Original article:

Morphometry and morphology of the human bicipital groove with its clinical significance

Rajapriya Venkatesan[1], *Jeyanthi C Gnanadeepam[2], Anjana Thamanan Sowdamman Rajavel[3], Srividhya Eswaran[4], Muralikumar Radhakrishnan[5], Babu Lakshmanan[6], Hemalatha Mathavan[7]

[1,2] Associate professor of Anatomy, [3,4] Assistant professor of anatomy, [5,6,7] Post graduates of M.D. Anatomy
Department of Anatomy, Government Kilpauk Medical College.
Corresponding author *

ABSTRACT

Introduction: The Bicipital Groove in the upper end of the humerus is a deep groove formed between the greater and lesser tubercles. The shape of the BG can have a great impact on the tendency for the LBT to be dislocated, subluxated, frayed, or torn.

Materials and Methods The study was carried out in 200 adult humeri (106 right and 94 left) from the Department of Anatomy, Government Kilpauk Medical College. The length, width, depth of the BG were accurately measured using digital vernier callipers.The medial and lateral wall angle were measured using goniometer. The data were analysed and mean + SD was calculated.

Results : The mean length, width & depth of BG was found to be 8.18+ 0.977, 8.99+ 1.51 and 4.6+ 1.09 respectively. The medial wall angle of BG on the right side was 57 ± 4 degrees and 56 ± 4 degrees on left side. The average length of the BG corresponds to 27.50 % of the length of the humerus. STR of Meyer was present in 58% of humeri out of which 28% from the right and 30% of those from the left. Medial wall spurs was present in 15.5% and Lateral wall spurs in 1.95%.

Conclusion: The present study is an attempt to determine the morphometry of the BG in the humeri of south Indian population. The data can be useful to anthropologists, orthopaedic surgeons and clinical anatomists. Osseous spurs and STR may predispose dislocation of tendon of biceps brachii.

Key words: Bicipital groove(BG), Morphometry, Supratubercular ridge (STR).

INTRODUCTION:

The upper end of humerus is formed by head and the two tubercles. The greater tubercle is on the lateral side of the upper end of humerus. The lesser tubercle is on the anterior side; between the two and their downward extensions is the intertubercular (bicipital) groove (1) .

It contains the long head of the biceps brachii muscle, its synovial sheath and an ascending branch of the anterior circumflex humeral artery. The transverse humeral ligament is shaped like a broad band passing between the tubercles and converting the sulcus into a canal and act as a retinaculum for the long tendon of the biceps brachii muscle .(2) The lesser tubercle may be prolonged upward as far as the epiphyseal line by a supratubercular ridge , which predisposes to fraying of biceps tendon as this curves medially above the tubercle.

Spurs projecting from the lesser tubercle ,increasing the possibility of damage to the biceps tendon , are often associated with supratubercular ridges. The lesser tubercle functions as a pulley for the long tendon of the biceps during flexion – extension movements and shoulder with shallower grooves and lesser angles are more disposed to dislocation of the long head of the biceps than are those with deeper grooves and greater angles. (3).

www.ijbamr.com P ISSN: 2250-284X , E ISSN : 2250-2858

The tendon of the long head of the long head of biceps play an important role in maintaining the alignment of the head of the humerus within the glenoid cavity of the scapula in movements involving the use of the arm and forearm. The humerus moves on the tendon of the long head of the biceps in all movements of the upper extremity.(4,5,6)

The anatomy of some shoulders favors dislocation of the long tendon of biceps when it is forced against the lesser tubercle either by sudden violent external rotation of the arm or (because of its angulation over the front of the head of the humerus) by forceful flexion of the internally rotated arm. Recommended treatment of painful dislocation of the biceps tendon is attatchment of the tendon to the floor of the groove, with removal of the portion above the groove . Subluxation and dislocations of the biceps tendon are more common in people with a shallow intertubercular sulcus.(7,8) During rotation of the shoulder, a shallow BG can cause trauma to the biceps tendon because of impingement of structures like the acromion, rotator cuff and coracoacromial arch.(9) The morphology of the BG has significant variability and affects the biomechanics of the tendon, and certain morphologic characteristics have been implicated in the development of bicipital tendinitis.(10) . Anatomic variations in the groove could give rise to sliding of the biceps brachii muscle tendon.(11) Rockwood and Matsen mentioned that humans are unique among primates in presenting marked variation in the configuration of the bicipital groove .The bicipital groove depth and width are important factors in preventing subluxation and dislocation of tendons. A thick tendon in a wide, shallow groove will have a tendency to dislocate. At the other extreme, a deep, narrow groove is likely to constrict the tendon and cause impingement syndrome.(12) Bicipital groove and proximal tendon disorders are becoming increasingly recognized as an important symptom generator in the shoulder.

The spectrum of abnormalities includes tenosynovitis, pulley lesions, biceps dislocations, and proximal tears. The bicipital groove (BG) and the long head of the biceps tendon (LBT) are intimately related; the shape of the BG can have a great impact on the tendency for the LBT to be dislocated, subluxated, frayed, or torn. It is understood that a shallow, wide BG can promote subluxation and/or dislocation of the LBT, a deep narrow BG can cause LBT irritation and tenosynovitis, osseous spurs in the BG can cause LBT fraying and the presence of the supratubercular ridge of Meyer is suspected to promote dislocation. [3] The data related to the bicipital groove in the Indian population is scarce.The knowledge of bicipital groove is highly useful in prosthetic sizing, positioning and designing. Bicipital groove also acts as an important landmark for placement of lateral fin of prosthesis in shoulder arthroplasty and humeral head replacement in fractures of upper end of humerus. [13] The bicipital groove shows a wide degree of variation and the present study is undertaken to determine the morphology and morphometry of the bicipital groove in the south Indian population.

MATERIALS AND METHODS:

A total of 200 humeri of adult humans, 106 right and 94 left sides, formed the basis of this study. The bones did not show gross evidence of disease. These bones were obtained from the department of anatomy ,Govt Kilpauk Medical college. The maximum length of the humerus was measured with the osteometric board. The length of the intertubercular sulcus and the maximum width and depth of the bicipital groove were measured with the digital vernier calliper. The angle between the

www.ijbamr.com P ISSN: 2250-284X , E ISSN : 2250-2858

floor of the bicipital groove and the medial wall (lesser tubercle) was measured with the goniometer as the medial wall angle . The angle between the floor of the bicipital groove and the lateral wall (greater tubercle) was measured as the lateral wall angle. The ratio between the length of the bicipital groove and the total length of the humerus was also calculated. The incidence of variations of the angle of the medial wall of the bicipital groove was studied.The data were recorded separately for right and left humeri. Data were presented as mean + SD. The humeri were also observed for the presence of supratubercular ridges and spurs in the medial and lateral walls of the groove.

RESULTS:

The mean length, width and depth of the BG were 8.18+O.977cm, 8.99+ 1.51mm, 4.6 + 1.09 mm respectively. (figure 1). The mean length of the humerus from its upper to lower end was found to be 29.74 + 2.19 cm.The mean length of the humerus and mean length of the bicipital groove was longer on the right side than the left .

The average length of the bicipital groove corresponds to 27.50 % of the length of humerus. The average medial wall angle was found to be 56.46 + 4.32 degrees. The average lateral wall angle was found to be 118.67 + 4.76 % .The average opening angle was found to be 62.21 + 4.54 degrees(figure 2). A supratubercular ridge of Meyer was seen in 58% of the specimens (26% complete and 32% partial) out of which 28% on right side and 30% on left side. (figure 3) Spurs were present in 23% on right side (1.8% in greater tubercle and 19.2% in lesser tubercle) and spurs were present in 13% on left side (2.1% in greater tubercle and 11.8% in lesser tubercle).(figure 4 and 5) .

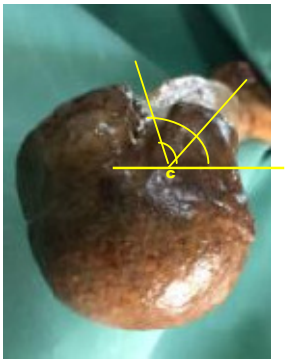
TABLE 1: MORPHOMETRY OF THE BICIPITAL GROOVE

S NO	Parameters	Right humeri (N=106) Mean +SD	Left humeri (N=94) Mean+SD	Mean + SD (N = 200)
1.	Length of humerus (cm)	30.01+2.15	29.43+2.21	29.74 + 2.19
2.	Length of BG (cm)	8.44+1.03	7.88+0.82	8.18 + 0.977
3.	Width of BG (mm)	9.12+1.37	8.86+1.65	8.99 + 1.51
4.	Depth of BG(mm)	4.65+1.04	4.55+1.146	4.6+1.09
5.	Medial wall angle(degrees)	57+ 4.35	55.83+4.21	56.46 + 4.32
6.	Lateral wall angle (degrees)	118+4.98	119+4.47	118.67 +4.76
7.	Supratubercular ridges-complete	17% (18 specimens)	36% (34 specimens)	26% (52 specimens)
8.	Supratubercular ridges-partial	35.8% (38 specimens)	29% (27 specimens)	32%(65 specimens)
9.	Spurs	21% (23 specimens)	14% (13 specimens)	17.5% (36 specimens)
10.	Spurs in (medial wall) lesser tubercle	19.2%(21 specimens)	11.8%(11 specimens)	15.5%(32 specimens)
11.	Spurs in (lateral wall) greater tubercle	1.8% (2 specimens)	2.1% (2 specimens)	1.95%(4 specimens)

www.ijbamr.com P ISSN: 2250-284X , E ISSN : 2250-2858

Figure 1- Length of bicipital groove

Figure 2-Medial wall angle ,lateral wall angle and opening angle



1) bcd - medial wall angle 2) bce - lateral wall angle 3) dce - opening angle

Figure 3- Complete supratubercular ridge

Figure 4 – Lesser tubercle spur

www.ijbamr.com P ISSN: 2250-284X , E ISSN : 2250-2858

Figure 5 – Spur in greater tubercle

DISCUSSION:

Primary bicipital tenosynovitis is a condition limited to the tendon without evidence of associated shoulder pathology. Individuals who participate in sports that require repeated overhead motions are at risk. Narrowing of the bicipital groove, which can occur when the bony anatomy is altered after fracture, glenohumeral joint arthritis and groove anomalies can all exacerbate biceps tenosynovitis. (11) Anatomic variations in the bicipital groove could give rise to sliding of the biceps brachii tendon. [14] The medial displacement or slipping of the long head of the biceps tendon is prevented by the supracondylar ridge of Meyer. In Wafae et al.'s morphometric study,(14) the average length of the groove corresponded to 25.2% of the length of the humerus. In muralimanju et al study,(15) the mean length of the BG corresponded to 27.8% of the total length of humerus. In the present study ,the mean length of the BG corresponded to 27.50% of the total length of the humerus. We observed that our data were similar to that of Wafae et al and Murlimanju et al study.(14,15) According to Vettivel et al,(16) the mean length of the right humeri was 30.2+ 0.2 cm and the left was 30.1 +_ 0.2 cms. In Murlimanju et al study, these lengths were 31 +1.8 and 30 + 2.5 cm, respectively. In the present study the mean length of the right and left humeri was 30+- 2.15cm and 29.4+_2.2 cm respectively.The only statistically significant difference in this study was that the right humerus was longer than the left. It has been reported that 90-95% of people are right-handed.(17) In the manual workers, the pressure of the tendon of the long head of the biceps is higher on the right side than on the left, which may be expected to change the morphometry of the BG.(16) Vettivel et al. observed that the mean width of the BG was greater on the right than the left humeri and the mean depths of the BG on right and left sides were similar.(16) The biceps is a muscle for heavy work and it is hypertrophied in manual laborers,(18) with a resultant increase in the size of its long tendon.(17) . It was reported that more pressure on the BG and accommodation of a larger, flat tendon could increase its length, width and depth. (19) The width of bicipital groove in the present study is less than the studies of vettivel et al(16) and Wafae et al(14) where as it is greater than the other studies. The depth of the bicipital groove in the present study is comparable to Cone et al , Muralimanju et al and Gupta S et al, more than Vettival et al and Wafae et al study and less than Levinsohn , Singh et al ,Prajakta Kishve et al study.(19-23)The width and depth of the bicipital groove was compared with the study of the other authors in table 2. On patient radiographs, Cone et al. found that the mean depth of the intertubercular sulcus was 4.6 mm. They also reported that 90% of their patients had a sulcus with a depth greater than 3 mm and 86% had a depth in the range of 4-6 mm. Finally they felt that a groove 3 mm deep or less should be viewed with suspicion in managing pathologic conditions

www.ijbamr.com P ISSN: 2250-284X , E ISSN : 2250-2858

of the shoulder.In the present study the mean depth of intertubercular sulcus was found to be 4.55+/-1.1 mm and 86.5 % had a depth greater than 3mm and 83.9% had a depth in the range of 4-6mm and 14.5% had a groove 3mm deep or less which is almost same as that of Cone et al study(19).(table 3)

TABLE 2: Comparison of width and depth of bicipital groove (mean)

S NO	Author	Width of bicipital groove (mm)	Depth of bicipital groove (mm)
1.	Cone et al (19)	8.8	4.3
2.	Levinsohn (20)	7	5
3.	Vettivel et al (16)	10.23	3.7
4.	Joseph et al (21)		5.1
5.	Muralimanju et al (15)	8.5	4.4
6.	Singh et al (22)	8	6
7.	Prajakta kishve et al (23)	5.5	9.4
8.	Wafae et al (14)	10.1	4
9.	Gupta s et al(24)	7.17	4.23
10.	Present study	9	4.6

TABLE 3: Comparison between depth of bicipital groove

S NO	Depth of the bicipital groove	Cone et al (19)	Present study
1.	</=3mm	10%	14.5%
2.	4-6 mm	86%	83.9%
3.	>6mm	4%	1.6%

Hitchcock and Bechtol analyzed a group of 100 humeri in regard to the conformation of the intertubercular groove; they found a partial or complete supratubercular ridge which has the effect both of making the groove more shallow and of affording a roughened area that may traumatize the tendon , in 67% of their specimens (8% complete and 59% partial).(25) Vettivel et al observed a supratubercular ridge of Meyer in 88% of right and 57% of left humeri, and reported that this ridge is probably more necessary on the right side to prevent medial displacement of the long head of the biceps tendon from the BG.(16) However, Cone et al., from their radiological interpretation, observed the supratubercular ridge as an osseous protuberance in about 50% of cases and reported that it does not seem to be pathologically significant.(19) In B.V.Murlimanju study, this ridge was identified in 23.1% of humeri. Of these, 15.4% were on the right and 7.7% were on the left side.(15) .In Gupta S et al study STR was seen in 42% of the humeri of which 71% were of the right side and 29% on the left.(24) In Arunkumar et al study the supratubercular ridge was found in 26.5% of the humeri out of which 18.1% on right side 8.4% on left side. (26). In the present study STR was seen in 58% of the specimens (26% complete and 32% partial) out of which 28% on right side

www.ijbamr.com P ISSN: 2250-284X , E ISSN : 2250-2858

and 30% on left side. The values of our study is less than Hitchcock and Bechtol ,Vettivel et al study and greater than Cone et al, Muralimanju et al , Gupta et al ,Arunkumar et al study. (table 4)

Table 4 : Comparison of supratubercular ridges (STR) among various authors

S NO	Author	% of STR	Right side (%)	Left side(%)
1.	Hitchcock and Bechtol (25)	67	-	-
2.	Vettivel et al(16)	-	88%	57%
3.	Cone et al (19)	50%	-	-
4.	B.V.Muralimanju et al (15)	23.1%	15.4%	7.7%
5.	Gupta S et al (24)	42%	71%	29%
6.	Arunkumar et al (26)	26.5%	18.1%	8.4%
7.	Present study	58%	28%	30%

Hitchcock and Bechtol found marked differences in the depth of the groove and in the angle that its medial wall makes with its floor, with 8 per cent having a medial wall that made an angle of less than 45 degrees. Hitchcock and Bechtol defined six variations of the angle of the medial wall of the bicipital groove . Type 1 grooves had an angle off 90 degrees. Type 2 grooves had an angle of 75 degrees. Type 3 grooves had an angle of 60 degrees. Type 4 grooves had an angle of 45 degrees. Type 5 grooves had an angle of 30 degrees. Type 6 grooves had an angle of 15 degrees.(25) In the present study type 3 is commonest followed by type 2. Type 4 is the least and other types are absent. In Hitchcock and Bechtol , Ashwini et al study type 2 is commonest and type 6 is the least and the present study doesn't coincide with the above authors study.(27)

Table 5: Incidence of variations in the medial wall angle of the bicipital groove

S NO	Type of variations	Degrees	Hitchcock and Bechtol	Present study
1.	Type 1	90	23%	-
2.	Type 2	75	27.09%	20.5%
3.	Type 3	60	21.70%	79%
4.	Type 4	45	17.39%	0.5%
5.	Type 5	30	7.30%	-
6.	Type 6	15	2.10%	-

The medial wall angle of BG of our study is greater than Rajani et al (22) and Abboud et al (28) , Arunkumar et al study and equal to that of Cone et al. The opening angle of BG in the present study is less than results of Abboud et al. and Rajani et al, Arunkumar et al study. (TABLE 6)

www.ijbamr.com P ISSN: 2250-284X , E ISSN : 2250-2858

Table 6: Comparison of medial wall angle of bicipital groove

S NO	Author	Medial wall angle (degrees)	Opening angle (degrees)
1.	Cone et al (19)	56	
2.	Abboud et al (28)	47	81
3.	Rajani et al (22)	48.91	82.2
4.	Arun kumar et al (26)	48.72	82.9
5.	Present study	56.46	62.21

In the present study medial spurs were found in 31% and is less than Ueberham et al study (29) and more than Ashwini et al (27)study as they reported 4.16% medial spurs. In the present study lateral spurs were found in 3.9% which is very less compared to Ueberham study in which they reported 32% lateral spurs. The present study was limited in that it did not include parameters such as the height, body build and gender of the donors. The length of the bicipital groove may be related to the height and build of the individual. A person with a broad body build is likely to have larger parameters. The age and occupation may also be especially important for defining the depth and width because increasing age and occupations requiring repetitive and strong movement of the tendon in the groove may influence these parameter

CONCLUSION

The present study is an attempt to determine the morphometry of the bicipital groove ,variations in the medial wall angle and supratubercular ridges in the humeri of south Indian population. The data is an attempt to add to the knowledge of the bicipital groove in the south Indian population which can be useful in planning of orthopaedic surgeries around the proximal humeri as well as diagnosis of the pathological conditions of the tendons and other structures around the groove. It can also be a used as a landmark for humeral head replacement in fractures of the upper end of the humerus. Osseous spurs and supratubercular ridge may predispose to dislocation of tendon of biceps brachii. Therefore the study is important as the knowledge of its morphometry is essential for the selection of prosthetic design, size and position. The data can also be useful for the anthropologists, radiologists, orthopaedicians and clinical anatomists.

REFERENCES

1. William Henry Hollinshead . Anatomy for Surgeons : The Back and Limbs . vol (3). New York : Harper & Brothers : 1958 .325-364 .

2. Ellis H, Healy JC, Johnson D, Williams A. Gray's anatomy. In: Standring S, editor. The Anatomical Basis of Clinical Practice. 39th edition. Spain: Churchill Livingstone; 2006:823-32.

3.Meyer, A.W. Spontaneous dislocation and destruction of tendon of long head of biceps brachii: Fifty nine instances. Arch. Surg. 17 : 493,1928.

4. Basmajian JV, Latif A. Integrated actions and functions of the chief flexors of the elbow: a detailed electromyographic analysis. J Bone Joint Surg Am. 1957 Oct;39-A(5):1106–1118.

5.Sullivan WE, Mortensen OA, Miles M, Greene LS. Electromyographic studies of m. biceps brachii during normal voluntary movement at the elbow. Anat Rec. 1950 Jul;107(3):243–251.

6.Travill A, Basmajian JV. Electromyography of the supinators of the forearm. Anat Rec. 1961 Apr;139:557–560.

7. Slatis P, Aalto K. Medial dislocation of the tendon of the head of the biceps brachii. Acta Orthop Scand 1979;50: 73-7.

8. Nevaiser RJ. Lesions of the biceps and tendinitis of the shoulder. Orthop Clin North Am 1980;11:343-8.

9. DePalma AF. Surgical anatomy of the rotator cuff and the natural history of degenerative periarthritis. Clin Orthop Relat Res 2008;466:543-51.

10. Karistinos A, Paulos LE. Anatomy and function of the tendon of the long head of the biceps muscle. Oper Tech Sports Med 2007;15:2-6.

11. NicholaMafulli, John P Furia: Rotator cuff disorders: Basic science and clinical medicine. 87-91,2012.

12. Rockwood CA and Masten FA. The Shoulder. Philadelphia, W. B. Saunders Company. Vol 2,1990.

13.Sethi N ,Wright R ,Yamaguchi K .Disorders of the long head of the biceps tendon. J Shoulder Elbow Surgery 1999; 8: 644-54.

14. Wafae N, Atencio Santamaría LE, Vitor L, Pereira LA, Ruiz CR, Wafae GC. Morphometry of the human bicipital groove (sulcus intertubercularis). J Shoulder Elbow Surg 2010;19:65-8.

15. Muralimanju BV, Prabhu LV, Pai MM, Shreya M, Prashant KU, Chettiiar GK, Rao CP. (2012). Anthropometric Study of the Bicipital Groove in Indians and Its Clinical Implications. Chang Gung Med J. (35), 155-9, 2012.

16. Vettivel S, Indrasingh I, Chandi G, Chandi SM. Variations in the intertubercular sulcus of the humerus related to handedness. J Anat. 1992 Apr;180(Pt 2):321-6.

17. Adams RD, Victor M. Principles of Neurology. 4th ed. Singapore: McGraw Hill, 1989:377-95.

18. Rasch PJ, Burke RK. Kinesiology and Applied Anatomy. 5th ed. Philadelphia: Lea & Febiger, 1974:22-40.

19. Cone RO, Danzig L, Resnick D, Goldman AB. The bicipital groove: radiographic, anatomic and pathologic study. AJR Am J Roentgenol 1983;141:781-8.

20. Levinsohn EMand Santelli ED. Bicipital groove dysplasia and medial dislocation of the Biceps Brachii Tendon. Skeletal Radiol. (20), 419-23, 1991.

21. Joseph AA, Arthur RB, Benjamin JW and Philip MD. Bicipital groove morphology on MRI has no correlation to intra-articular biceps tendon pathology. J. Shoulder Elbow Surg. (19), 790-794, 2010.

22. Singh Rajani, Singh Man. Review of Bicipital Groove Morphology and Its Analysis in North Indian Population. Hindawi Publishing Corporation ISRN Anatomy. 2013 , 1-7.

23. Kishve P, Joshi M, Wabale R. Morphometry of Intertubercular sulcus of humerus and its variations. International journal of scientific research, vol 3, Issue 6,318-19, 2014.

24. Gupta S, Naqshi BF, Shah AB et al. Variations in the bicipital groove in north Indian population: a morphological and morphometric study and review of literature. Int J Health Sci Res. 2015; 5(9):220-226

25.Hitchcock ,H. H., and Bechtol , C. O. Painful Shoulder : Observations on the role of the tendon of the long head of the biceps brachii in its causation . J. Bone & Joint Surg. 30-A: 263 , 1948.

26. Arunkumar K R, Manoranjitham R, Delhi Raj U, Shalini R. Morphometric study of Bicipital groove in South Indian population and its clinical implications. Int J Anat Res 2016;4(2):2187-2191.

27.Ashwini. N.S, Venkateshu.K.V. Morphometric Analysis Of Bicipital Groove Of Upper End Of Humerus In South Indian Population. Int J Anat Res 2017;5(2.2):3870-3875

28. Abboud JA, Bartolozzi AR, Widmer BJ, DeMola PM. Bicipital groove morphology on MRI has no correlation to intra-articular biceps tendon pathology. J Shoulder Elbow Surg 2010;19:790-4.

29. Ueberham K, Le Floch-Prigent P.Intertubercular sulcus of the humerus: biometry and morphology of 100 dry bones. Surg Radiol Anat. 1998;20(5):351-4.