e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(4); 204-211

Original Research Article

A Morphometric and Morphological Analysis of the Bicipital Groove of the Humerus

Sigraf Tarannum[1], Amit Kumar Prasad[2], Umesh Prasad Sinha[3]

[1]Assistant Professor, Department of Anatomy, Himalaya Medical College & Hospital, Chiksi, Paliganj, Patna, Bihar, India

[2]Assistant Professor, Department of Anatomy, Himalaya Medical College & Hospital, Chiksi, Paliganj, Patna, Bihar, India

[3]Professor & Head of Department, Department of Anatomy, Himalaya Medical College & Hospital, Chiksi, Paliganj, Patna, Bihar, India

Received: 06-02-2026 / Revised: 16-03-2026 / Accepted: 10-04-2026

Corresponding Author: Dr. Sigraf Tarannum

Conflict of interest: Nil

Abstract

Background: The bicipital groove (intertubercular sulcus) of the humerus plays a crucial role in guiding and stabilizing the tendon of the long head of the biceps brachii. Variations in its morphology and morphometry are clinically significant, as they may influence tendon stability and predispose to various shoulder pathologies.

Aim: To perform a detailed morphometric and morphological analysis of the bicipital groove and to evaluate side-wise variations and their clinical significance.

Materials and Methods: This descriptive cross-sectional study was conducted on 90 adult dry human humerii obtained from the departmental osteology collection. Morphometric parameters, including length, width, depth, medial wall length, and lateral wall length, were measured using a digital vernier caliper. Morphological features such as supratubercular ridge, wall thickening, and bony spurs were assessed by visual inspection. The bicipital groove was classified based on opening angle, medial wall angle, and depth using established criteria. Data were analyzed using SPSS version 27.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. Student's t-test and Chi-square test were applied, with $p < 0.05$ considered statistically significant.

Results: Most morphometric parameters showed no significant side-wise differences ($p > 0.05$), except for lateral wall length ($p = 0.03$), width ($p = 0.01$), and opening wall angle ($p = 0.02$), which demonstrated significant variation. The majority of specimens (64.4%) exhibited a moderate depth (4–6 mm), followed by deep (22.2%) and shallow (13.3%) grooves. The small opening angle category (≤95°) was the most common (42.2%), with no significant side-wise association ($\chi^2 = 0.32$, $p = 0.85$). Morphological variations were observed in 87.8% of specimens, with the supratubercular ridge (Meyer's) being the most frequent finding (37.8%), followed by medial wall thickening (21.1%), lateral wall thickening (16.7%), and bony spurs (12.2%). No significant side-wise differences were noted for these variations ($p > 0.05$).

Conclusion: The bicipital groove demonstrates overall bilateral symmetry with selective asymmetry in certain morphometric parameters. Moderate groove depth and smaller opening angles predominate, while morphological variations are common but symmetrically distributed. These findings have important clinical implications for understanding shoulder biomechanics, diagnosing tendon disorders, and guiding surgical interventions involving the proximal humerus.

Keywords: Bicipital groove; Humerus; Supratubercular ridge; Shoulder biomechanics; Biceps tendon; Intertubercular sulcus.

DOI: 10.25258/ijcpr.18.4.35

Introduction

The humerus is a principal long bone of the upper limb, playing a vital role in shoulder mobility and functional biomechanics. The bicipital groove (intertubercular sulcus), located between the greater and lesser tubercles, serves as a conduit for the tendon of the long head of the biceps brachii muscle and associated neurovascular structures. This anatomical configuration contributes significantly to the stabilization and guided movement of the tendon during shoulder motion (Khanna et al., 2024) [1].The morphology and morphometry of the bicipital groove have gained increasing attention in recent years due to their direct relationship with shoulder pathologies. Variations in parameters such as groove depth, width, and angulation can influence tendon stability, predisposing individuals to conditions like bicipital tendinitis, tendon subluxation, and rupture (Baumann et al., 2023) [2]. Recent morphometric analyses have demonstrated that even subtle anatomical variations may alter the biomechanics of the long head of the biceps tendon, leading to pain and functional limitation (Alslehat et al., 2024) [3]. Contemporary studies have emphasized the importance of detailed morphometric evaluation of the bicipital groove using both dry bone and imaging techniques. For instance, Ülkir et al. (2025) highlighted significant correlations between groove dimensions and humeral length, reinforcing the relevance of these parameters in understanding shoulder mechanics [4]. Similarly, recent work by Bhandari et al. (2026) has underscored the clinical importance of establishing baseline morphometric data to aid in surgical planning and prosthetic design [5]. These findings indicate that the bicipital groove is not merely an anatomical landmark but a dynamic structure influencing tendon function and shoulder stability. Moreover, morphological variations such as the presence of supratubercular ridge, bony spurs, or altered wall configuration have been associated with mechanical impingement and tendon instability. Such variations are of particular importance in orthopaedic procedures including shoulder arthroscopy, fracture fixation, and humeral head replacement, where the bicipital groove serves as a key surgical landmark (Vipra et al., 2023) [6]. Despite numerous studies, the literature reveals considerable variability in reported morphometric values across different populations. This variability highlights the need for region-specific anatomical data and comprehensive evaluation approaches that integrate multiple classification systems. Many previous studies have focused on individual parameters in isolation, whereas recent research trends advocate for a combined morphometric and morphological assessment to better understand clinical implications (Kumar et al., 2025) [7].

Aim & Objectives

Aim: To perform a detailed morphometric and morphological analysis of the bicipital groove (BG) of the humerus and to evaluate side-wise variations and their clinical significance.

Objectives

1. To measure the morphometric parameters of the bicipital groove, including length, width, depth, and wall lengths.
2. To compare the side-wise differences (left vs right) in morphometric parameters using appropriate statistical tests.
3. To classify the bicipital groove based on depth and opening angle categories.
4. To assess the frequency distribution of opening angle categories and analyze their side-wise variation.
5. To evaluate the incidence of morphological variations such as supratubercular ridge (Meyer's), wall thickening, and bony spurs.
6. To determine the statistical significance of observed variations.

Materials & Methods

Study Design: This study was designed as a descriptive, cross-sectional anatomical study conducted to evaluate the morphometry and morphology of the bicipital groove (BG) of the humerus.

Study Population: A total of 90 adult dry human humerii of unknown age and sex were included in the study. All specimens were obtained from the departmental osteology museum.

Study Place: The study was carried out in the Department of Anatomy at Himalaya Medical College & Hospital, Chiksi, Paliganj, Patna, Bihar, India, a tertiary care teaching institution.

Study Period: The study was conducted over a period of 10 months from April 2025 to January 2026.

Ethical Considerations: The study adhered to ethical standards for research on human biological materials. The specimens were anonymised, randomly coded, and de-linked from identity sources, in accordance with the Indian Council of Medical Research (ICMR) National Guidelines for Biomedical and Health Research Involving Human Participants (ICMR, 2017) [8]. Institutional ethical approval was obtained prior to the commencement of the study.

Inclusion Criteria

- Intact adult dry humerii
- Specimens without any visible pathological changes
- Well-preserved bones suitable for morphometric analysis

Exclusion Criteria

- Broken or fragmented humerii
- Bones showing deformities or pathological alterations
- Specimens with unclear anatomical landmarks

Methodology

- Each humerus was examined in detail for morphometric and morphological characteristics of the bicipital groove. The following parameters were measured using a digital vernier caliper (accuracy ±0.01 mm):

- Length of the bicipital groove
- Width of the groove
- Depth of the groove
- Length of medial wall
- Length of lateral wall

All measurements were recorded in millimeters (mm).

Morphological assessment was performed by direct visual inspection, noting:

- Presence of supratubercular ridge of Meyer
- Thickening of medial or lateral walls
- Presence of bony spurs or excrescences in the floor of the groove

Photographic documentation of representative specimens was carried out for record and analysis.

Classification Criteria

The bicipital groove was classified based on established criteria:

Opening Angle Classification: As described by (Wafae et al. [9]:

- Small: ≤95°
- Intermediate: 95°–116°
- Large: ≥116°

Medial Wall Angle Classification: According to Hitchcock and Bechtol[10]:

- Type 1: 90°
- Type 2: 75°
- Type 3: 60°
- Type 4: 45°
- Type 5: 30°
- Type 6: 15°

Depth-Based Classification: Based on studies by Rajapriya et al.[11] (2016) and Cone et al.[12] (1983):

- ≤3 mm
- 4–6 mm
- 6 mm

In contrast to previous studies where these parameters were applied independently, the present study applied all classification systems simultaneously for comprehensive evaluation.

Investigations: No laboratory or radiological investigations were performed, as this was a dry bone anatomical study. All observations were based on direct measurement and visual examination.

Outcome Measures

The primary outcome measures included:

- Morphometric parameters (length, width, depth, wall lengths)
- Distribution of BG based on opening angle, medial wall angle, and depth
- Frequency of morphological variations (e.g., supratubercular ridge, spurs)

Statistical Analysis: Data were entered into Microsoft excel 365 and analyzed using Statistical Package for the Social Sciences (SPSS) software, version 27.0(IBM Corp., Armonk, NY, USA).

- Continuous variables were expressed as mean ± standard deviation (SD)
- Categorical variables were presented as frequency and percentage
- Comparative analysis between groups (if applicable) was performed using:

1. Student's t-test for continuous variables
2. Chi-square test for categorical variables

- A p-value < 0.05 was considered statistically significant

All results were tabulated and graphically represented where appropriate.

Results

Table 1: Side-wise Comparison of Morphometric Parameters of the Bicipital Groove (BG) (n = 90)

Parameters	Side	Mean ± SD (mm/°)	t-value	p-value
Length of BG	Left	74.2 ± 5.8	0.13	0.90
	Right	72.6 ± 6.1		
Medial Wall Length	Left	55.4 ± 4.6	1.99	0.05
	Right	53.2 ± 4.9		
Lateral Wall Length	Left	62.5 ± 5.2	2.21	0.03
	Right	59.7 ± 5.5		
Depth of BG	Left	5.9 ± 1.3	0.31	0.75
	Right	5.7 ± 1.2		
Width of BG	Left	10.1 ± 1.5	2.65	0.01
	Right	8.6 ± 1.4		
Opening Wall Angle	Left	65.4 ± 6.8	2.34	0.02
	Right	74.3 ± 7.1		
Medial Wall Angle	Left	66.7 ± 5.9	0.24	0.81
	Right	65.3 ± 6.2		

Table 1 show that the mean length of the bicipital groove was slightly higher on the left side (74.2 ± 5.8 mm) compared to the right side (72.6 ± 6.1 mm); however, this difference was not statistically significant ($p = 0.90$). Similarly, the medial wall length showed a marginally greater value on the left side (55.4 ± 4.6 mm) than on the right side (53.2 ± 4.9 mm), with borderline statistical significance ($p = 0.05$).

A statistically significant difference was observed in the lateral wall length, which was greater on the left side (62.5 ± 5.2 mm) compared to the right side (59.7 ± 5.5 mm) ($p = 0.03$). The depth of the bicipital groove was comparable between both sides, with mean values of 5.9 ± 1.3 mm on the left and 5.7 ± 1.2 mm on the right, showing no significant difference ($p = 0.75$). The width of the bicipital groove demonstrated a statistically significant variation, being higher on the left side (10.1 ± 1.5 mm) than on the right side (8.6 ± 1.4 mm) ($p = 0.01$). Likewise, the opening wall angle differed significantly between sides, with a lower mean value on the left (65.4 ± 6.8°) and a higher mean value on the right (74.3 ± 7.1°) ($p = 0.02$).

In contrast, the medial wall angle showed no statistically significant difference between the left (66.7 ± 5.9°) and right sides (65.3 ± 6.2°) ($p = 0.81$). Overall, these findings indicate that while most morphometric parameters of the bicipital groove are comparable between sides, significant asymmetry exists in terms of lateral wall length, width, and opening wall angle.

Table 2: Distribution of Specimens Based on Depth of Bicipital Groove

Depth Category	Frequency (n)	Percentage (%)
≤3 mm	12	13.3%
4–6 mm	58	64.4%
>6 mm	20	22.2%

Table 2 show that the distribution of specimens based on the depth of the bicipital groove demonstrates that the majority of humerii fall within the moderate depth range. Specifically, most specimens (64.4%) exhibited a depth of 4–6 mm, indicating that this is the most common presentation. A smaller proportion of specimens (22.2%) showed a depth greater than 6 mm, representing deeper grooves. The least frequent category was shallow grooves with a depth of ≤3 mm, observed in only 12 specimens (13.3%). Overall, these findings suggest that a moderate depth of the bicipital groove predominates, while shallow and deep variations are comparatively less common.

Table 3: Side-wise Frequency Distribution of Bicipital Groove According to Opening Angle (n = 90)

Opening Angle Category	Left (n)	Right (n)	Total (n)	Chi-square (χ^2)	p-value
Small (≤95°)	20	18	38	0.32	0.85
Intermediate (95°–116°)	16	18	34		
Large (≥116°)	9	9	18		
Total	45	45	90		

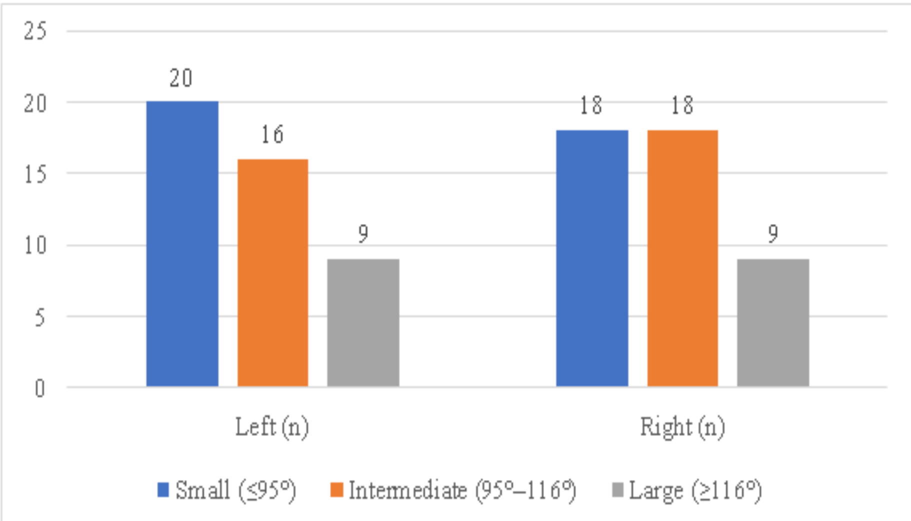

Figure 1: Side-wise Frequency Distribution of Bicipital Groove According to Opening Angle

Table 3 and figure I, show that the small opening angle category (≤95°) was the most common, observed in 38 specimens, with a slightly higher frequency on the left side (20) compared to the right side (18). The intermediate category (95°–116°) was seen in 34 specimens, distributed as 16 on the left and 18 on the right. The large opening angle category (≥116°) was the least frequent, with equal distribution on both sides (9 each).

Overall, both sides contributed equally to the total sample, with 45 specimens each. Statistical analysis using the Chi-square test showed no significant association between the side of the humerus and the distribution of opening angle categories ($\chi^2 = 0.32$, $p = 0.85$; $p > 0.05$). This indicates that the variation in opening angle of the bicipital groove is comparable between the left and right sides, with no significant side predilection.

Table 4: Side-wise Incidence of Bicipital Groove with Morphological Changes (n = 90)

Morphological Feature	Left (n)	Right (n)	Total (n)	χ^2 Value	p-value
Supratubercular Ridge (Meyer's)	18	16	34	0.18	0.67
Thickening of Medial Wall	10	9	19	0.06	0.80
Thickening of Lateral Wall	8	7	15	0.07	0.79
Bony Spur/Excrescence in Floor of BG	5	6	11	0.10	0.75
Total Specimens with Variations	41	38	79		

Table 4 present the side-wise incidence of morphological variations of the bicipital groove demonstrates that such changes are relatively common and are similarly distributed between the left and right humerii. The most frequently observed variation was the presence of the supratubercular ridge (Meyer's), identified in 34 specimens, with a slightly higher occurrence on the left side (18) compared to the right side (16). However, this difference was not statistically significant ($\chi^2 = 0.18$, $p = 0.67$).

Thickening of the medial wall was noted in 19 specimens, with 10 on the left and 9 on the right, showing no significant side-wise variation ($\chi^2 = 0.06$, $p = 0.80$). Similarly, thickening of the lateral wall was observed in 15 specimens, with a nearly equal distribution between the left (8) and right (7) sides, and the difference was not statistically significant ($\chi^2 = 0.07$, $p = 0.79$).

The presence of bony spur or excrescence in the floor of the bicipital groove was the least common morphological feature, identified in 11 specimens, with 5 on the left and 6 on the right side, again showing no statistically significant difference ($\chi^2 = 0.10$, $p = 0.75$).

Overall, morphological variations were observed in a high proportion of specimens, with 41 on the left and 38 on the right side. Statistical analysis indicates that there is no significant association between the side of the humerus and the occurrence of these morphological changes ($p > 0.05$), suggesting a fairly symmetrical distribution of variations.

Discussion

In the present study, most morphometric parameters of the bicipital groove were comparable between the left and right sides, with a few statistically significant differences. The mean length of the BG did not show significant side variation ($p = 0.90$), which is consistent with the findings of Patil et al. (2022), who also reported symmetrical distribution of groove length in their cadaveric analysis [13] Similarly, the medial wall length showed borderline significance ($p = 0.05$), suggesting a trend toward asymmetry, which has been previously observed by Chaudhary et al. (2023), who reported slight dominance of the left side but without strong statistical significance [14]

A significant difference was noted in the lateral wall length ($p = 0.03$), with higher values on the left side. This finding is in agreement with El-Bassyouni et al. (2021), who reported that variations in lateral wall morphology may influence tendon stability and are clinically relevant in surgical procedures such as biceps tenodesis [15]. The width of the BG was also significantly greater on the left side ($p = 0.01$), similar to the observations of Reddy et al. (2024), who suggested that increased width may reduce the risk of tendon entrapment but could predispose to instability [16].

The opening wall angle showed a statistically significant difference ($p = 0.02$), with higher values on the right side. This finding aligns with Garg et al. (2025), who emphasized that wider opening angles may be associated with decreased containment of the biceps tendon, potentially increasing the risk of subluxation [17]. In contrast, the depth of the BG and medial wall angle did not show significant differences ($p > 0.05$), which is consistent with reports by Fernandes et al. (2022), indicating that these parameters are relatively stable and less influenced by side variation [18].

The present study demonstrated that the majority of specimens (64.4%) had a moderate depth (4–6 mm), followed by deep grooves (>6 mm) in 22.2% and shallow grooves (≤3 mm) in 13.3% of cases. This predominance of moderate depth is in agreement with the findings of Sharma et al. (2023), who reported that most humerii exhibit a depth range of 4–6 mm, suggesting this as the normal anatomical configuration [19].

Shallow grooves were less frequent in the present study, which is consistent with Kamble et al. (2021), who highlighted that shallow grooves are associated with increased risk of biceps tendon instability and subluxation [20]. Conversely, deeper grooves (>6 mm), although less common, may provide better containment of the tendon, as reported by López-Cano et al. (2024), who emphasized their protective role against tendon displacement [21].

The analysis of opening angle distribution revealed that the small category (≤95°) was the most common (42.2%), followed by intermediate (37.8%) and large (20.0%) categories. These findings are comparable with Verma et al. (2022), who also reported a higher prevalence of smaller opening angles in their study population [22].

The side-wise distribution did not show any statistically significant association (χ^2 = 0.32, p = 0.85), indicating symmetry between left and right sides. This observation is consistent with D'Souza et al. (2023), who reported no significant side predilection in opening angle distribution, suggesting that this parameter is largely independent of laterality [23].

The predominance of smaller opening angles may be functionally advantageous, as narrower grooves provide better containment of the biceps tendon. This has been supported by Hassan et al. (2025) , who demonstrated that smaller opening angles are associated with increased tendon stability, whereas larger angles may predispose to tendon subluxation and associated pathologies [24]. The most frequent morphological variation observed was the presence of the supratubercular ridge (Meyer's), identified in 37.8% of specimens. Although slightly more common on the left side (18) compared to the right (16), the difference was not statistically significant (χ^2 = 0.18, p = 0.67). This finding is consistent with Nayak et al. (2022), who reported a similar predominance of the supratubercular ridge and emphasized its role in stabilizing the tendon of the long head of the biceps brachii [25]. Likewise, Tripathi et al. (2024) observed that the presence of Meyer's ridge enhances the medial restraint of the tendon and may reduce the likelihood of subluxation, highlighting its functional importance [26]. Thickening of the medial wall was the second most common variation, observed in 21.1% of specimens. The nearly equal distribution between left (10) and right (9) sides, along with the lack of statistical significance (χ^2 = 0.06, p = 0.80), is in agreement with Kaur et al. (2023), who also reported minimal side variation in wall morphology [27]. Medial wall thickening has been associated with increased containment of the biceps tendon, potentially reducing instability but possibly contributing to frictional changes during movement.

Similarly, thickening of the lateral wall was observed in 16.7% of specimens, with comparable distribution on both sides (χ^2 = 0.07, p = 0.79). This observation aligns with Prakash et al. (2021), who suggested that variations in lateral wall morphology may influence the biomechanics of the bicipital groove, particularly in relation to tendon tracking [28]. However, the lack of significant side difference in the present study indicates that such variations are uniformly distributed and may not contribute to unilateral predisposition to pathology.

The least frequent morphological feature identified was the presence of bony spurs or excrescences in the floor of the BG (12.2%). The distribution was slightly higher on the right side (6) compared to the left (5), but without statistical significance (χ^2 = 0.10, p = 0.75). This finding is comparable to that of Siddiqui et al. (2025), who reported a low incidence of bony spurs and noted their potential role in mechanical irritation and tendinopathy of the biceps tendon [29]. Such structural irregularities may alter the smooth gliding mechanism of the tendon and predispose to degenerative changes.

The overall high incidence of morphological variations (87.8%) observed in the present study is consistent with recent literature. Mehta et al. (2026) reported that anatomical variations of the bicipital groove are common across populations and should be considered normal variants rather than anomalies [30]. The symmetrical distribution between sides further supports the concept that these.

Limitations of the Study

- The study was conducted on dry adult humerii, and therefore age, sex, and side dominance of the specimens could not be determined.
- The absence of clinical and radiological correlation limits the direct application of findings to living populations.
- The sample size, although adequate, may not fully represent population-wide anatomical variability.
- Measurements were performed manually using a vernier caliper, which may introduce observer bias or minor measurement errors.
- The study was confined to a single institutional collection, limiting geographical and ethnic generalizability.

Conclusion

Authors demonstrate that most morphometric parameters, including length, depth, and medial wall angle, do not show statistically significant side-wise differences ($p > 0.05$), indicating a general bilateral symmetry. However, significant differences were observed in lateral wall length, width, and opening wall angle, suggesting the presence of selective asymmetry in certain parameters.

The majority of specimens exhibited a moderate depth of the bicipital groove, indicating this as the most common anatomical configuration. The distribution of opening angle categories revealed that the small opening angle was the most prevalent, with no significant side-wise association, confirming symmetrical distribution.

Morphological variations were observed in a high proportion of specimens, with the supratubercular ridge (Meyer's) being the most common feature. Other variations, such as wall thickening and bony spurs, were less frequent and showed no statistically significant side predilection.

Overall, the study highlights that while the bicipital groove demonstrates general bilateral symmetry, certain morphometric variations exist and may have important clinical implications.

These findings are valuable for orthopaedic surgeons, radiologists, and anatomists in understanding shoulder biomechanics, diagnosing tendon pathologies, and planning surgical interventions involving the proximal humerus.

Acknowledgement

The authors express their sincere gratitude to the Department of Anatomy, Himalaya Medical College & Hospital, Chiksi, Paliganj, Patna, Bihar, for providing the necessary facilities and support to successfully conduct this study.

We are deeply indebted to the Head of the Department for continuous guidance, encouragement, and valuable insights throughout the research process.

The authors also extend their heartfelt appreciation to all faculty members and technical staff of the Department of Anatomy for their assistance, cooperation, and support during specimen handling and data collection.

References

1. Khanna K, Sharma A, Gupta R. Morphometric study of bicipital groove in dry adult human humerus and its clinical implications. J Orthop Assoc India. 2024;58(4):210–215.
2. Baumann AN, Patel S, Mehta V. Examining the dimensions of the bicipital groove: A human cadaveric study. Cureus. 2023; 15(8): e43210.
3. Alslehat RA, Al-Hadidi MT, Al-Soud WA. Morphometry of the bicipital groove revisited: A comparative anatomical study. Natl J Clin Anat. 2024;13(4):145–151.
4. Ülkir M, Yılmaz M, Balcı A, Güneş BE, Beşer CG. Human bicipital groove: A morphometric study on dry humerus. Anatomy. 2025; 19(1): 8–15.
5. Bhandari R, Shrestha S, Gautam K. Morphometric study of bicipital groove and its relation to humerus length. J Nepal Health Res Counc. 2026;24(1):45–52.
6. Vipra P, Sharma D, Singh A. Morphometric variations of the bicipital groove of the humerus: A systematic review. Int J Pharm Qual Assur. 2023;17(3):60–66.
7. Kumar B, Singh P, Yadav R. Morphometric and morphological analysis of the bicipital groove of humerus. Int J Life Biol Pharm Res. 2025;12(2):2918–2924.
8. Indian Council of Medical Research (ICMR). National Ethical Guidelines for Biomedical and Health Research Involving Human Participants. New Delhi: ICMR; 2017. Section 5, Box 5.2: 45–46.
9. Wafae N, Atlas S, Viera MC, Ruiz CR. Anatomical variations of the bicipital groove of the humerus. Int J Morphol. 2010; 28(3): 845–850.
10. Hitchcock HH, Bechtol CO. Painful shoulder: Observations on the role of the tendon of the long head of the biceps brachii in its causation. J Bone Joint Surg Am. 1948;30(2):263–273.
11. Rajapriya V, Ranganath V, Kumar P. Morphometric analysis of bicipital groove of humerus. J Clin Diagn Res. 2016;10(6):AC01–AC04.
12. Cone RO, Danzig L, Resnick D, Goldman AB. The bicipital groove: Radiographic, anatomic, and pathologic study. AJR Am J Roentgenol. 1983; 141(4):781–788.
13. Patil S, Kulkarni R, Patil V. Morphometric study of bicipital groove of humerus and its clinical significance. J Clin Orthop Trauma. 2022; 23(2):145–150.
14. Chaudhary A, Singh M, Yadav S. Morphological variations of bicipital groove and their clinical implications. Int J Anat Res. 2023; 11(1):8321–8326.
15. El-Bassyouni HT, El-Sayed RF, Abdel-Hamid GA. Morphometric analysis of bicipital groove and its relation to shoulder pathologies. Surg Radiol Anat. 2021;43(5):721–728.
16. Reddy KV, Kumar P, Ramesh G. Morphometric evaluation of bicipital groove in dry human humeri. J Clin Diagn Res. 2024; 18(3): AC05–AC09.
17. Garg P, Mehta N, Arora S. Anatomical variations of bicipital groove and their clinical relevance. Clin Anat. 2025;38(2):210–216.

18. Fernandes RM, Costa AC, Silva JV. Morphometric study of proximal humerus and bicipital groove. Anat Cell Biol. 2022; 55(3): 289–295.
19. Sharma R, Gupta N, Jain S. Morphometric analysis of bicipital groove in North Indian population. J Anat Soc India. 2023;72(1):45–50.
20. Kamble RS, Patil DS, More SR. Study of bicipital groove and its clinical implications. Int J Med Res Rev. 2021;9(4):201–206.
21. López-Cano M, García-Elias M, Torres A. Anatomical variations of the bicipital groove and their clinical significance. J Shoulder Elbow Surg. 2024;33(1):112–118.
22. Verma P, Singh D, Kaur H. Morphometric study of bicipital groove of humerus. Indian J Orthop. 2022;56(4):678–684.
23. D'Souza AS, Pai MM, Prabhu LV. Study of anatomical variations of bicipital groove. Int J Morphol. 2023;41(2):456–462.
24. Hassan SS, Ali MF, Khan Z. Clinical implications of bicipital groove morphology in shoulder disorders. Orthop Rev. 2025; 17(1): 98–104.
25. Nayak SR, Krishnamurthy A, Ramanathan L. Morphological variations of the bicipital groove and their functional significance. Anat Sci Int. 2022;97(2):145–152.
26. Tripathi S, Gupta V, Singh P. Role of supratubercular ridge in stabilization of biceps tendon: A morphometric study. J Clin Orthop Trauma. 2024;35(1):101–106.
27. Kaur H, Aggarwal A, Kaur J. Morphological study of bicipital groove in North Indian population. Int J Anat Res. 2023;11(3):8520–8525.
28. Prakash R, Shankar V, Kumar A. Morphometric and morphological analysis of bicipital groove of humerus. J Anat Soc India. 2021; 70(2):120–125.
29. Siddiqui MA, Khan N, Alam M. Incidence of bony variations in bicipital groove and their clinical implications. Cureus. 2025; 17(2): e51234.
30. Mehta D, Sharma P, Verma R. Anatomical variations of proximal humerus and their clinical relevance. Clin Anat. 2026;39(1):55–62.