Original Article

Morphometric Analysis of the Bicipital Groove of Humerus in the North Indian Population: An Osteological Study

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Abstract

Background: The tendon of the long head of the biceps brachii fits into the bicipital groove (intertubercular sulcus). This humeral canal is important in the stability of the tendons in all shoulder movements. Its morphological variations have been associated with biceps tendinopathy, tendon instability, and anterior shoulder pain. Population-specific morphometric data are needed for anatomical knowledge and to provide guidance for orthopedic and radiological procedures. The objective is to examine the morphometry of the bicipital groove of the humerus in a population from North India, a side-wise bloc, correlations between humeral length and groove size, and comparisons with existing published literature are conducted. **Material and Methods:** It is a descriptive, cross-sectional osteological study conducted at the Department of Anatomy, Sardar Patel Medical College, Bikaner. One hundred (55 right and 45 left) adult dry humeri (unidentified sex) were studied. Humerus length, bicipital groove length, width, depth, and medial and lateral wall lengths were measured with a digital vernier caliper and osteometric board. SPSS software was used to analyze the data. Data were analyzed using an independent t-test and the correlation coefficient between the two, with $p < 0.05$ considered statistically significant. **Results:** The average length of the humeri was found to be 31.75 2.38 cm. Mean bicipital groove length, width, and depth were recorded as 64.61 /18.94 mm, 7.13/1.41 mm, and 3.98/0.95 mm, respectively. None of the statistically significant differences between the right and left sides were observed ($p > 0.05$). It was found that there were significant positive relations between humerus length and groove length ($r = 0.324$), groove width ($r = 0.256$), and medial wall length ($r = 0.415$) and the lateral wall length ($r = 0.387$). According to the classification, 23.8% were narrow, and 17.8% were shallow. **Conclusion:** Bilateral symmetry is accompanied by significant morphometric variations in the bicipital groove in this population of North Indians. The comparatively smaller and less deep grooves were found to have a clinical implication on biceps tendon stability. The article is also important because it provides essential osteological background data and highlights the need to standardize measurement technologies and account for anatomical age-related specifics.

Keywords: Bicipital groove, Humerus, Morphometry, North Indian population, Osteological study, Shoulder anatomy.

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Introduction

The bicipital groove, also referred to as the intertubercular sulcus of the humerus, is a very significant structure that harbors the tendon of the long head of the biceps brachii muscle. It plays an essential role in providing tendon stability and inhibiting tendon movement during shoulder movements.[12] The dimensions of the bicipital groove (length, breadth, depth, and the structure of the medial and lateral walls) were reported to be linked with biceps tendinitis, tendon subluxation, and syndromes of shoulder pain.[3,4]

The orthopedic surgeons, radiologists, and anatomists should be knowledgeable of the normal morphometric parameters of the bicipital groove. These parameters are crucial when performing shoulder arthroscopy, designing a prosthesis, and conducting processes involving the proximal humerus.[5,6] Past research has shown that the morphology of the bicipital groove varies across populations, suggesting that genetic, racial, and environmental factors contribute.[7-9]

Measurements of groove dimensions are relatively uniform across most available Indian studies, but differ markedly from findings in other populations. Moreover, the use of inconsistent measurement methods and anatomical variables has led to variation across studies.

The present study was undertaken to provide detailed morphometric data of the bicipital groove in a North Indian population using dry humeri, to compare right and left sides, to assess correlations between humeral length and groove dimensions, and to compare the findings with previously published literature.

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Materials and Methods

Study Design and Setting: This is a descriptive cross-sectional osteological study conducted in the Department of Anatomy, Sardar Patel Medical College, Bikaner, Rajasthan.
Study Material: A total of 100 adult dry humeri of unknown sex were included in the study. The bones were obtained from the departmental osteology collection and were free from fractures, deformities, or pathological changes.

- Right humeri: 55
- Left humeri: 45

Bones with damaged proximal ends or eroded anatomical landmarks were excluded.

Parameters Measured

The following parameters were measured using a digital vernier caliper (accuracy 0.01 mm) and an osteometric board:

1. Total humerus length (cm) – distance from the most superior point of the head to the lowest point of the trochlea
2. Length of bicipital groove (mm) – superoinferior extent of the groove
3. Width of bicipital groove (mm) – transverse distance between medial and lateral lips at midpoint
4. Depth of bicipital groove (mm) – vertical depth at midpoint
5. Length of medial wall (mm) – measured along the medial lip of the groove
6. Length of lateral wall (mm) – measured along the lateral lip of the groove

All measurements were taken twice by the same observer, and the average was recorded to minimize observer error.

Statistical Analysis

Data were analysed using SPSS software.

- Results were expressed as mean ± standard deviation
- An independent t-test was used to compare the right and left sides
- Pearson's correlation coefficient was used to assess relationships between humerus length and groove parameters
- A p-value < 0.05 was considered statistically significant

Results

The mean length of the humerus was 31.75 ± 2.38 cm, with no significant difference between right and left sides. The mean bicipital groove length was 64.61 ± 8.94 mm, width 7.13 ± 1.41 mm, and depth 3.98 ± 0.95 mm.

No statistically significant differences were observed between right and left sides for any measured parameter ($p > 0.05$).

Correlation analysis showed a positive and significant correlation between humerus length and:

- Groove length ($r = 0.324$, $p < 0.01$)
- Groove width ($r = 0.256$, $p < 0.05$)
- Medial wall length ($r = 0.415$, $p < 0.01$)
- Lateral wall length ($r = 0.387$, $p < 0.01$)

Based on the width and depth classification:

- 23.8% of grooves were narrow
- 17.8% were shallow

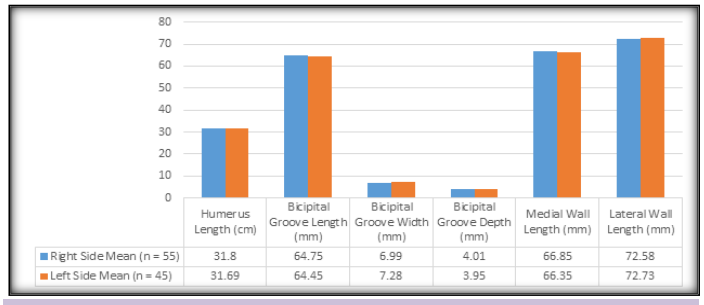

Figure 1: Comparison of bicipital groove dimensions between right and left sides

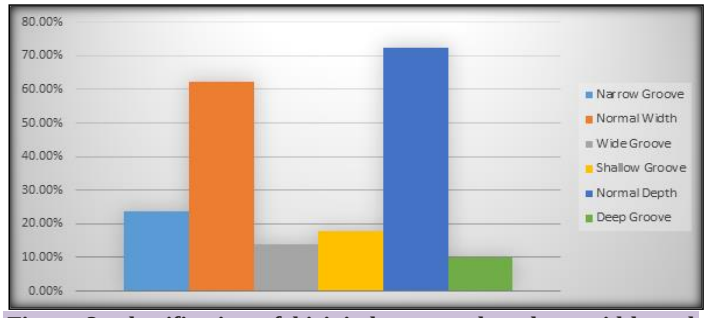

Figure 2: classification of bicipital grooves based on width and depth

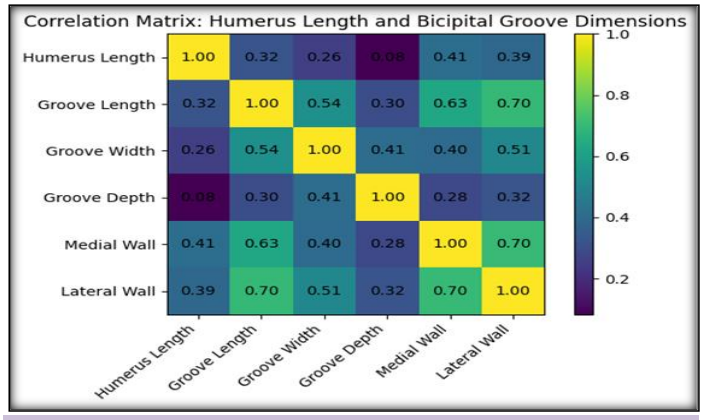

Figure 3: correlation matrix between humerus length and bicipital groove dimensions.

Table 1: Descriptive Statistics of Humerus and Bicipital Groove Measurements (Overall and by Side)

Variable	Overall (n=100)	Right Side (n=55)	Left Side (n=45)
Humerus Length (cm)	31.75 ± 2.38	31.80 ± 2.41	31.69 ± 2.36
Bicipital Groove Length (mm)	64.61 ± 8.94	64.75 ± 9.03	64.45 ± 8.89
Bicipital Groove Width (mm)	7.13 ± 1.41	6.99 ± 1.31	7.28 ± 1.51
Bicipital Groove Depth (mm)	3.98 ± 0.95	4.01 ± 0.94	3.95 ± 0.97
Medial Wall Length (mm)	66.62 ± 6.38	66.85 ± 6.42	66.35 ± 6.35
Lateral Wall Length (mm)	72.65 ± 8.92	72.58 ± 9.12	72.73 ± 8.72

Data presented as Mean ± Standard Deviation.

Table 2: Comparison of Bicipital Groove Dimensions Between Right and Left Sides (Independent t-test)

Variable	Right Side (Mean ± SD)	Left Side (Mean ± SD)	p-value
Humerus Length (cm)	31.80 ± 2.41	31.69 ± 2.36	0.809
Bicipital Groove Length (mm)	64.75 ± 9.03	64.45 ± 8.89	0.864
Bicipital Groove Width (mm)	6.99 ± 1.31	7.28 ± 1.51	0.276
Bicipital Groove Depth (mm)	4.01 ± 0.94	3.95 ± 0.97	0.744
Medial Wall Length (mm)	66.85 ± 6.42	66.35 ± 6.35	0.694
Lateral Wall Length (mm)	72.58 ± 9.12	72.73 ± 8.72	0.929

Note: $p < 0.05$ indicates significant difference.

Table 3: Classification of Bicipital Grooves Based on Width and Depth

Category	Definition	Frequency (n)	Percentage (%)
Narrow Groove	Width < 6 mm	24	23.8%
Normal Width	Width 6–9 mm	63	62.4%
Wide Groove	Width > 9 mm	14	13.9%
Shallow Groove	Depth < 3 mm	18	17.8%
Normal Depth	Depth 3–5 mm	73	72.3%
Deep Groove	Depth > 5 mm	10	9.9%

Table 4: Correlation Matrix Between Humerus Length and Bicipital Groove Dimensions

Variable	Humerus Length	Groove Length	Groove Width	Groove Depth	Medial Wall	Lateral Wall
Humerus Length	1.000	0.324**	0.256*	0.082	0.415**	0.387**
Groove Length	0.324**	1.000	0.542**	0.301**	0.634**	0.698**
Groove Width	0.256*	0.542**	1.000	0.410**	0.402**	0.512**
Groove Depth	0.082	0.301**	0.410**	1.000	0.285**	0.324**
Medial Wall	0.415**	0.634**	0.402**	0.285**	1.000	0.701**
Lateral Wall	0.387**	0.698**	0.512**	0.324**	0.701**	1.000

*Correlation coefficients (Pearson's r) are shown. **$p < 0.01$, $p < 0.05$.

Discussion

The present osteological study provides detailed morphometric data on the bicipital groove (BG) of the humerus in a North Indian population. It highlights clinically significant variations when compared with earlier Indian and international studies. The bicipital groove plays a vital role in stabilizing the tendon of the long head of the biceps brachii, and its morphology has been strongly associated with biceps tendinitis, tendon subluxation, and anterior shoulder pain syndromes.[1–3] In the present study, no statistically significant differences were observed between the right and left humeri for any of the measured parameters, including humerus length, bicipital groove length, width, depth, and medial and lateral wall lengths. This observation correlates with results obtained in a population of North India by Gupta et al,[12] in eastern India by Karmali and Modi,[13] in South India by Rajan and Kumar,[9] and in South Africa by Khan et al.[3] Bilateral symmetry has also been observed as similar in cadaveric and dry bone studies by Baumann et al,[6] and Ülkir et al.[11] There was no major difference in the lateral dominance, indicating that genetic and developmental determinants might have a higher degree of control over bicipital groove morphology than lateral mechanical loading or handedness.

An average width of bicipital groove (7.13 +/-1.41 mm) and depth (3.98 +/-0.95 mm) of the present study are smaller than most of the Indian and international studies. A report by Singh and Singh gave mean values of 8.0mm and 6.0mm width and depth respectively in a population in North India.[4] In a similar study, Rajan and Kumar provide average values of depths of over 4.2 mm in South Indian humeri,[9] whereas Karen et al. provide much higher values of the mean depth (greater than 7 mm) in their South African population.[3] The comparatively lower width and depth of the present study might suggest decreased biceps tendon their role in containing the tendon and being prone to tendon instability and tendinopathy. Of the humeri 23.8 percent showed narrow grooves and 17.8 percent shallow grooves. Singh and Singh stated that deep and flat grooves are linked to larger and more frictional forces of the long head of the biceps tendon and are likely to expose people to the pain of the anterior shoulder.[4] The same also can be supported by the fact that the mean medial (66.62 + 6.38 mm) and lateral (72.65 + 8.92 mm) wall lengths were found to be significantly higher than in most former studies (23-37 mm has been reported).[4,9,12,13] The implications of the present study also include the fact that the mean medial (66.62 + 6.38 mm) and the lateral (72.65 + 8.92 mm) wall differ in length, the most probable cause of this discrepancy is probably a difference in the methodology used in measurement, but not in the actual anatomy. Other scholars like Rajan and Kumar,[9] and Karmali and Modi,[13] expressed wall height as a vertical distance between the crest of the tubercles up to the inferior limit of the groove. Conversely, the current experiment was able to measure the linear extent across medial and lateral lingual lips of the groove, which by default gives higher numbers. Baumann et al. reported the common methodological inconsistencies in the current literature and the absence of standard anatomical landmarks as the key weaknesses in the strategy to study bicipital grooves.[6] This highlights the importance of consistency in measuring the different dimensions of measurement in order to compare studies across different studies.

The current research established a positive relationship between the total length of the humerus and various parameters of the bicipital groove, including length, breadth, and the medial and lateral wall lengths. These results can be compared with those of

Hoque et al., who reported a strong positive relationship between bicipital groove length and humerus length,[7] and Hoque and Anwar, who stressed the forensic implications of such relationships in the reconstruction of long bones.[8] The lack of a significant association between humerus length and groove depth indicates that a relationship between the groove depth and long arm bones can be more associated with localized biomechanical remodeling and requirements than with overall bone size.

International studies show a clear difference in the population-based morphology of bicipital grooves. Wider and deeper grooves are usually found in South African,[3] Turkish,[11] and European cadaveric models than in the current North Indian population. These differences may be influenced by genetic, ethnic, and biomechanical factors, underscoring the role of location-specific anatomy in orthopedic and shoulder arthroplasty implant design, as the precise replication of native anatomy is required to achieve optimal tendon stability and prosthetic positioning.[6,11]

The fairly large proportion of small and shallow grooves noted in this study points to an anatomical risk factor for biceps tendon pathology in a certain section of the North Indian population. These differences are important in the case of orthopedic surgeons performing procedures such as biceps tenodesis, rotator cuff repair, and shoulder arthroscopy, as they are unaware of the groove morphology, which can interfere with the surgical process.[1,6]

The current study supports bilateral symmetry of the bicipital groove and also reveals significant population-specific morphometric differences. The grove width and depth in this North Indian group may also play a significant clinical role, as they are often relatively smaller. Future studies must standardize their measurement methods and incorporate radiological comparisons.

Conclusion

Morphometric variability of the bicipital groove of the humerus is significantly different in the North Indian population under research. No notable differences on the sides were discovered. Groove width and depth were relatively smaller than those of other populations, whereas the medial and lateral wall lengths were much higher, which is probably attributable to methodological differences.

These results will provide useful baseline information for anatomists, orthopedic surgeons, and radiologists, and indicate the need for standardized measurement methods. It is advisable to conduct further research, including well-defined landmarks and radiological correspondence.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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