Original Article

http://dergipark.org.tr/en/pub/anatomy
Received: February 12, 2023; Accepted: July 28, 2023
doi:10.2399/ana.23.1381703

anatomy
An International Journal of Experimental and Clinical Anatomy

Correlation of the depth, medial wall and opening angle of the bicipital groove and the dimensions of long head of the biceps tendon

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Abstract

Objectives: The aim of this study was to investigate the relationship between the morphological measurements of bicipital groove and long head of biceps tendon and determine the effect of age and gender on these measurements.

Methods: The study included 110 patients (60 females, 50 males) aged 18–50 years, who underwent magnetic resonance imaging of the left shoulder between January and December 2020. The patients had stable biceps tendons, and did not have a rotator cuff tear. The bicipital groove morphology was evaluated based on depth, opening angle, medial wall angle and the biceps tendon morphology was assessed based on thickness (anteroposterior length) and width (transverse length).

Results: There was no difference between the females and males in terms of age, opening angle and medial wall angle (p>.05). The bicipital groove depth was lower in the females than in the males (p<.001), while the biceps tendon was thicker in the males compared to the females (p<.001). There was no correlation between age and the sizes of bicipital groove and the biceps tendon. A negative correlation was observed between the bicipital groove depth and opening angle (r=-0.55), and a positive correlation between medial wall angle (r=0.51), tendon thickness (r=0.50) and tendon width (r=0.34). Bicipital groove depth had a positive correlation with tendon thickness (r=0.54) in women and tendon width in men (r=0.28).

Conclusion: The morphological measurements of bicipital groove and the biceps tendon showed correlations. There were also gender differences in these morphological measurements.

Keywords: bicipital groove; long head of the biceps tendon; magnetic resonance imaging; measurement

Anatomy 2023;17(2):49–54 ©2023 Turkish Society of Anatomy and Clinical Anatomy (TSACA)

Introduction

The bicipital groove (BG) is an indentation formed between the lesser and greater tubercles in the proximal part of the humerus. The lateral edge of the lesser tubercle forms the medial border of BG. This groove includes the long head of the biceps (LHB) tendon, its synovial sheath, and the ascending branch of the anterior circumflex humeral artery. BG is also transformed into a canal by the fibrous transverse humeral ligament that runs between the lesser and greater humeral tubercles.[1–6]

One of the causes of shoulder pain and immobility is abnormalities of the LHB tendon and its synovial sheath. The relationship between the instability of the LHB tendon and the morphology of BG was investigated in some previous studies.[7–10] In these publications, the BG morphology was evaluated based on depth, angle of opening (OA), and medial wall angle (MWA). However, to the best of our knowledge, there is no study investigating the relationship between the morphological measurements of BG and the LHB tendon in individuals with stable LHB tendons.

The aim of this study was to investigate the correlation between the measurements of BG and the LHB tendon and determine the effect of age and gender on these measurements.

Materials and Methods

Patients who underwent left shoulder magnetic resonance imaging (MRI) for shoulder pain between January and December 2020 were retrospectively evaluated. The exclusion criteria were as follows: age below 18 or above 50 years, rotator cuff and LHB tendon partial/full-thickness tear, LHB tendon subluxation/dislocation, history of trauma and operation, mass lesions in bone or soft tissue at shoulder level, cyst in the lesser tubercle region, inflammatory arthritis; inability to evaluate MRI images due to motion artifacts and low quality. After applying the exclusion criteria, 110 patients (60 females, 50 males) were included in the study.

The MRI images (Signa Explorer, GE Medical System, Milwaukee, WI, USA) of the patients were taken with a 1.5T unit using extremity coil. A standardized MRI examination protocol was used and the following five sequences were performed for each patient as oblique coronal T1-weighted fast spin echo (FSE) (repetition of time (TR): 521 ms; echo of time (TE): 15.8 ms; thickness: 3 mm; matrix: 224×224; and field of view (FOV): 16×16 cm), oblique coronal fat-suppressed T2-weighted FSE (TR: 5178 ms; TE: 85 ms; thickness: 3 mm; matrix: 224×224, and FOV: 16×16 cm), oblique sagittal T1-weighted FSE (TR: 575 ms; TE: 15.7 ms; thickness: 3 mm; matrix: 224×224; and FOV: 16×16 cm), oblique sagittal fat- suppressed T2-weighted FSE (TR: 5825 ms; TE: 75 ms; thickness: 3 mm; matrix: 224×224; and FOV: 16x16 cm), oblique axial fat-suppressed proton-density FSE (TR: 2250 ms; TE: 38 ms; thickness: 3 mm; matrix: 224×224; and FOV: 16×16 cm).

As described in previous publications, morphological measurements were performed from the deepest part of the BG midline in each patient.[7–10] The necessary lines and angles were drawn using PACS Viewer (Teknoritma PACS Viewer, v5, Teknoritma Software, Ankara, Türkiye) by a single radiologist (SD).

The morphology of BG was evaluated based on depth, OA, and MWA. The BG depth was defined as the vertical distance between the line connecting the highest points of the greater and lesser tubercles and the line passing through the deepest point of the groove[7,8] (**Figure 1a**). OA represents the angle between the line joining the deepest point of the groove and the highest point of the greater tubercle and the line connecting the deepest point of the groove and the highest point of the lesser tubercle[7,8] (**Figure 1b**). MWA represents the angle between the line connecting the deepest point of the groove to the highest point of the lesser tubercle and the line passing through the deepest point of the groove[7,8] (**Figure 1c**). Lastly, the LHB tendon width (transverse length) and thickness (antero-posterior length) were measured in the same plane (**Figures 2a** and **2b**).

Data were analyzed using IBM SPSS Statistics Standard Concurrent User v. 26 (IBM Corp., Armonk, NY, USA).

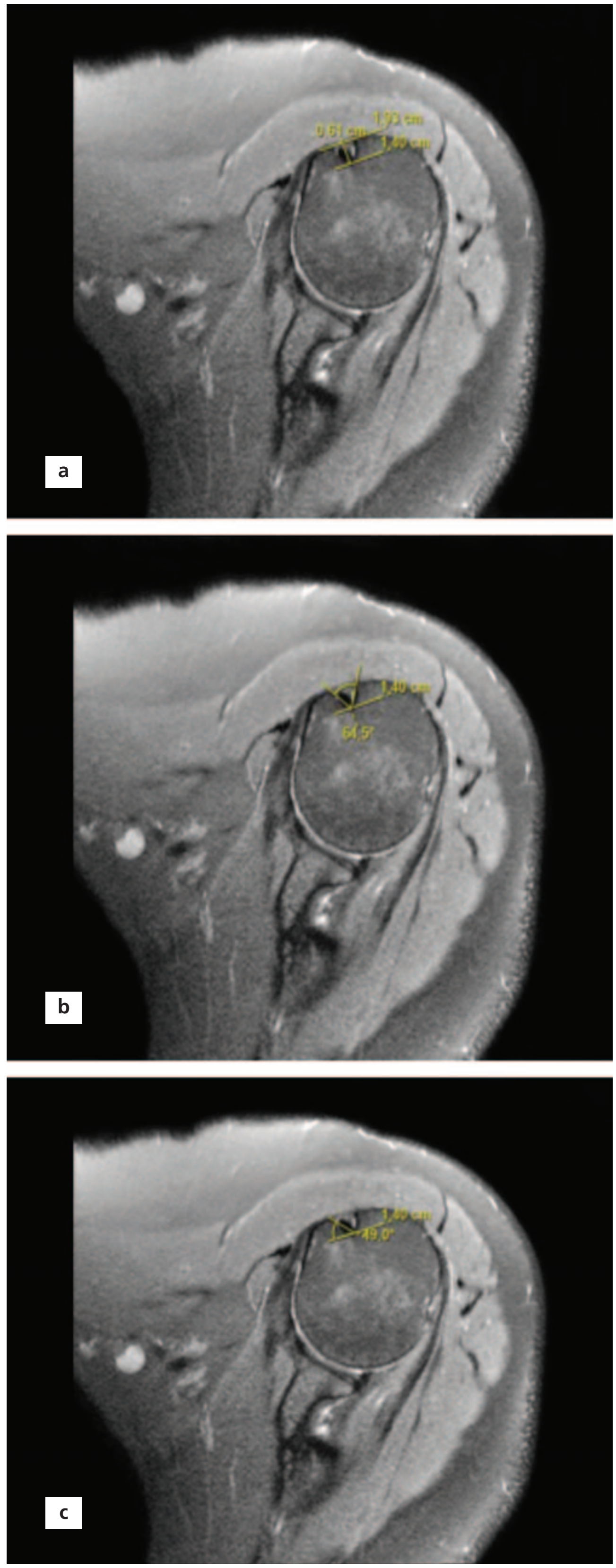

Figure 1. Measurement of the bicipital groove depth (**a**), opening angle (**b**) and medial wall angle (**c**) in a patient on the MR images.

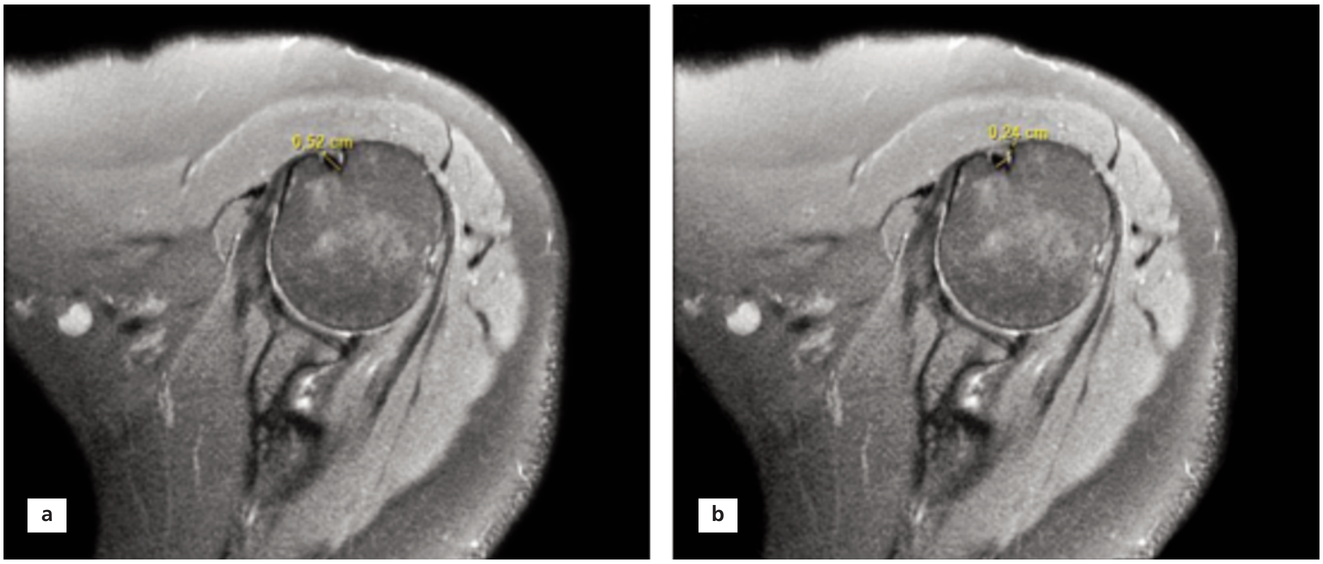

Figure 2. Measurement of the long head of the biceps tendon thickness (**a**) and width (**b**) on the axial MR images.

Descriptive statistics were given as mean±standard deviation ($\overline{X}$±sd) values. The normal distribution of the data belonging to numerical variables was evaluated using the Shapiro-Wilk test of normality, and the homogeneity of the variances was evaluated with the Levene test. The independent-samples t-test was used for the comparisons between gender and age, BG depth, OA, MWA, and LHB tendon thickness and width. Relationships between numerical variables were analyzed with the Pearson correlation analysis. A p-value of <0.05 was considered statistically significant.

Results

The results of the morphological measurements in the study group and the distribution of these measurements by gender are given in **Table 1**.

Of the 110 patients, 60 were females (54.5%) and 50 were males (44.5%). The mean age of the cases was 44.4±11.7 years (44.4±10.1 for the females and 44.5±13.3 years for the males) with no significant difference between the genders.

There was no statistically significant gender difference in terms of OA (p=0.262) and MWA (p=0.054). The BG depth was statistically significantly lower in the females than in the males (p<0.001). The LHB tendon thickness (p<0.001) and width (p=0.001) were statistically significantly lower in the females compared to the males.

No correlation was found between age and the morphological measurements of BG and the LHB tendon for the whole sample. There was a negative correlation

Table 1
Distribution of morphological measurements according to gender and all patients (mean±SD).

	Gender			
	All patients (n=110)	Female (n=60)	Male (n=50)	p-value
Age (year)	44.4±11.7	44.4±10.1	44.5±13.3	0.950
BG depth (mm)	4.78±0.54	4.51±0.54	5.06±0.54	<0.001
Opening angle (0)	79.63±8.30	80.53±8.71	78.73±7.90	0.262
Medial wall angle (0)	48.86±5.60	47.91±5.70	50.01±5.55	0.054
LHB tendon thickness (mm)	4.50±0.43	4.12±0.35	4.88±0.52	<0.001
LHB tendon width (mm)	2.46±0.31	2.35±0.28	2.57±0.37	0.001

BG: bicipital groove; **LHB tendon:** long head of the biceps tendon.

between the BG depth and OA (r=-0.55), and a positive correlation between MWA (r=0.51) and the LHB tendon thickness (r=0.50) and width (r=0.34). In the female patient group, there was also a negative correlation between the BG depth and OA (r=-0.62), and a positive correlation between MWA (r=0.51) and the LHB tendon thickness (r=0.54). A negative correlation was observed between the BG depth and OA (r=-0.50), and a positive correlation between MWA (r= 0.46) and the LHB tendon width (r=0.28) for the male patient group. **Table 2** presents the detailed results of the correlation analysis.

Discussion

One of the findings of the current study is the positive correlation between depth of BG and the LHB tendon. In the current study, the BG depth/LHB tendon thickness ratio was 91% in women and 96% in men.

The BG morphology is important both as an anatomical landmark for LHB tendon stability. The literature contains studies on the anatomical features of BG,[1–6,11,12] of which most have been conducted in cadavers and cadaveric bone collections. In these studies, the BG depth has been commonly measured, and this value is reported to range from 4 to 7 mm.[1–6,11,12] In the current study, we found the BG depth to be 4.78±0.54 mm, which is consistent with previous studies.[1–4,6,12]

Studies on OA and MWA are very limited.[1–3] The measurement of OA was previously reported as 78.31±21.85° by Rajani and Man[1] and 82.58±24.3° by Arunkumar et al.[3] In our study, the mean OA was 79.63±8.3°, which was consistent with the former study. MWA was previously determined as 50.85±10.93° by Rajani and Man,[1] 49.63±10.41° by Arunkumar et al.,[3] and 55.83±4.21° by Ventakesen et al.[2] In the current study, we found the mean MWA to be 48.86±5.6°, which is in agreement with the studies of Rajani and Man[1] and Arunkumar et al.[3]

Different from the studies in the literature, we also investigated the correlation between the morphological measurements of BG. We detected a negative correlation between the BG depth and OA, indicating that OA would be larger in a shallower groove. In contrast, there was a positive correlation between the BG depth and MWA; i.e., MWA would be expected to be lower in a shallower groove.

To the best of our knowledge, there is no publication in the literature investigating the effect of gender on the morphological measurements of BG. Pfahler et al.[13] showed that the BG width and depth differed by gender on X-ray films. The mean width of BG was smaller in women than in men. Khan et al.[5] reported that the BG depth was greater in women compared to men, but this was statistically non-significant. Kavak et al.[7] revealed that women with unstable LHB tendons had a smaller MWA than men. In our study, the BG depth was statistically significantly lower in the females compared to the males. OA was greater and MWA was smaller in the females compared to the males, but there were no statistically significant differences in these parameters.

The morphology of BG should be considered as a potential factor affecting the stability of the biceps tendon.[8] There are publications in the literature reporting that a shallow bicipital groove, defined based on a larger OA, smaller MWA, and shallower depth, may be a predisposing factor for biceps tendon instability.[7,8] In our study, we showed that the women had shallower grooves. There is a need for further studies to determine whether women are more prone to LHB tendon instability.

There are very few publications in the literature investigating the effect of gender on the LHB tendon sizes.[14–16] Walton et al.[14] demonstrated that this tendon had an ovoid cross-sectional shape. In a cadaver study, Khan et al.[15] revealed that the LHB tendon width was

Table 2

Correlation between the morphological measurements of BG and the LHB tendon.

		Opening angle		Medial wall angle		LHB tendon thickness		LHB tendon width		BG depth	
		r	p	r	p	r	p	r	p	r	p
All patients	Age	-0.151	0.115	0.065	0.501	0.137	0.154	0.029	0.761	0.082	0.395
	BG depth	**-0.557**	**< .001**	**0.518**	**<.001**	**0.505**	**<.001**	**0.344**	**<.001**		
Female patients	Age	-0.249	0.055	0.055	0.504	0.121	0.357	0.181	0.166	0.076	0.412
	BG depth	**-0.627**	**<.001**	**0.517**	**<.001**	**0.543**	**<.001**	0.186	0.156		
Male patients	Age	-0.059	0.685	-0.138	0.341	0.207	0.146	-0.077	0.597	-0.119	0.411
	BG depth	**-0.501**	**<.001**	**0.468**	**0.001**	0.134	0.352	**0.283**	**0.046**		

BG: bicipital groove; **LHB tendon:** long head of the biceps tendon; **r:** Pearson's correlation coefficient.

higher in women than in men, but this was not statistically significant. Kim et al.[16] measured the sagittal and transverse diameters of the LHB tendon in the right shoulder on ultrasound and reported these values as 2.65±0.86 mm and 5.60±1.57 mm, respectively. The authors noted that the LHB tendon of the males was thicker compared to the females. In our study, we found the mean LHB tendon width as 4.5±0.43 mm and thickness as 2.46±0.31 mm. The tendon sizes were statistically significantly smaller in the female patients than in the males. Our findings are consistent with those reported by Kim et al.[16]

In our study, there was a positive correlation between the BG depth and the LHB tendon measurements. In cases where the BG depth was greater, the LHB tendon was thicker. We also showed that the BG depth was correlated with the LHB tendon thickness among the women and the LHB tendon width among the men. In cases where the BG depth was greater, the LHB tendon was thicker in the female patient group.

In the current study, the BG depth/LHB tendon thickness ratio was 91% in women and 96% in men. This shows the effectiveness of soft tissue stabilizers in maintaining the stability of the tendon. The superior glenohumeral ligament, subscapularis and supraspinatus tendons are known as the main soft tissue stabilizers of the LHB tendon and prevent the subluxation of the LHB tendon during the multidirectional biomechanical movements of the arm.[1] Further studies are needed to demonstrate the effect of the LHB tendon morphology on its stability.

No correlation was found between age and the morphological measurements of BG and the LHB tendon for the two gender. Bone morphology of the bicipital groove has an impact on the development of LHBT pathologies. BG depth, MWA and OA are the parameters to be used in the evaluation of this morphology. By determining the predisposition to LHB tendon pathologies, programs for strengthening soft tissue stabilizers can be applied.

Our study has certain limitations. First, it had a retrospective design and a small sample size. Second, the dominant side of the patients included in the study was unknown. Lastly, information on the physical and sports activities of the patients could not be obtained.

Conclusion

The morphological measurements of BG and the LHB tendon showed correlations. There were also gender differences in these morphological measurements. These findings may provide useful information in orthopedic surgery and clinical anatomy.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

SD: project development, data collection and analysis, manuscript writing, editing; EG and VC: data collection and analysis, manuscript writing.

Ethics Approval

The study was approved by the of Yüksek İhtisas University Clinical Research Ethics Committee (No: 2022/05/03) and carried out in accordance with the Helskinki declaration of principles.

Funding

The authors declare no financial support.

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Conflict of interest statement: No conflicts declared.

 How to cite this article: Duran S, Çayhan V, Günaydın E. Correlation of the depth, medial wall and opening angle of the bicipital groove and the dimensions of long head of the biceps tendon. Anatomy 2023;17(2):49–54.