ORIGINAL ARTICLE e-ISSN: 2349-0659 p-ISSN; 2350-0964

# Morphometric Evaluation of the Indian Goat Mandible for Biomechanical and Dental Implant Research

Vishal[1], Tanya Khaitan[2]*, Shantala R. Naik[3], Dharmendra Kumar Sinha[4], Rakhi Singh[5]

## Abstract

**Background:** Biomechanical testing of maxillofacial fracture fixation hardware, as well as the placement of dental implants for practice, requires a suitable bone medium that may mimic human bone. Indian goat may be an appropriate candidate for the same due to its availability. However, clearly, a research gap exists in identifying a suitable region in the goat mandible for biomechanical and dental implants research. This study evaluated the morphometric characteristics of the Indian goat mandible and identified anatomically suitable sites for these experimental studies. **Materials and Methods:** A descriptive cadaveric cross-sectional study was performed on 30 adult Indian goat mandibles obtained from a slaughterhouse. Various horizontal and vertical morphometric parameters were recorded. Buccolingual thickness of the mandibular body was measured at the anterior, middle, and posterior dentate regions at the alveolar crest and 6 mm and 12 mm below the crest. **Results:** The mean mandibular length was 147.09 ± 4.74 mm, and the mean maximum mandibular height was 85.90 ± 23.55 mm. Buccolingual thickness progressively increased from the anterior to the posterior mandible. The posterior dentate region demonstrated the greatest bone width, measuring 8.19 mm at the alveolar crest, 12.12 mm at 6 mm, and 14.65 mm at 12 mm below the alveolar crest. **Conclusion:** Despite morphological differences from the human mandible, the goat mandible can be a suitable anatomical site for tribological studies. The posterior and middle dentate mandible appear most appropriate for biomechanical studies of fixation devices, practicing osteotomies, and implant placements.

**Keywords:** Biomechanical testing, Goat anatomy, Implants, Maxillofacial surgery, Morphometry

*Asian Pac. J. Health Sci.*, (2026); DOI: 10.21276/apjhs.2026.13.3.05

## Introduction

The mandible is one of the largest and strongest bones of the facial skeleton and helps in mastication, speech, deglutition, and maintenance of facial contour. Owing to its unique anatomical characteristics and isolated position, the mandible is frequently involved in traumatic injuries and often requires open reduction and internal fixation. In the field of dentistry, it is a common site for placing dental implants and osteotomies related to reconstructive surgical procedures such as orthognathic surgeries. Researchers, dental professionals, as well as students, often require a suitable human bone mimicking medium for biomechanical testing or simply practicing mock surgeries before actually performing *in vivo*.

Human cadaveric mandibles remain the first choice as a substitute. Synthetic mandibles provide an alternative but are expensive and lack natural bone architecture.[1] However, their limited availability, ethical concerns, and high cost have encouraged researchers to explore animal models. Although goat mandibles are readily available and have favorable bone quality, detailed morphometric information regarding the Indian goat mandible is lacking. Furthermore, no study has attempted to identify the region of the goat mandible that is most suitable for implant placement and biomechanical testing. Such information would help standardize experimental models used in oral and maxillofacial research. Consequently, an ideal experimental model should possess anatomical dimensions, cortical thickness, and bone quality comparable to those of the human mandible while remaining readily available.

Goat or *Capra aegagrus hircus* is a common domestic animal in India, primarily used as a milk and meat source. Goat mandibles satisfy many of the mentioned requirements and are easily obtainable from slaughterhouses without the need for sacrificing animals solely for research purposes. Several morphometric studies have described the mandibular anatomy of different goat breeds, including the Saanen goat of Switzerland, the Raeini Cashmere goat of Iran, the Gurcu goat of Anatolia, and indigenous African breeds.[2-5] These investigations have primarily focused on comparative anatomy and regional morphometry.

Establishing baseline morphometric characteristics of the goat mandible is important not only for veterinary anatomical research but also for assessing its suitability as an experimental model in different specialties of dentistry, including oral and

[1]Department of Oral and Maxillofacial Surgery, Rama Dental College, Hospital and Research Centre, Kanpur, Uttar Pradesh, India.

[2]Department of Oral Medicine and Radiology, Awadh Dental College and Hospital, Jamshedpur, Jharkhand, India.

[3]Department of Oral Medicine and Radiology, Dental Institute, Rajendra Institute of Medical Sciences, Ranchi, Jharkhand, India.

[4]Department of Prosthodontics, Rama Dental College, Hospital and Research Centre, Kanpur, Uttar Pradesh, India.

[5]Department of Endodontics and Conservative Dentistry, Vananchal Dental College and Hospital, Garhwa, Jharkhand, India.

**Corresponding Author:** Dr. Tanya Khaitan, Department of Oral Medicine and Radiology, Awadh Dental College and Hospital, Jamshedpur, Jharkhand, India. E-mail: tanyakhaitan@gmail.com

**How to cite this article:** Vishal, Khaitan T, Naik SR, Sinha DK, Singh R. Morphometric Evaluation of the Indian Goat Mandible for Biomechanical and Dental Implant Research. Asian Pac. J. Health Sci., 2026;13(3):15-18.

**Source of support:** Nil.

**Conflicts of interest:** None.

**Received:** 11/07/2026 **Revised:** 18/07/2026 **Accepted:** 10/08/2026

maxillofacial surgery. Parameters such as mandibular dimensions and the location of important anatomical landmarks may influence the design and interpretation of *in vitro* studies involving fracture fixation systems and dental implants.

Therefore, the present cadaveric study was undertaken to evaluate the gross morphometric characteristics of the Indian goat mandible and assess its potential applicability as an experimental model for internal fixation-related biomechanical studies.

## Materials and Methods

This study was initiated after obtaining approval from the institutional ethics committee. A descriptive, cross-sectional, morphometric study was conducted to evaluate the gross anatomical characteristics of adult Indian goat mandibles. They were obtained from a local government-authorized slaughterhouse. The sample size was 30, and only right-sided mandibles were used in the study. The specimens were collected immediately after slaughter and transported to the experimental site for further processing. No animals were sacrificed specifically for this study.

Adult Indian goat mandibles with complete dentition and identifiable anatomical landmarks suitable for morphometric measurements were selected for the study. Goat mandibles showing fractures, congenital deformities, pathological lesions, and mandibles with post-slaughter damage were excluded from the study.

All attached soft tissues, muscles, periosteum, and connective tissue were carefully removed using blunt dissection. The cleaned mandibles were washed thoroughly with running water and air-dried before morphometric analysis. All measurements were performed using a digital vernier caliper with an accuracy of 0.01 mm by a single investigator to minimize interobserver variability. Each measurement was recorded 3 times, and the mean value was used for statistical analysis.

The parameters taken into consideration are mentioned below:

### Horizontal Parameters

A: Mental foramen to the base of the mandible, B: Lateral incisor to the mental foramen, C: First premolar to the mental foramen, D: Diastema length, E: First premolar to the distal surface of the last molar, F: Incisal edge of the lateral incisor to the mental foramen, G: Mental foramen to the caudal border of the mandible, H: Total mandibular length [Figure 1].

### Vertical Parameters

I: Maximum mandibular height, J: Height of the mandible up to the condylar process, K: Distance between the condylar and coronoid processes, L: Mandibular foramen to the ventral border of the mandible [Figure 1].

### Thickness of the Mandible

The buccolingual thickness of the mandibular body was measured at three standardized locations: (1) at the first tooth immediately posterior to the diastema, (2) at the last molar tooth, and (3) at the midpoint between these two locations. Since the number of cheek teeth varied among the specimens, the third measurement site was standardized by selecting the midpoint between the anterior and posterior measurement locations. At each site, buccolingual thickness was measured at three vertical levels: (i) at the alveolar crest, (ii) 6 mm below the alveolar crest, and (iii) 12 mm below the alveolar crest [Figure 2].

Statistical analysis was performed using the Statistical Package for the Social Sciences version 31.0 (IBM Corp., Armonk, NY, USA). Data were presented as mean ± standard deviation.

## Results

The various horizontal and vertical measurements in millimeters and their standard deviation are represented in Tables 1 and 2. Table 3 shows the mean buccolingual bone width at the three selected points at various depths in millimeters.

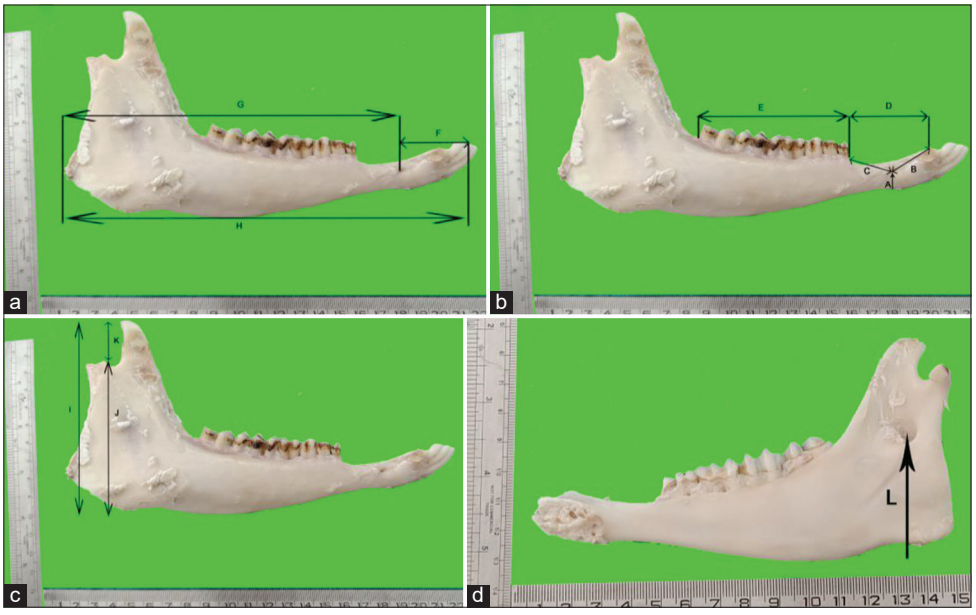


**Figure 1:** (a-d) Representation of the vertical and horizontal parameters of the goat mandible

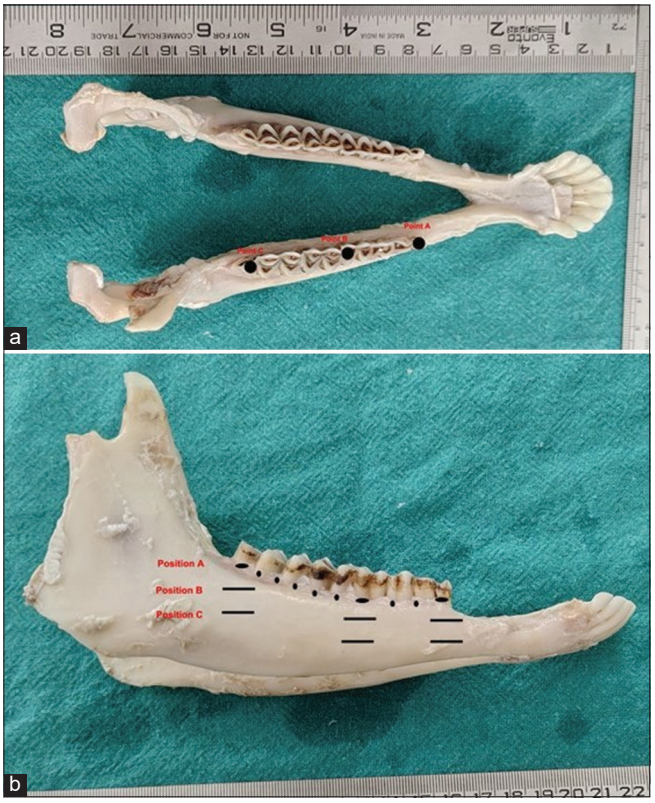


**Figure 2:** (a and b) Representation of the buccolingual thickness of the goat mandible

**Table 1:** Horizontal measurements

| *Reference number* | *Horizontal landmarks* | *Mean (mm)* | *SD* |
|---|---|---|---|
| A | Mental foramen to the base of the mandible | 8.16 | 0.86 |
| B | Lateral incisor and mental foramen | 24.80 | 1.37 |
| C | First premolar and mental foramen | 14.45 | 2.62 |
| D | Diastema length | 38.87 | 1.84 |
| E | First premolar to the distal surface of the last molar | 60.57 | 3.56 |
| F | Incisal edge of the lateral incisor to the mental foramen | 40.74 | 0.87 |
| G | Mental foramen to the caudal mandibular border | 121.77 | 6.49 |
| H | Mandibular length | 147.09 | 4.74 |

SD: Standard deviation

**Table 2:** Vertical measurements

| *Reference number* | *Vertical landmarks* | *Mean (mm)* | *SD* |
|---|---|---|---|
| I | Maximum mandibular height | 85.90 | 23.55 |
| J | Height of the mandible till the condylar process | 23.55 | 1.29 |
| K | Condylar process to coronoid process | 60.86 | 4.00 |
| L | Mandibular foramen to the ventral margin of the mandible | 35.84 | 1.17 |

SD: Standard deviation

**Table 3:** Mean thickness of the mandible

| *Reference point* | *First anterior tooth* | *Middle tooth* | *Last posterior tooth* |
|---|---|---|---|
| At the level of the alveolus | 6.23 | 7.77 | 8.19 |
| 6 mm below the alveolus | 8.44 | 9.76 | 12.12 |
| 12 mm below the alveolus | 5.89 | 9.46 | 14.65 |

## DISCUSSION

When finding a cadaveric animal model for experimental oral surgery and dentistry, the convenience, budget, and size of the bone are the key aspects evaluated to ensure ease of surgical access, fracture creation and immobilization or implantation.[6] The use of a goat mandible as an experimental model requires careful planning because its morphology differs from that of the human mandible in several respects.

The goat mandible differs from the human mandible in several important anatomical aspects. Unlike the U-shaped human mandible, the goat mandible is V-shaped and possesses a cartilaginous symphysis rather than a fused bony symphysis. It also has a prominent anterior diastema, in which the mental foramen is located. Another notable difference is the progressive reduction in the dimensions of the mandibular body from the posterior to the anterior region in all three planes, resulting in a marked decrease in bone volume anteriorly.

The findings of the present study indicate that the anterior region of the goat mandible is unsuitable for dental implant placement or the fixation of bone plates because of its limited bone dimensions. In contrast, the posterior mandibular body demonstrated adequate corticocancellous bone volume and morphology, making it a suitable site for biomechanical studies involving mandibular fracture fixation and dental implants. Furthermore, the middle dentate region of the goat mandible may serve as a useful experimental model for simulating the human dentate region in oral and maxillofacial research.

Several veterinary anatomical studies have described the morphometric characteristics of goat and sheep mandibles from different breeds.[2-5] The present study demonstrated that the Indian *Capra hircus* mandible is slightly smaller than those reported for several foreign goat breeds. Nevertheless, despite these dimensional differences, the Indian goat mandible provides several anatomically suitable sites for oral and maxillofacial research when compared with the dimensions of commonly used maxillofacial fixation hardware and standard dental implants.

From a maxillofacial trauma perspective, the posterior mandibular region of the Indian goat appears to be an appropriate experimental model for simulating subcondylar, angle, body, and parasymphysis fractures, allowing the application and evaluation of conventional miniplate fixation systems. Olivera *et al*. demonstrated the feasibility of performing sagittal split ramus osteotomies in sheep mandibles.[7] Similarly, the morphometric findings of the present study indicate that the Indian goat mandible may be a suitable model for such experimental procedures. Sheep and goats have similar anatomy of the mandible; studies by various authors, such as Suer *et al*., Jafarian *et al*., Alfakhrany *et al*., and Alkan *et al*., have shown that the sheep mandible can be used as a suitable medium to test biomechanical properties of miniplates and screws.[8-12] Similarly, for implant research, the middle and

posterior dentate regions provide adequate bone height and cortico-cancellous thickness for the placement of conventional dental implants. A microanatomical comparison of cancellous bone by Pal *et al*. revealed that the trabecular microstructure of the goat mandible is highly similar to that of humans across multiple levels.[13]

Cortico-basal implantology is also a technique in the field of dental implants that requires cortical engagement for primary stability and immediate loading. The goat mandible is thin anteriorly and possesses limited bone dimensions, but it is mostly cortical in nature, which may still serve as a suitable site for the evaluation of short corticobasal implants.[14]

The present study has certain limitations. The mandibles were collected from a local slaughterhouse, and the exact age of the goats could not be confirmed. As mandibular dimensions may increase with age, variations in the morphometric measurements due to age-related differences cannot be excluded. Furthermore, logistical and resource constraints limited the sample size, which may affect the generalizability of the findings. Future studies involving a larger sample with known age and breed distribution are recommended to validate the present observations.

## Conclusion

Within the limitations of this study, the posterior body of the Indian goat mandible demonstrated adequate morphometric characteristics for biomechanical investigations involving mandibular fracture fixation, dental implant placement, and osteotomy procedures. The middle dentate region may also serve as a suitable model for simulating the human dentate mandible. These findings provide baseline morphometric data that may facilitate the standardization of goat mandibular models in oral and maxillofacial research.

## References

1. Russett S, Major P, Carey J, Toogood R, Boulanger P. An experimental method for stereolithic mandible fabrication and image preparation. Open Biomed Eng J 2007;1:4-10.
2. Wang X, Liu A, Zhao J, Elshaer FM, Massoud D. Anatomy of the skull of Saanen goat. An anesthesiology and stereology approach. Int J Morphol 2021;39:423-9.
3. Olopade JO, Onwuka SK. Some aspects of the clinical anatomy of the mandibular and maxillofacial regions of the West African dwarf goat in Nigeria. Int J Morphol 2005;23:33-6.
4. Monfared AL, Naji H, Sheibani MT. Applied anatomy of the head region of the Iranian native goats *(Capra hircus*). Glob Vet 2013;10:60-4.
5. Dalga S. Applied anatomy to the Gurcu Goat's mandible in Kafkas and its clinical significance in regional anesthesia. Turk J Vet Res 2021;5:51-6.
6. Borie E, Calzzani R, Dias FJ, Fuentes R, Salamanca C. Morphometry of rabbit anatomical regions used as experimental models in implantology and oral surgery. Biomed Res (India) 2017;28:5468-72.
7. Olivera LB, Sant´ana E, Manzato AJ, Guerra FL, Arnett GW. Biomechanical *in vitro* evaluation of three stable internal fixation techniques used in sagittal osteotomy of the mandibular ramus: A study in sheep mandibles. J Appl Oral Sci 2012;20:419-26.
8. Evcim B, Kara ME. Morphometric analysis of the mandibula in sheep, goat and rabbit. Sloven Vet Res 2025;62:189-99.
9. Suer BT, Kocyigit ID, Kaman S, Tuz HH, Tekin U, Atil F. Biomechanical evaluation of a new design titanium miniplate for the treatment of mandibular angle fractures. Int J Oral Maxillofac Surg 2014;43:841-5.
10. Jafarian M, Pourdanesh F, Esmaeelinejad M, Dehghani N, Aghdashi F, Tabrizi R. Assessment of compression and strength of divergent screws mounted on miniplates for fixation of mandibular fractures: An *in vitro* experimental study. Br J Oral Maxillofac Surg 2015;53:613-7.
11. Alfakhrany A, Hasanein AM. Biomechanical evaluation of three dimensional titanium miniplates in mandibular fracture fixation. Egypt Dent J 2018;64:1015-28.
12. Alkan A, Metin M, Muğlali M, Özden B, Çelebi N. Biomechanical comparison of plating techniques for fractures of the mandibular condyle. Br J Oral Maxillofac Surg 2007;45:145-9.
13. Pal TK, Chakraborty A, Banerjee S. A micro-anatomical comparison of goat jaw cancellous bone with human mandible: Histomorphometric study for implant dentistry. J Int Clin Dent Res Organ 2014;6:20-3.
14. Ihde S. Indications and treatment modalities with corticobasal jaw implants. Ann Maxillofac Surg 2019;9:379-86.