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To analyze the morphological and morphometric variations of the human mandible

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ABSTRACT

Background:
The mandible is the strongest bone of the facial skeleton and plays a critical role in mastication. The inferior alveolar nerve passes through the mandibular canal within the mandible to innervate the lower teeth. Accurate morphometric analysis of the mandible facilitates proper localization of this nerve for anesthetic blocks and provides essential ratios useful during surgical procedures. **Aim and Objective:** To study the variations in various morphometric parameters of the human mandible. **Materials and Methods:** The study was conducted on 122 adult dry human mandibles at the Department of Anatomy, Index Medical College Hospital & Research Centre, Indore. Various parameters of the mandible were measured using digital vernier calipers. **Results:** The gonial angle in male mandibles ranged from 116° to 141°, with an average of 126.41°. In females, the average gonial angle was 137.5°. The mandibular angle was observed to be less than 162° in males and greater than 110° in females. The maximum recorded mandibular angle was 134°, which was correctly estimated in 84% of male and 67% of female mandibles. A statistically significant difference ($p < 0.001$) was noted in the mean mandibular angle values between males and females. **Conclusion:** The triangular type of mandible is more commonly seen in males. Among various types of coronoid processes, the triangular form is the most prevalent.

Keywords: Mandible, ramus, lingula

Introduction,

The mandible is the largest and strongest bone of the face. It has a horizontally curved body, convex anteriorly, and two broad rami that ascend posteriorly. These rami bear the coronoid and condyloid processes [1]. The lingula is a tongue-shaped bony projection that overlies the mandibular foramen, which leads into the mandibular canal extending from the ramus to the body, below the alveolar sockets. The inferior alveolar nerve enters through the mandibular foramen to supply the lower jaw structures, making the anatomical relationship of the lingula with the nerve clinically significant for dental surgeons. Precise knowledge of lingula morphology is essential to avoid nerve damage during mandibular surgeries such as osteotomy.

The **mental foramen**, located on the anterolateral aspect of the mandible, allows passage of the mental nerve and vessels. Its variations—ranging in shape, size, and position, including presence of accessory foramina or, rarely, complete absence—are of particular importance in dental anesthesia and surgical interventions of the lower anterior teeth [2]. The mandible is also the only movable bone in the skull and supports the lower dentition. Understanding the morphometric parameters of the mandible is vital in multiple fields including forensic science, orthodontics, and maxillofacial surgery. In forensic science, mandible characteristics assist in identification of individuals [3]. In orthodontics, accurate mandibular measurements are essential in diagnosing and treating skeletal and dental malocclusions [5].

Mandibular morphology and morphometry vary significantly with age, sex, and ethnicity. Important morphometric parameters include the gonial angle, ramus height, and body length. These parameters provide insights into population-based anatomical differences, and such knowledge is crucial in clinical and anthropological contexts [6]. Previous studies have described different lingula types—triangular, truncated, nodular, and assimilated—with the triangular form reported as the most prevalent [7]. Variations in lingula morphology and mandibular foramen structure have been linked to failure in achieving effective inferior alveolar nerve blocks [8,9].

The **coronoid process** (from Greek: "like a crown") is of special interest in maxillofacial surgery, often harvested as an autogenous bone graft for reconstructive procedures [10,11]. Variations in its anatomy can influence vestibular space, particularly when the medial coronoid process lies close to the distal molars [1]. Among skeletal bones, the pelvis and skull are most reliable for sex determination. However, in cases where the pelvis is unavailable, the mandible serves as a crucial alternative due to its durability and resistance to post-mortem distortion [13]. Given its functional and forensic importance, detailed morphometric analysis of the mandible is warranted. The present study aims to investigate and document various morphometric parameters of the human mandible to enhance anatomical knowledge useful in clinical and forensic practices.

Material and method

Study Design:
Observational cross-sectional study.

Place of Study:
Department of Anatomy, Index Medical College Hospital & Research Centre, Indore.

Sample Size:
122 adult dry human mandibles.

Inclusion Criteria:

- Adult mandibles with Presence of bilateral molar teeth
- Prominent alveolar sockets
- Intact condylar and coronoid processes
- Well-developed and undamaged bone

Exclusion Criteria:

- Mandibles that were broken, deformed, or showed signs of pathology.

Instrument Used:

- Digital vernier caliper was used to measure all parameters.

Statistical Analysis: Data were analyzed using SPSS software. A p-value < 0.05 was considered statistically significant.

RESULTS

The study was conducted on 122 adult dry human mandibles collected from the Department of Anatomy, Index Medical College Hospital & Research Centre, Indore. Morphometric parameters were measured and statistically analyzed, with significant differences observed between male and female mandibles in several features, particularly the gonial angle.

The shape of coronoid process was classified into 3 types:
1. Triangular: Tip pointing directly upwards.
2. Rounded: Tip rounded.
3. Hook: Tip pointing backwards.

Table 1: Variations in the shapes of lingual of 122 mandibles (244 sides)

Gender	Triangular			Truncated			Nodular			Assimilated		
	Rt	Lt	Total	Rt	Lt	Total	Rt	Lt	Total	Rt	Lt	Total
Male	120	70	95	30	20	25	40	12	26	13	17	15
Female	65	25	45	20	10	15	18	8	13	8	12	10

Table 2: Variations in the shapes of coronoid process of 122 mandibles (244 sides)

Variable	Male	Female	Total
Triangular	95	45	140
Hook Shaped	40	25	65
Rounded	26	13	39

Figure 1: Variations in the shapes of coronoid process of 122 mandibles (244 sides)

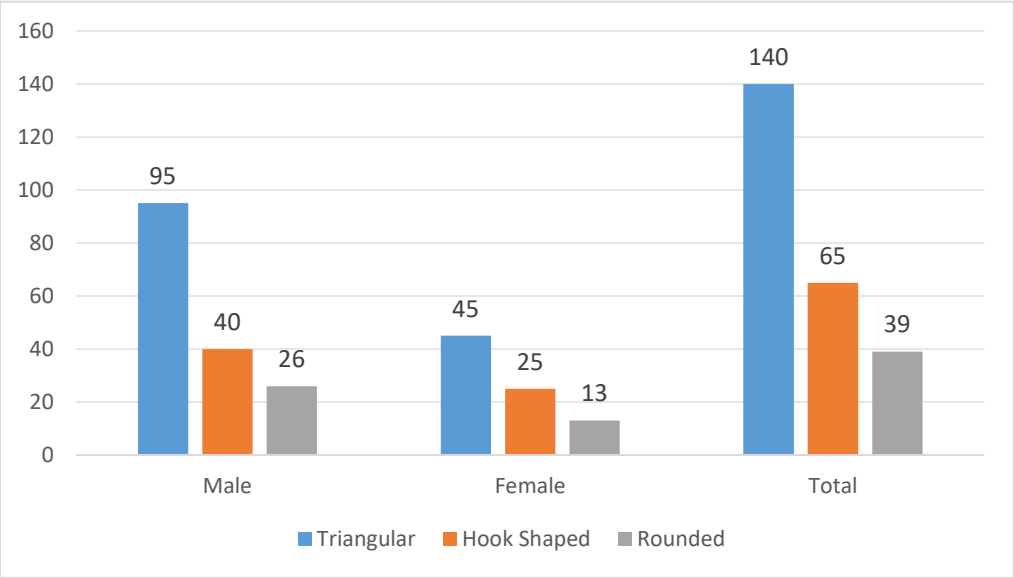
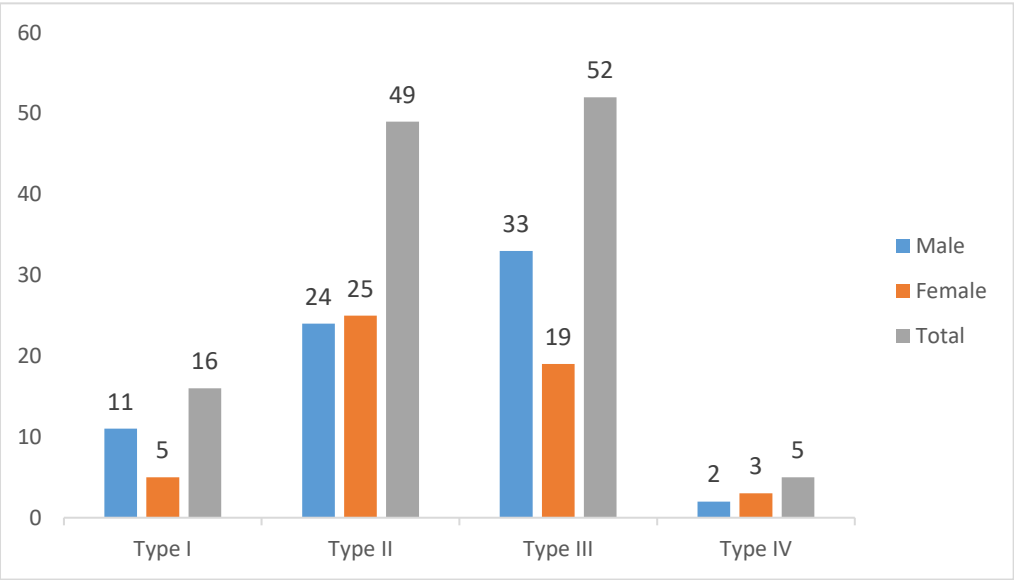


Table 3: Distribution of patterns of genial tubercles

Gender	Type I	Type II	Type III	Type IV
Male	11	24	33	2
Female	5	25	19	3
Total	16	49	52	5

Figure 2: Patterns of Genial Tubercles in the study population Mandibles



The most common lingula is triangular, or 57.37%. Males are more likely to have it (38%). The truncated kind (10%) is the least common. Bilaterally, in 95 mandibles, unilaterally in 27 bones on the right side, and in 21 bones on the left, triangular ligulae

were discovered. Just 11 mandibles on both sides and 13 bones on the right and left were found to have truncated types. The most common type of genial tubercles were Type II (42.62%), while the least common type was Type IV (4.09%).

Discussion

The present study was conducted in the Department of Anatomy, Index Medical College and Hospital, Indore, Madhya Pradesh, India, on dry, unidentified mandibles of both male and female origin. Among the various morphological features examined, the **lingula** showed notable sexual dimorphism.

The lingula was first described by Johannes-Baptist Spix in 1815 and is sometimes referred to as *Spix's ossicle* or *Spix's spine* [14]. While many standard anatomy textbooks describe only the triangular shape of the lingula, research has shown significant morphological variation. Nicholson [15] and other researchers [16] highlighted the sexual dimorphism evident in lingula morphology. In our study, the triangular type was found most frequently, accounting for 57.37% of cases—278 lingulae (132 bilateral and 29 unilateral). These findings surpass the prevalence reported in earlier studies [17].

In contrast, a higher prevalence of **truncated** lingula was observed among the Thai population [18], followed by nodular, triangular, and assimilated types. The **triangular type** was observed more frequently in males (38%), whereas the truncated type was the least common (10%). In our study, the triangular lingula was found bilaterally in 95 mandibles, unilaterally on the right in 27, and on the left in 21 bones. Truncated types were present bilaterally in 11 mandibles and unilaterally on both sides in 13 cases.

Regarding the **genial tubercles**, the most common type observed was **Type II** (42.62%), while **Type IV** was the least common (4.09%). These morphological variations might carry ethnic significance and warrant further large-scale studies to establish racial patterns.

Although many textbooks discuss only the triangular form of the lingula, other studies [19–23] have identified additional shapes such as truncated, nodular, and assimilated types, each with varying frequencies. Despite these classifications, detailed data on their distribution were often lacking.

In the present study, the **coronoid process** also showed shape variation. Among the shapes observed, **57.38% were triangular**, **26.64% hook-shaped**, and **15.98% rounded**, with the triangular form again more common in males. The coronoid process develops as a separate ossification center within the **temporalis muscle anlage**, which fuses with the ramus around the eighth week of gestation [24]. Its medial and anterior surfaces serve as the main attachment site for the **temporalis muscle**, and part of the lateral surface accommodates the **masseter** muscle. These attachments are essential for mastication and influence the coronoid's morphology.

Previous studies have shown that the coronoid process is affected by **diet, genetics, hormones**, and **masticatory muscle activity** [25]. While the triangular shape was predominant in most Indian studies, studies from **Turkey** and **Bangladesh** reported the **hook-shaped** process as most common [10,11].

Clinically, the coronoid process holds great significance. It is used as a graft in reconstructive surgery, particularly for **orbital floor defects** due to its favorable morphology and **biocompatibility** [19,29,30]. Pathological conditions like **osteochondroma, osteoma, exostosis**, and **coronoid hyperplasia** can cause **enlargement**, which may lead to **mandibular hypomobility**. Though **coronoid fractures** are rare (2% incidence), understanding the anatomy is essential for diagnosis and management, especially when impingement on the zygomatic arch is present [26–28].

The anatomical configuration of the coronoid process—projecting upward and slightly forward with a convex upper and concave lower border—makes it suitable for **paranasal augmentation**, offering benefits such as ease of harvesting, shape compatibility, and reduced operation time [29,30].

Conclusion

In the present study, various non-metrical qualitative features of the mandible were evaluated. Among them, the **lingula** was identified as a **sexually dimorphic structure** and may be reliably used for sex determination in anthropological and forensic contexts. The **triangular lingula** was the most common type, especially among males. Similarly, the **triangular coronoid process** was the most prevalent shape observed. The **pattern of genial tubercles** also exhibited diversity, and its potential **racial significance** warrants further investigation using a larger sample size.

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