

Dimensional Analysis of Intertubercular Sulcus in Adult Dry Humeri: A Cross-sectional Study

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ABSTRACT

Introduction: Intertubercular Sulcus (ITS) is a depression in the superior end of humerus, located between the greater tubercle and lesser tubercle. It lodges the Long Head of Biceps Brachii Tendon (LHBT) and ascending branch of circumflex humeral artery. The dimensions of the ITS play a key role in the biomechanics of LHBT and are associated with complications of the shoulder region.

Aim: To analyse the dimensions and associated parameters of ITS of humerus.

Materials and Methods: This cross-sectional study was conducted in the Department of Anatomy at Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research (CDSIMER), Dayananda Sagar University, Harohalli, Karnataka, India. A total of 80 humeri (47 right-sided and 33 left-sided) were included in the study. Morphometric parameters such as length, width, depth, medial wall length, lateral wall length, and incidence

of supratubercular ridge of Meyer were noted. The mean and standard deviation for each independent variable were calculated, and t-test was used to compare the same for right and left-sides. A p-value of <0.05 was considered statistically significant.

Results: The mean±SD for length, width, depth, medial wall length, and lateral wall length (in mm) were observed to be 68.5±7.6, 6.4±1.1, 4.8±0.9, 61.4±6.9, and 73.3±7.3 on the right-side, and 65.1±7.6, 6.02±1.2, 4.7±0.9, 57.9±7.3, and 69.7±8.3 on the left-side, respectively. The mean±SD for the medial and opening angles on the right and left-sides were found as 46.7°±5.9, 64.7°±8.31 and 47.4°±5.6, 62.1°±6.1, respectively. The incidence of the supratubercular ridge of Meyer was observed to be 25% on the right-side and 9% on the left-side.

Conclusion: The ITS serves as an important anatomical landmark for aligning prostheses in shoulder arthroplasty. Understanding the dimensional variations is crucial for comprehending the functional nature of the shoulder region.

Keywords: Humerus, Long head of biceps tendon, Shoulder

INTRODUCTION

The Intertubercular Sulcus (ITS) is a vertical concavity in the proximal end of humerus, located between the greater tubercle laterally and lesser tubercle medially [1,2]. It accommodates the Long Head of the Biceps Tendon (LHBT) and ascending branch of circumflex humeral artery [3,4]. The transverse humeral ligament converts ITS into a canal, positioning itself over LHBT, thereby providing stability and preventing subluxation during arm movements [3]. The ITS presents a medial wall, lateral wall, and a floor into which the pectoralis major, teres major, and latissimus dorsi insert, respectively [1]. The morphometry and morphology of ITS are significant, as its anomalies have been linked to shoulder pain. Additionally, it serves as an important anatomical landmark for aligning prostheses in shoulder arthroplasty. It is also said to impact the biomechanics of LHBT and complications in the shoulder region, including inflammation, impingement, degeneration, and dislocation [5-7].

Given the paucity of data regarding the morphometry and morphology of ITS, and its crucial role in understanding variations that impact the functional nature of the shoulder region, the present study aimed to analyse the dimensions and associated parameters of ITS of humerus in South Indian population.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Anatomy at Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research (CDSIMER), Dayananda Sagar University, Harohalli, Karnataka, India from June 2023 to August 2023. Approval was obtained from the Institutional Ethical Committee (CDSIMER/MR/0091/IEC/2023).

Inclusion criteria: Total 80 humeri (47 right-sided and 33 left-sided) of unknown sex and age were included in the study.

Exclusion criteria: Bones with obvious deformities were excluded from the study.

Study Procedure

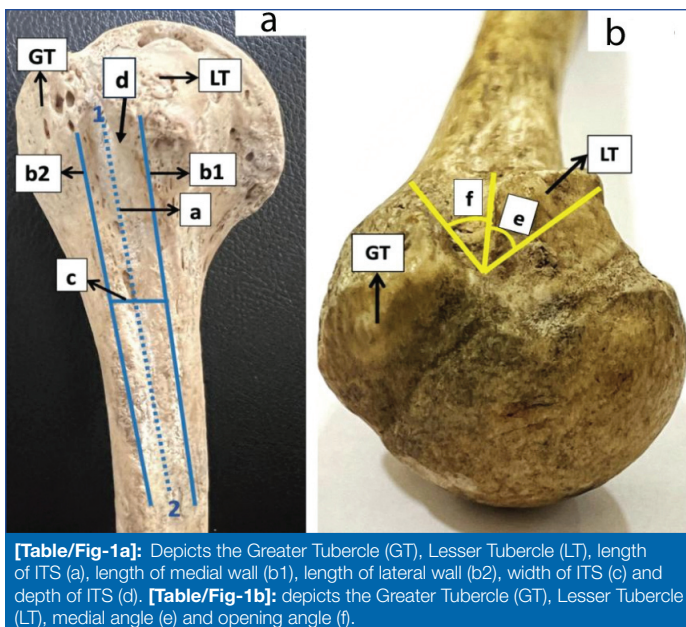
The materials required for the present study included digital vernier callipers and goniometer.

The following parameters of ITS were measured using vernier callipers [Table/Fig-1a]:

- Length (mm): This was measured between the midpoint of greater and lesser tubercles (depicted as '1' in [Table/Fig-1a]) and meeting point of medial and lateral lip of ITS (depicted as '2' in [Table/Fig-1a]).
- Width (mm): The average distance between medial and lateral wall of ITS.
- Depth (mm): The vertical distance from the deepest point of the ITS to the line connecting the highest points of the tubercles.
- Lengths of the medial and lateral walls (mm) of ITS.

The following parameters of ITS were measured using a goniometer [Table/Fig-1b]:

- Medial Angle (degrees)- angle between the lines connecting the deepest point on bicipital groove to the highest point on lesser tubercle.
- Opening Angle (degrees)- angle between the line connecting the deepest point on the bicipital groove and the highest point on both lesser and greater tubercles.



[Table/Fig-1a]: Depicts the Greater Tubercle (GT), Lesser Tubercle (LT), length of ITS (a), length of medial wall (b1), length of lateral wall (b2), width of ITS (c) and depth of ITS (d). **[Table/Fig-1b]:** depicts the Greater Tubercle (GT), Lesser Tubercle (LT), medial angle (e) and opening angle (f).

Incidence of the supratubercular ridge of Meyer (continuous osseous protrusion in the superior portion of the lesser tubercle) was also noted.

STATISTICAL ANALYSIS

The measurements were tabulated, and appropriate statistical tests were applied using Statistical Package of Social Sciences (SPSS) version 21.0. The mean and standard deviation for each independent variable (length, breadth, depth of ITS, medial and lateral wall length, medial and opening angles) were calculated, and t-test was used to compare the results for right and left-sides. Incidence of supratubercular ridge of Meyer was noted using percentage. A p-value of <0.05 was considered statistically significant.

RESULTS

It was observed that there was statistically significant difference between the right and left humeri with respect to length of the ITS, as well as the lengths of the medial and lateral walls. The incidence of the supratubercular ridge of Meyer was found to be higher on the right-side (25%) compared to the left-side (9%), and the difference was found to be statistically significant [Table/Fig-2].

Parameters	Mean±SD (right-side)	Mean±SD (left-side)	p-value (t-test was used)
Length of ITS	68.5±7.6 mm	65.1±7.6 mm	0.049
Width of ITS	6.4±1.1 mm	6.02±1.2 mm	0.142
Depth of ITS	4.8±0.9 mm	4.7±0.9 mm	0.596
Medial wall length	61.4±6.9 mm	57.9±7.3 mm	0.033
Lateral wall length	73.3±7.3 mm	69.7±8.3 mm	0.044
Medial wall angle	46.7°±5.9	47.4°±5.6	0.622
Opening angle	64.7°±8.31	62.1°±6.1	0.124
Supratubercular ridge of Meyer	12 (25%)	3 (9%)	0.097

[Table/Fig-2]: Measurement of different parameters of the ITS.

DISCUSSION

Variations in ITS may impact how the LHBT tendon functions and could lead to tendon instability and attritional damage. A lengthy ITS may contribute to increased tendon stability within the groove during multidirectional shoulder joint movement [8]. The length of ITS in the present study comprehends with very few other studies [1,8]. It was seen that 90-95% of individuals

with right-handed dominance presented with larger length and width of ITS [9].

Determination of width and depth of ITS is crucial, as a shallow groove could escalate the risk of LHBT instability, while a deep groove may increase the risk of lesions brought on by impingement against walls of ITS during rotational movement of the shoulder joint [5].

In the present study, mean width and depth of ITS agreed with studies done by Karmali NK and Modi S, as well as Rajan YS and Sampath SK [10,11]. Although the mean width and depth of ITS in the present study were greater on the right than the left-side, this difference was not statistically significant, probably because of a lesser sample size. The depth of the ITS did not show a statistically significant difference between the two sides, probably because the constant pressure exerted by the pulley effect of the tendon of the long head of biceps is greater on the medial wall of the ITS and lesser tubercle than on the floor of the ITS [12].

Opening and medial wall angles are crucial for maintaining the position of the LHBT tendon within the ITS. Proper positioning of tendon is important for maintenance of stability of shoulder joint, as it aligns the head of humerus within the glenoid cavity [4]. A greater opening angle and reduced medial angle may be a risk factor for the development of biceps tendon instability [13]. The authors also opined that the stability of the biceps tendon may be impacted by the anatomy of ITS. Ahovuo J et al., It has been hypothesised that medial angles of 20° and 30° can lead to spontaneous subluxation occurring in bicipital groove [14]. An Magnetic Resonance Imaging (MRI) study done on patients with rotator cuff injuries showed medial angle of less than 30 degrees in 22 shoulders. The mean medial and opening angle values in present study correlated with work done by few studies [3,15]. A study by Pfahler M et al., noted a higher incidence of LHBT pathology in patients with smaller medial wall angles and narrow ITS [16].

It is anticipated that the longer medial and lateral walls of the ITS will provide the LHBT tendon in the bicipital groove with more stability than the shorter walls when performing multidirectional biomechanical activities. If the lengths of the medial and lateral walls decline, instability may worsen, and the LHBT tendon is more likely to sustain damage [13]. The mean values were statistically significant between the right and left-sides [3,4,17]. The medial and lateral wall lengths of the ITS were measured by a few authors [Table/Fig-3] [3,4,10,11,17].

While biceps tendon instability within the ITS causes subluxation and dislocation, tendinitis and tenosynovitis are linked to overuse or degenerative alterations of the sulcus. Chronic bicipital tenosynovitis may be attributed to degeneration of areas where tendons and ligaments attach to the sulcus, especially if there are bony growths on the floor of the ITS. In a study done among 111 patients to analyse the anatomical aspects of ITS using 3D-CT, it was observed that patients aged over 55 years had a narrower ITS compared to those under 55 years. The sulcus was also observed to be wider and deeper in men compared to women [18].

One of the possible causes of biceps tendinitis or subluxation may be the presence of Meyer's tubercle, and the risk increases if it is combined with a narrow ITS. In 17.5% of the 200 humeri examined, Meyer AW noticed the presence of a supratubercular ridge and proposed that the presence of this ridge raises the risk of the biceps tendon dislocating from the bicipital groove [19]. Hitchcock HH and Betchol CO associated its presence with that of biceps tendinitis

Authors name/Year of the study	Population	Side	No	Length (mm)	Width (mm)	Depth (mm)	MWL (mm)	LWL (mm)
Kumar P et al., [4] (2021)	North India	Right	57	71.8±6.9	8.4±1.8	5.8±1.1	53.3±10.1	59.1±9.0
		Left	43	74.5±8.04	10.03±2.2	5.6±1.1	56.8±5.6	62.9±5.8
Rajani S and Man S, [3] (2013)	North India	Right	56	85±0.9	9.0±2.1	5.0±1.0	22±4	31±6
		Left	45	83±10.1	8.9±1.1	6±1.0	23±5	31±5
Karmali NK and Modi S [10] (2019)	Eastern India	Right	49	83.9±5.6	6.7±0.5	4.1±0.5	23.9±1.0	32.1±2.1
		Left	37	86.5±6.2	7.5±1.05	5.01±1.0	23.1±2.4	31.9±0.2
Ashwini ZA [17] (2016)	South India	Right	39	89.9 ±6.3	8.5±1.5	6.4±1.1	81.7±6.3	89.6±6.0
		Left	48	88.8±8.1	7.9±1.3	6.1±1.0	79.5±7.6	89.1±8.2
Rajan YS and Sampath SK [11] (2016)	South India	Right	50	84.7±5.8	6.8±1.01	4.2±0.5	24.2±1.02	32.5±2.21
		Left	50	87.3±6.4	7.7±1.9	4.2±0.5	23.3±2.2	31.1±0.24
Present study (2023)	South India	Right	47	68.5±7.6	6.4±1.1	4.8±0.9	61.4±6.9	73.3±7.3
		Left	33	65.1±7.6	6.02±1.2	4.7±0.9	57.9±7.3	69.7± 8.3

[Table/Fig-3]: Comparison of different parameters of present study with previous studies [3,4,10,11,17].

Authors name/year of the study	Population	Side	No	Supratubercular ridge of meyer	Medial wall angle (°)	Opening angle (°)
Kumar P et al., [10] (2021)	North India	Right	57	21%	64.8±7.4	77.4±17.3
		Left	43	9%	65.8±13.9	65.3±17.0
Rajani S and Man S, [3] (2013)	North India	Right	56	71%	47.3±9.6	47.3±9.6
		Left	45	29%	50.8±10.9	50.8±10.9
Arun Kumar KR et al., [15] (2016)	South India	Right	48	18%	47.1±7.8	47.1±7.8
		Left	50	8%	49.6±10.4	49.6±10.4
Present study (2023)	South India	Right	47	25%	46.7±5.9	64.7±8.31
		Left	33	9%	47.4±5.6	62.1±6.1

[Table/Fig-4]: Comparison of different parameters of present studies with previous studies [3,10,15].

in their study. In the present study, presence of Meyer's tubercle was observed in 25% of right humeri and 9% of left humeri, which showed statistical significance [20]. Several studies displayed an increased incidence of this tubercle on the right humeri compared to the left [3,4,15]. The comparison of different parameters of present studies with previous studies has been depicted in [Table/Fig-4] [3,10,15].

This could be because of right-handedness in Indian population. Vettivel S et al., documented a supratubercular ridge in 88% of right humeri and 57% of left humeri, respectively. Subsequently, it was reported that this feature may be more relevant for the right shoulder to prevent LHBT dislocation, since right-handedness is more common among humans [9]. However, Cone RO et al., observed it in 50% in their study, and from their radiological interpretation, the authors contradicts that its presence does not seem to be pathologically significant [21].

Limitation(s)

The sample size of the present study was limited due to availability of only 80 bones in the Department. Multicentric studies with larger sample size, as well as known gender and age, could provide statistically significant and better results.

CONCLUSION(S)

The present study provides insight into the ITS of humerus, with an emphasis on its dimensions in a South Indian population. Knowledge of the morphometry and morphology of ITS enlightens us to determine the stability criteria for the long head of biceps tendon. The anatomical aspects of the sulcus can be implicated in surgical outcomes.

Declaration: This paper was presented as an original paper at the 23rd Karnataka Chapter of Anatomists Conference (KACON)

conference. [https://impressions.manipal.edu/cgi/viewcontent.cgi?article=1074&context=kcacon-202] (https://impressions.manipal.edu/cgi/viewcontent.cgi?article=1074&context=kcacon-202)

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