International Journal of Anatomy and Research,
Int J Anat Res 2016, Vol 4(4):3009-15. ISSN 2321-4287
DOI: http://dx.doi.org/10.16965/ijar.2016.394

Original Research Article

MORPHOMETRIC ANALYSIS OF BICIPITAL GROOVE OF HUMERUS WITH ITS CLINICAL IMPLICATIONS: A STUDY IN WEST BENGAL

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ABSTRACT

Background: Bicipital groove (BG) is defined as an indentation present on the anterior aspect of upper end of humerus. Morphometry of BG is known to play important role in maintaining the stability and function of shoulder joint during multidirectional biomechanical movement of arms. Therefore, knowledge regarding detailed osseous anatomy of BG is essential for better understanding of variety of causes of shoulder pain and disability.

Aim: The goal of the present study was to describe the detailed morphometric features of BG in dry humerii of West Bengal population and also to correlate its clinical implications through literature review.

Materials and Methods: The study was undertaken on 107 dry human humerii of unknown age and sex without any gross pathology collected from different medical colleges of West Bengal. Total length, antero-posterior and transverse width of humerii at surgical neck along with length, width, depth, medial wall and opening angles of BG were measured. Data obtained were statistically analyzed. Finally, results were compared with other similar type of studies.

Results: Total length, antero-posterior and transverse width of humerii were 303.71 ± 21.25, 22.39 ± 1.35 and 24.89 ± 2.00 mm. on right and 294.69 ± 24.39, 21.60 ± 1.38 and 24.01 ± 1.62 mm. on left sides respectively. The length, width and depth of BG were 71.59 ± 3.78, 8.42 ± 0.85 and 4.63 ± 0.38 mm. on right and 70.78 ± 5.04, 7.7 ± 0.50 and 4.45 ± 0.30 mm. on left sides respectively. The mean length, width and depth of BG corresponded to 23.84% of total length, 33.22% of transverse width and 20.65% of antero-posterior width of humerii respectively. The average medial wall and opening angles of BG were 50.22 ± 5.35^0 and 81.41 ± 10.90^0 on right and 53.83 ± 6.80^0 and 79.31 ± 11.32^0 on left sides respectively. Statistical significant differences were found in length, width, depth and medial wall angles of BG between right and left sides ($p < 0.05$). Supratubercular ridge of Meyer was not found in any specimen.

Conclusion: The present study revealed detailed morphometric parameters of BG among West Bengal population which may be helpful for anatomists, anthropologists, orthopaedic surgeons and radiologists.

KEY WORDS: Bicipital groove, Morphometry, Shoulder joint, West Bengal.

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Access this Article online

Quick Response code

DOI: 10.16965/ijar.2016.394

Web site: International Journal of Anatomy and Research
ISSN 2321-4287
www.ijmhr.org/ijar.htm

Received: 01 Sep 2016
Peer Review: 05 Sep 2016
Revised: None
Accepted: 29 Sep 2016
Published (O): 31 Oct 2016
Published (P): 31 Oct 2016

INTRODUCTION

Bicipital Groove (BG) is an important anatomical landmark present on the anterior aspect of upper end of humerus. It lies between lesser

tubercle/tuberosity medially and greater tubercle/tuberosity laterally. Intertubercular sulcus is continued distally for about 5 cm. on the shaft of humerus and altogether considered as BG. This groove presents lateral, medial lips and floor. Its lateral and medial lips provide attachment of pectoralis major and teres major tendon respectively while its floor is occupied by the tendon of latissimus dorsi. The BG along with transverse humeral ligament bridging it superiorly give passage to the tendon of long head of biceps brachii muscle with its synovial sheath and an ascending branch of anterior circumflex humeral artery [1,2]. Coracohumeral ligament directly overlies the transverse humeral ligament/ muscle fibres and becomes continuous with rotator cuff. This groove with transverse humeral ligament/muscle fibres of subscapularis, supraspinatus, pectoralis major bridging it provide stability and smooth functioning of tendon of long head of biceps brachii muscle and prevent its subluxation during multidirectional biomechanical movements of arms [2-4].

Since BG and tendon of biceps are intimately related, it is quite sensible to believe that variation in morphology and morphometry of BG may influence the function of the tendon and consequently play vital role in a variety of causes of shoulder pain and disability. Pathologies of biceps tendon in the form of primary or secondary tendinitis and accordingly different treatment regimens for each of these entities have been discussed in a series of reports by various workers [5,6]. Such pathologies of biceps tendon causing impingement, pre-rupture or instability of tendon at the entry into BG have been postulated to be among most frequent causes of pain and disability of shoulder region. A radiological study recommended that entire length of BG be examined to determine the osseous anatomy of the groove [7]. Recently, there has been an upsurge and renewed interest on anatomical knowledge of BG regarding its morphology and morphometry due to development of various advanced shoulder reconstruction technique for selection of suitable prosthesis device [8].

Supratubercular ridge of Meyer (STR) was originally described by Meyer in 1928 and later on by Hitchcoch and Bechtol in 1948 as a bony protuberance extending from superior aspect of lesser tubercle/tuberosity more than the half distance to the head of humerus [9,10]. Vettivel pointed out presence of this ridge as an indicator of handedness. When it is present, it allows the tendon a more gradual change in direction as it enters BG by lifting and forcing it laterally, thus may prevent medial dislocation of tendon [11].

Taking into consideration of increasing clinical interest in recent past, data on this topic is meager especially on West Bengal population. Therefore, the present study was attempted to provide additional information regarding morphometry of BG and to correlate with its clinical implications through literature review.

MATERIALS AND METHODS

The present study was performed on unpaired 107 dried cadaveric humerii (59 belonging to right side and 48 of left sides) of unknown age and sex collected from different medical colleges of West Bengal. The humerii which exhibited damage or any pathological changes were excluded from the present study. Total length, antero-posterior and transverse width of humerii at surgical neck along with length, width, depth, medial wall and opening angles of BG were measured. The total length was measured with the help of ruler. The antero-posterior and transverse width of humerii at surgical neck along with other parameters like length, width, depth of BG were analyzed by vernier caliper. The length of BG was determined as maximum distance between most proximal and distal point of the groove. Similarly, width was estimated as maximum distance between medial and lateral lips of the groove and depth as distance between greater or lesser tubercle/tuberosity to floor of the groove [Figure 1]. Angle formed between the plane of the floor and medial wall of the groove was defined as medial wall angle and the angle between the planes of lateral and medial walls of the groove as opening angle respectively. These angles were computed by image analysis technique as follows.

Image analysis: Once the photograph was taken, the image was transferred to a computer. On each image, a line was drawn tangential to the superior margin of greater and lesser tubercle/ tuberosity of humerus. A second line was drawn

Fig. 1: Showing length, width and depth of bicipital groove (BG).

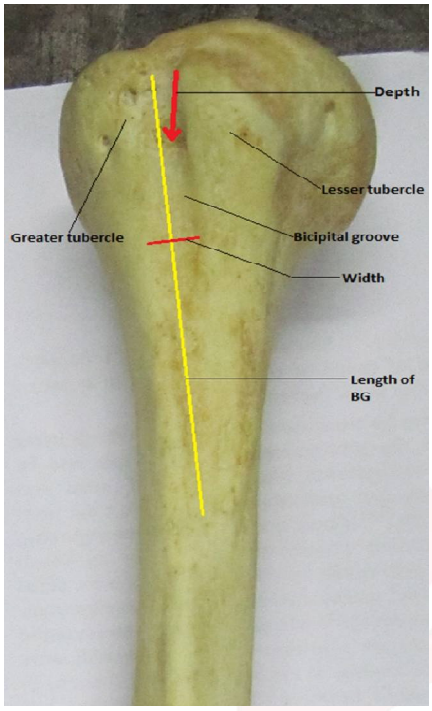
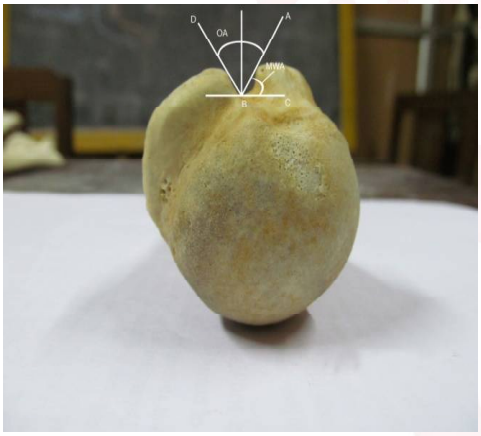


Fig. 2: Showing Medial wall angle (MWA) and Opening angle (OA).



ABC = MWA (Medial wall angle) and ABD = OA (Opening angle).

tangent to the medial wall of the groove. Similarly third line was drawn along lateral margin of the groove. Once the lines were drawn, print-outs of all images were taken and medial wall and opening angles were measured accordingly as angles of intersection of different lines with the help of protractor [Figure 2].

All these parameters were accurately measured by two observers separately and average values were taken. Data obtained were tabulated as Mean ± SD and statistically analyzed using SPSS version 16. The difference between right and left humerii were compared statistically by independent sample t-test, the difference was considered as significant if the p-value was found less than 0.05. All humerii were examined for the presence of STR. Finally, results were compared with other similar type of studies.

RESULTS

The comparisons of Mean ± SD of different parameters between the sides are presented in Table 1. Mean length of BG on the right side was 71.59 ± 3.78 mm. and that of the left side was 70.78 ± 5.04 mm. The width of BG on right side was 8.42 ± 0.85 mm. and that on the left side was7.7 ± 0.50 mm. The depth of BG on right side was 4.63 ± 0.38 mm. and that on the left side was 4.45 ± 0.30 mm. The average medial wall and opening angles of BG were 50.22± 5.35^0 and 81.41±10.90^0 on right sides and 53.83± 6.80^0 and 79.31±11.32^0 on left sides respectively.

Average length, antero-posterior and transverse diameters of humerii were 303.71 ± 21.25, 22.39 ± 1.35 and 24.89 ± 2.00 mm. on right and 294.69 ± 24.39, 21.60 ± 1.38 and 24.01 ± 1.62 mm. on left sides respectively. The means of total length (TLH), antero-posterior diameters (APD) and transverse diameter (TD) at surgical necks of humerii were observed as 299.67 ± 23.05, 22.04 ± 1.41 and 24.50 ± 1.88 mm. respectively. The mean length (L_BG), width (W_BG) and depth of BG (D_BG) were 71.23 ± 4.39, 8.10 ± 0.80 and 4.55 ± 0.35 mm. respectively which corresponded to 23.84% of average total length of humerus, 33.22% of average width of humerus and 20.65% of average depth of humerus respectively. It was observed that there was no statistical significant difference between right and left side in respect to different parameters of humerus except transverse diameters at surgical neck. But when data was compared regarding bicipital groove, it was statistical significant difference was observed in respect to length, width and depth between right and left sides. Later on, when medial wall angle (MWA) and opening angle (OA) were compared between two sides of humerus, higher values were observed on right side but the difference was not significant in case of OA but significantly lower MWA was observed on right BG. However, STR was not observed on any humerus in the present study.

Table 1: Showing different morphometric parameters of humerus and bicipital groove (n = 107).

Values are presented as Mean ± SD, Statistical significance (independent t-test,* $p < 0.05$).

Abbreviations: BG: Bicipital groove; TLH: Total length of humerus; APD: Antero - posterior diameter at surgical neck; TD: Transverse diameter at surgical neck; L: Length; W: Width; D: Depth; MWA: Medial wall angle; OA: Opening angle; STR: Supratubercular ridge.

Parameters	Right side	Left side	p-value
TLH(mm.)	303.71 ± 21.25	294.69 ± 24.39	0.05
APD(mm.)	22.39 ± 1.35	21.60 ± 1.38	0.36
TD(mm.)	24.89 ± 2.00	24.01 ± 1.62	0.00*
L_BG(mm.)	71.59 ± 3.78	70.78 ± 5.04	0.01*
W_BG(mm.)	8.42 ± 0.85	7.7 ± 0.50	0.00*
D_BG(mm.)	4.63 ± 0.38	4.45 ± 0.30	0.02*
MWA(^{0})	50.22 ± 5.35	53.83 ± 6.80	0.003*
OA(^{0})	81.41 ± 10.90	79.31 ± 11.32	0.88
STR	Nil	Nil	-

Table 2: Showing comparison of morphometric parameters of Bicipital Groove between present and other previous studies.

Authors	L_BG (mm.)	W_BG (mm.)	D_BG (mm.)	MWA (^{0})	OA (^{0})	STR (%)
Waefae et al. 2010 [13]	81	10.1	4	-	-	-
Cone et al. 1983 [16]	-	8.8	4.3	56	-	50
Abboud et al. 2010 [19]	-	-	5.1	47	81	-
Murlimanju et al. 2012 [14]				-	-	
Right	86.0 ± 10.1	8.3 ± 2.4	4.7 ± 2.0			15.4
Left	83.3+ 11.5	8.7 ± 2.2	4.2 ± 1.6			7.7
Rajani et al. 2013 [3]				-	-	
Right	85 ± 09	9.0 ± 2.1	5.0 ± 1.0			17
Left	83 ± 10.1	8.9 ± 1.1	6.0 ± 1.0			20
Rajan et al. 2016 [12]				-	-	
Right	84.79 ± 5.84	6.84± 1.01	4.21 ± 0.58			17
Left	87.33 ± 6.40	7.74± 1.96	5.01± 1.05			14
Arunkumar et al. 2016 [4]	83	8.4	5	48.7	82.9	26.5
Gupta et al. 2015 [15]	74.1	10.8	5.5	-	-	-
Present study						-
Right	71.59 ± 3.78	8.42± 0.85	4.63 ± .38	50.22 ± 5.35	81.41± 10.90	
Left	70.78 ± 5.04	7.7 ± 0.50	4.45 ± 0.30	53.83 ± 6.80	79.31± 11.32	

DISCUSSION

Variation is the rule in God's creation. The human body is of no exception to this law. Some variations which may be developmental or acquired can give rise to abnormal functioning of the system. BGs of humerus also show variations in their morphology and morphometry. Since BG and biceps tendon are intimately related, it is understood that variation of BG may influence the function of biceps tendon and consequently play important role in causing tendon instability and attritional damage [3,5].

Therefore, morphometry of BG allowing space for the passage of biceps tendon can be determined by various dimensions of the groove in the form of its length, width and depth along with their correlation with respective dimensions of humerii.

The results of the present study have been compared with other anthropometric studies of BG carried out by various authors available in accessible literature which are shown in Table 2.

The implication of long wall is expected to ensure greater stability of the tendon within BG during multidirectional movement of shoulder joint. Rajani et al. and Rajan et al. conclusively reported length of medial and lateral walls of BG of both sides [3,12]. But in our study, we did not measure the length of the walls separately rather average total length which when compared with that of previous studies it was found lower [4,13,14], but higher than that observed by Kaur and Gupta [2] and was close

to the findings of Gupta et al. [15]. The depth and width of BG have been implicated to be the most important contributing factors for retention of tendon of long head of biceps brachii muscle in position. In this respect, width of the present study is compared with those of similar parameters reported by other authors [3-4,12-14]. According to Cone et al, wide groove of more than 17 mm. are often shallow which together may predispose subluxation or dislocation of the tendon [16]. Shallow BG may lead to chronic trauma or impingement by the overlying acromion, rotator cuff and coracoacromial arch while deep groove are more likely to cause constriction of the tendon as propounded by De Palma [17]. It is quite evident that a shallow and wide groove promotes subluxation/dislocation of biceps tendon often than a deep and narrow groove which on the other hand can cause irritation and tenosynovitis. Therefore, measurement of width and height of biceps tendon itself were undertaken by Rajani and Man in order to reach precise definition of narrow and shallow groove [3]. Sex related difference of BG in terms of width and depth was observed by Pfalher et al. [18] while Kaur and Gupta [2] discussed significant gender based difference regarding length and depth. The average depth of BG i.e. 4.55 ± 0.35 mm. in our study coincide more or less observations of Murlimanju et al. [14], but lower than the results of various studies [3-4,15,19] and found higher than that of Waefae et al.[13].

In our study, length, width and depth of BG were statistically more significant on right side as compared to left side. This can be explained on the basis that the higher pressure exerted by long tendon on the right side in manual workers may consequently alter the morphometry of BG on the respective side in terms of increase in its length, width and depth [11].

In the present study, average length, width and depths of BG corresponded to 23.84%, 33.22% and 20.65% of total length, transverse and antero-posterior diameters of humerii respectively which showed minor degree of variations when compared with other studies [14,15]. It could be due to the fact that humans are unique among primates in presenting marked variations in the configuration of BG as mentioned by Rockwood & Masten [20].

The concept of MWA was proposed by Hitchcock and Bechtol as important factor retaining the biceps tendon in intertubercular sulcus [10]. As majority of people use their right hands, medial wall is more pressed upon leading to marked reduced angle on right side. More is the medial wall pressed by the tendon, lesser will be its angle thus leading to markedly smaller angle on right side than the left as shown by Kaur et al. and Arun kumar et al. [2,4]. Our study results also matched with them in this aspect. Levinsohn and Santelli [5] reported that medial dislocation of the biceps tendon may be associated with flattened medial wall of BG, but Cone et al. [16] observed no such correlations. Vettivel et al. in their study documented wider BG with more acute MWAs are associated on dominant extremity and therefore reported morphometry of BG as indicators of handedness [21]. According to O Donoghue, more acute MWA ($<30^0$) may predispose to subluxation and obtuse ($<90^0$) to tenosynovitis by causing restriction of movement of the biceps tendon [22].

After reviewing the literature, it has been observed that bony excrescences present in the floor of BG or medial wall spurs could be related either to chronic biceps tenosynovitis or might be the result of continuous friction of tendon against medial wall during medial rotation of arms [2,10,23]. The presence of STR was reported to allow the tendon a more gradual change in direction as it enters BG by lifting and forcing it laterally, thus may prevent medial dislocation of tendon [16]. Association of STR with bicipital tendinitis has also been reported [10]. On the contrary, Nevaiser et al. explained the harmful effects of STR that it might favor forward displacement of biceps tendon. STR could thus be the cause of all primary lesions of long head of Biceps Brachii [24,25]. Regarding STR, Cone et al. [16] observed in about 50% subjects whereas Vettivel et al. [21] pointed out presence of this ridge as an indicator of handedness necessary to prevent medial displacement of tendon of long head of biceps from the groove. Low incidence of STR as 18.1% and 15.4% on right and 8.4% and 7.7% on left side were reported by Arunkumar et al. and Murlimanju et al. respectively [4,14]; while Rajan

and Kumar [12] observed 17% and 14% on right and left side respectively which was more or less similar to observations made by Rajani and Man [3]. But, in our study we failed to observe STR in any specimen. These differences in the occurrence of STR in various populations may be attributed to racial and regional variations which should be investigated further.

Limitation:

The humerii used for the present study were of unknown age and sex. In this study, we did not include parameters like height and body build of the subjects whose bones were used. The length of BG may be related to height and build of the individuals. Thus a more detailed analysis could have been done if this data was available. It would have been very much useful if additional information regarding occupation and pattern of upper limbs usage of the individuals were known. Then, a functional correlation with the value of morphometric data obtained could have been performed. The accuracy and reliability of method used in the present study cannot of course be compared to methods using sophisticated tools and imaging techniques [8,26].

CONCLUSION

Since abnormalities of biceps tendon and its synovial sheath have been implicated in a variety of causes of shoulder pain and disability, morphometric assessment of BG could offer useful information for welfare of patients with a view to undertake better shoulder reconstruction surgery. Though minor differences have been observed between past and present study, knowledge of present study highlighting anatomical variant of BG seemed to be relevant and clinically noteworthy. Therefore, the future implications of this study include identification of detailed osseous anatomy of BG in geographically diversified region.

ACKNOWLEDGEMENTS

Authors sincerely acknowledge faculties of the department of Anatomy and statistician for their hands of help.

Conflicts of Interests: **None**

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How to cite this article:

Phalguni Srimani, Ritaban Saha, Biplab Goswami, Sibani Mazumdar. MORPHOMETRIC ANALYSIS OF BICIPITAL GROOVE OF HUMERUS WITH ITS CLINICAL IMPLICATIONS: A STUDY IN WEST BENGAL. Int J Anat Res 2016;4(4):3009-3015. **DOI:** 10.16965/ijar.2016.394