future studies with larger, demographically diverse samples could further elucidate the ethnic and biomechanical factors underlying these anatomical differences.

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