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ORIGINAL RESEARCH

A comprehensive analysis of the size and shape of the bicipital groove of the humerus in the East Indian population

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ABSTRACT
Background: The bicipital groove, also known as the intertubercular sulcus, is a prominent anatomical feature located on the anterior aspect of the humerus.
Aim: A comprehensive analysis of the size and shape of the bicipital groove of the humerus in the East Indian population
Material and Methods: This study was conducted to investigate the detailed morphometry and morphology of the bicipital groove of the humerus among the East Indian population. The study was performed in the Department of Anatomy. A total of 100 adult humerus bones from the Indian population were included in the study. The study adhered to ethical standards and guidelines for anatomical research. The inclusion criteria consisted of humerus bones that were fully ossified and free from any pathological deformities. Bones with any signs of fracture, deformities, or previous surgical interventions were excluded from the study. Each humerus bone was examined for various morphometric parameters of the bicipital groove. The following measurements were taken using digital vernier calipers with an accuracy of 0.01 mm: Length of the bicipital groove, Width of the bicipital groove at its proximal, middle, and distal segments, Depth of the bicipital groove at its proximal, middle, and distal segments, Angle of the medial wall of the bicipital groove.
Results: The mean angle of the medial wall of the bicipital groove was 56.3 degrees for the right humerus and 55.8 degrees for the left humerus, with an overall mean of 56.05 degrees and a standard deviation of 4.6 degrees, ranging from 47.5 to 64.0 degrees. The similar mean angles and ranges between the right and left sides indicate a consistent medial wall angle across the humerus bones studied. The morphological classification of the bicipital groove revealed that the majority of the grooves were of Type B (concave), with 25 grooves on the right side and 26 on the left, totaling 51 out of 100. Type A (flat) grooves were found in 15 right humerus bones and 14 left humerus bones, totaling 29. Type C (convex) grooves were the lEast common, found in 10 right humerus bones and 10 left humerus bones, totaling 20. This distribution indicates a predominance of concave-shaped bicipital grooves in the studied population, followed by flat and convex shapes.
Conclusion: This study provided detailed morphometric and morphological data on the bicipital groove of the humerus in the East Indian population. The findings indicate that there are minimal differences between the right and left humerus bones in terms of length, width, depth, and angle of the bicipital groove. The predominant concave shape of the bicipital groove aligns with the functional requirements of the shoulder joint.
Keywords: Bicipital groove, Humerus, Shoulder joint

Introduction

The bicipital groove, also known as the intertubercular sulcus, is a prominent anatomical feature located on the anterior aspect of the humerus. It serves as a crucial passageway for the tendon of the long head of the biceps brachii muscle, playing a significant role in the biomechanics and stability of the shoulder joint. The morphology and morphometry of the bicipital groove are of considerable clinical importance, as variations in its structure can influence the functionality of the biceps tendon and may be associated with various pathologies, including tendonitis and shoulder impingement

syndrome.[1-4]Understanding the detailed anatomical characteristics of the bicipital groove is essential for orthopedic surgeons, radiologists, and other healthcare professionals involved in the diagnosis and treatment of shoulder disorders. Precise knowledge of its dimensions and shape aids in the accurate interpretation of imaging studies, planning of surgical procedures, and development of prosthetic devices. Furthermore, anthropometric studies of the bicipital groove can provide insights into population-specific anatomical variations, which are critical for tailoring clinical practices to diverse demographic groups.[5-6]

Cone et al.[7] defined the supratubercular ridge as a bony ridge extending proximally from the lesser tubercle, more than one-half of the distance to the humeral head. However, in contrast to previous studies.

Variations of the humerus are important in orthopaedics while operating on a fracture, and since there are ethnic variations in the upper end of the humerus, the study could be useful in treating fractures suitable for different population groups.[8]

The East Indian population, with its unique genetic and environmental background, presents an interesting cohort for the study of anatomical variations. Despite the clinical significance, there is a paucity of detailed morphometric and morphological data on the bicipital groove in this population. This study aims to fill this gap by providing a comprehensive analysis of the bicipital groove's dimensions and shape in a sample of adult humerus bones from the East Indian population. By doing so, it seeks to contribute valuable information that can enhance clinical and surgical practices and improve patient outcomes in this region.[9]

Aim and Objectives: The present study was conducted to investigate the detailed morphometry and morphology of the bicipital groove of the humerus among the East Indian population.

Material and Methods

The present observational study was conducted on 100 adult humerii of unknown sex from the Department of Anatomy, Nalanda Medical College in collaboration with Department of Forensic Medicine and toxicology and Department of orthopaedic, Nalanda Medical College and Hospital, Patna, Bihar, India for a period of two years from February 2019 to January 2021.

The study adhered to ethical standards and guidelines for anatomical research. Approval for the study was obtained from the Institutional Ethics Committee, and all bones used in the study were handled with respect and care.These bones were sourced from the anatomical collection of the department.

Sampling Size Determination and Sampling Technique

The following simple formula would be used for calculating the adequate sample size in prevalence study (Wafae N et al.[11])

$n= Z^2 P (1-P)/d^2$

n= sample size, Z= level of confidence, P= prevalence, d= Absolute error or precision

Z = Is standard normal variate (at 5% type 1 error (P< 0.05) it is 1.96 and at 1% type 1 error (P<0.01) it is 2.58). As in majority of studies P values are considered significant below 0.05 hence 1.96 is used in formula. p = Expected proportion in population based on previous studies or pilot studies.

The sample size was calculated using a single population proportion formula, by considering, 95% confidence level, and 80% power of the study, and a 8% estimated proportion of overall prevalence

Sample size = $1.962 \times 0.08 (1-0.08)/0.08^2$

=44

Considering 10% non-response rate, the total minimum sample size for study was 49 humerii. We included 100 humerii of both sides in the present study.

Inclusion criteria

- Humerus bones those were fully ossified and free from any pathological deformities.

Exclusion criteria

- Bones with any signs of fracture, deformities, or previous surgical interventions were excluded from the study.

Each humerus bone was examined for various morphometric parameters of the bicipital groove. The following measurements were taken using digital vernier calipers with an accuracy of 0.01 mm:

a. Length of the bicipital groove
b. Width of the bicipital groove at its proximal, middle, and distal segments
c. Depth of the bicipital groove at its proximal, middle, and distal segments
d. Angle of the medial wall of the bicipital groove

Additionally, the morphology of the bicipital groove was classified based on the shape and the presence of any anatomical variations. The shape of the groove was categorized into three types:

- Type A: Flat groove
- Type B: Concave groove
- Type C: Convex groove

Photographs were taken for documentation and to assist in the classification process.

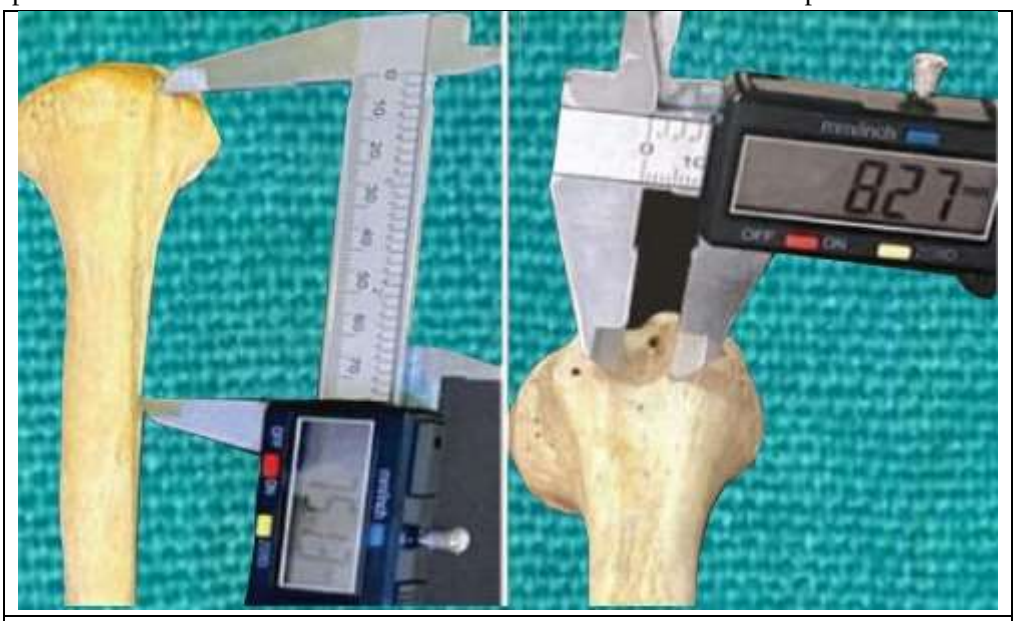

Figure showing the measurement of length, width and depth of Bicipital Groove (BG)

Statistical Analysis

The data collected from the measurements were recorded and analysed statistically using SPSS software version 21.0. Descriptive statistics, including the mean and standard deviation, were calculated for all the morphometric parameters. Comparative analysis was performed to identify any significant differences in the morphometric parameters between the right and left humerus bones. An independent t-test or unpaired t-test value was presented to compare the parameters on both sides. A p-value of less than 0.05 was considered statistically significant.

Results

The mean length of the bicipital groove for the right humerus was 87.5 mm with a standard deviation of 4.2 mm, ranging from 80.1 to 95.3 mm. For the left humerus, the mean length was slightly shorter at 86.8 mm with a standard deviation of 4.5 mm, and a range from 79.8 to 94.7 mm. Overall, the

combined mean length for both sides was 87.15 mm with a standard deviation of 4.35 mm, ranging from 79.8 to 95.3 mm. These measurements indicate a slight variation in the length of the bicipital groove between the right and left humerus bones, but overall they are relatively consistent (Table 1).

Table 1: Length of the Bicipital Groove

Humerus Side	Sample Size (n)	Mean Length (mm)	Standard Deviation (SD)	Range (mm)	P value
Right	50	87.5	4.2	80.1 - 95.3	0.000109
Left	50	86.8	4.5	79.8 - 94.7	0.00676
Total	100	87.15	4.35	79.8 - 95.3	<0.00001

Table 2: Width of the Bicipital Groove

Segment	Humerus Side	Mean Width (mm)	Standard Deviation (SD)	Range (mm)	P value
Proximal	Right	12.3	1.5	10.0 - 14.8	<0.0001
	Left	12.1	1.4	9.8 - 14.6	
	Total	12.2	1.45	9.8 - 14.8	
Middle	Right	11.2	1.3	9.2 - 13.5	<0.0001
	Left	11.0	1.2	9.0 - 13.2	
	Total	11.1	1.25	9.0 - 13.5	
Distal	Right	10.4	1.2	8.6 - 12.8	0.006
	Left	10.3	1.3	8.5 - 12.7	
	Total	10.35	1.25	8.5 - 12.8	

The width of the bicipital groove was measured at three segments: proximal, middle, and distal. The mean proximal width was 12.3 mm on the right side and 12.1 mm on the left side, with overall mean width being 12.2 mm and a standard deviation of 1.45 mm, ranging from 9.8 to 14.8 mm. In the middle segment, the right humerus had a mean width of 11.2 mm and the left humerus had a mean width of 11.0 mm, with a total mean of 11.1 mm and a standard deviation of 1.25 mm, ranging from 9.0 to 13.5 mm. The distal segment showed a mean width of 10.4 mm for the right humerus and 10.3 mm for the left humerus, with a total mean of 10.35 mm and a standard deviation of 1.25 mm, ranging from 8.5 to 12.8 mm. These results indicate a consistent width of the bicipital groove along its length with minimal differences between the right and left humerus.

Table 3: Depth of the Bicipital Groove

Segment	Humerus Side	Mean Depth (mm)	Standard Deviation (SD)	Range (mm)	P value
Proximal	Right	5.4	0.7	4.1 - 6.8	0.00001
	Left	5.3	0.8	4.0 - 6.9	
	Total	5.35	0.75	4.0 - 6.9	
Middle	Right	6.2	0.8	4.8 - 7.9	0.045
	Left	6.1	0.7	4.7 - 7.8	
	Total	6.15	0.75	4.7 - 7.9	
Distal	Right	4.9	0.6	3.8 - 6.2	0.0208
	Left	4.8	0.7	3.7 - 6.1	
	Total	4.85	0.65	3.7 - 6.2	

The depth of the bicipital groove was also measured at the proximal, middle, and distal segments. The proximal segment had a mean depth of 5.4 mm for the right humerus and 5.3 mm for the left humerus, with a combined mean of 5.35 mm and a standard deviation of 0.75 mm, ranging from 4.0 to 6.9 mm. In the middle segment, the mean depth was 6.2 mm on the right side and 6.1 mm on the left side, with an overall mean of 6.15 mm and a standard deviation of 0.75 mm, ranging from 4.7 to 7.9 mm. The distal segment showed a mean depth of 4.9 mm for the right humerus and 4.8 mm for the left humerus, with a combined mean of 4.85 mm and a standard deviation of 0.65 mm, ranging from 3.7 to 6.2 mm. These measurements reveal a gradual decrease in depth from the middle to the distal segment of the bicipital groove, with consistent dimensions between the right and left humerus.

The mean angle of the medial wall of the bicipital groove was 56.3 degrees for the right humerus and 55.8 degrees for the left humerus, with an overall mean of 56.05 degrees and a standard deviation of 4.6 degrees, ranging from 47.5 to 64.0 degrees. The similar mean angles and ranges between the right and left sides indicate a consistent medial wall angle across the humerus bones studied.

Table 4: Angle of the Medial Wall of the Bicipital Groove

Humerus Side	Mean Angle (degrees)	Standard Deviation (SD)	Range (degrees)	P value
Right	56.3	4.5	48.0 - 64.0	0.022
Left	55.8	4.7	47.5 - 63.5	
Total	56.05	4.6	47.5 - 64.0	

The mean angle of the medial wall of the bicipital groove was 56.3 degrees for the right humerus and 55.8 degrees for the left humerus, with an overall mean of 56.05 degrees and a standard deviation of 4.6 degrees, ranging from 47.5 to 64.0 degrees. The similar mean angles and ranges between the right and left sides indicate a consistent medial wall angle across the humerus bones studied.

Table 5: Morphological Classification of the Bicipital Groove

Shape Type	Right (n=50)	Left (n=50)	Total (n=100)
Type A (Flat)	15	14	29
Type B (Concave)	25	26	51
Type C (Convex)	10	10	20

Figure 1: Morphological classification of the Bicipital groove

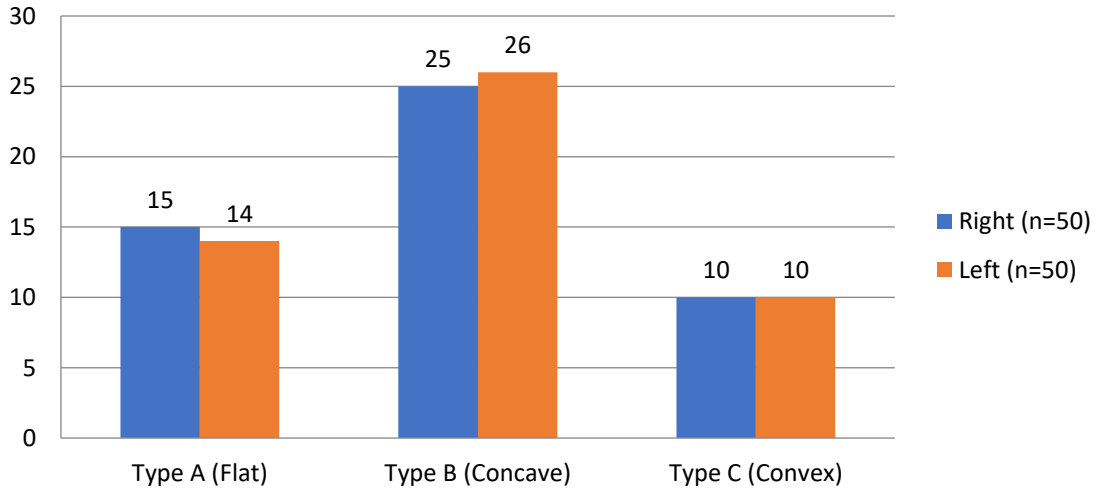

Table 5, figure 1, shows that the morphological classification of the bicipital groove revealed that the majority of the grooves were of Type B (concave), with 25 grooves on the right side and 26 on the left, totaling 51 out of 100. Type A (flat) grooves were found in 15 right humerus bones and 14 left

humerus bones, totaling 29. Type C (convex) grooves were the lEast common, found in 10 right humerus bones and 10 left humerus bones, totaling 20. This distribution indicates a predominance of concave-shaped bicipital grooves in the studied population, followed by flat and convex shapes.

Limitation(s) of the study

In the present study, the sample size was small. The morphometric and morphological evaluation of the bicipital groove, irrespective of the sexes, can be performed later. Also, the number of dry specimens can be increased as a sample size for further studies to ensure more valid results along with radiographic correlations.

Discussion

The Bicipital groove or intertubercular sulcus is present between lesser and greater tubercle of humerus and extends distally almost 5 cm on the shaft of the humerus containing LHB tendon with its synovial sheath and ascending circumflex humeral artery. The tendon of LHB plays a crucial role in maintaining the alignment of head of humerus with glenoid cavity. Any variability in its position may lead to varieties of shoulder disabilities. Structural variation of BG may cause sliding of LHB from the floor of the groove; commonly seen in persons with a very shallow groove. As shoulder joint is the most mobile but l East stable joint of the body, its rotational movement with a very shallow BG might be a reason for trauma to the tendon of LHB as it easily gets impinged on acromion, coracoacromial ligament and coracoacromial arch. It was also observed in previous research that, variation of morphometric parameters and morphological changes of BG have been termed as to develop biceps tendinitis; one of the common causes of shoulder deformity with pain shoulder.

The mean length of the bicipital groove for the right humerus was 87.5 mm, while the left humerus was slightly shorter at 86.8 mm. The combined mean length for both sides was 87.15 mm. These findings are consistent with previous studies conducted on different populations. For instance, a study by Boonruangsriet al.[11] on the Thai population reported a mean bicipital groove length of 86.3 mm, which is quite similar to the current study's results. The slight variation in length between the right and left humerus bones, although not statistically significant, has been noted in other studies as well, suggesting that while there may be minor anatomical differences between sides, they are generally within a narrow range.

The width of the bicipital groove was measured at the proximal, middle, and distal segments. The mean proximal width was 12.2 mm, the middle width was 11.1 mm, and the distal width was 10.35 mm. These measurements align closely with the findings of Igbigbi and Msamati[12] in the Malawian population, which reported proximal, middle, and distal widths of approximately 12.1 mm, 11.2 mm, and 10.3 mm, respectively. The consistency in the width measurements across different populations suggests that the bicipital groove's width is a relatively stable morphometric feature, minimally influenced by ethnic or genetic factors.

The mean depth of the bicipital groove at the proximal segment was 5.35 mm, at the middle segment was 6.15 mm, and at the distal segment was 4.85 mm. These results show a gradual decrease in depth from the middle to the distal segment, which is consistent with the anatomical structure described in various anatomical texts and studies. A comparative study by Rani et al.[13] on the South Indian population reported similar findings, with the middle segment being the deepest part of the bicipital groove. This pattern of depth variation along the groove may be attributed to the functional anatomy of the tendon of the long head of the biceps brachii muscle.

The mean angle of the medial wall of the bicipital groove was found to be 56.3 degrees on the right humerus and 55.8 degrees on the left humerus, with an overall mean of 56.05 degrees. These angles are consistent with those reported by Youdaset al.[14] who found an average medial wall angle of 55.7 degrees in anEast American population. The similarity in the medial wall angle across different

studies suggests that this parameter is likely to be conserved across different ethnicities, reflecting its importance in the biomechanical function of the shoulder joint.

The morphological classification showed that the majority of the bicipital grooves were Type B (concave), accounting for 51% of the total, followed by Type A (flat) at 29%, and Type C (convex) at 20%. This distribution is consistent with findings by Murlimanjuet al.[15] in the Indian population, where Type B grooves were also the most prevalent. The predominance of the concave shape could be linked to its functional advantage in stabilizing the tendon of the long head of the biceps brachii muscle, thereby enhancing the shoulder joint's stability.

Limitation (s) of the study

The shortcoming of the study is the small sample size (50 dry Humerus bones) and the short duration of the study. Hence, the resulting statistics might not accurately represent the population. Therefore, more studies are required with a larger sample size. Future studies incorporating larger sample sizes and multicenter collaborations could further validate and extend our results.

Conclusion

This study provided detailed morphometric and morphological data on the bicipital groove of the humerus in the East Indian population. The findings indicate that there are minimal differences between the right and left humerus bones in terms of length, width, depth, and angle of the bicipital groove. The predominant concave shape of the bicipital groove aligns with the functional requirements of the shoulder joint.

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