Available online at www.medicinescience.org

ORIGINAL ARTICLE

Medicine Science International Medical Journal

Medicine Science 2021;10(2):555-9

Morphometric and Morphologic anatomic study and clinical significance of Greater tubercle

Merve Onder[1], Fatih Inci[2]

[1]*Akdeniz University Medicine Faculty, Deparmant of Anatomy, Antalya, Turkey*
[2]*Ankara City Hospital, Clinic of Orthopedics and Traumatology, Ankara, Turkey*

Received 28 March 2021; Accepted 26 April2021
Available online 18.05.2021 with doi: 10.5455/medscience.2021.03.102

Abstract

In this study, in tuberculum majus fractures, which are proximal humerus fractures; Morphometric measurements were made to guide surgeons and future implants. With the morphometric measurement of the greater tubercle, the length of the base, the length of the height, the length at its widest part, and its circumference were calculated. A 3D scanning device (Faro Focus 3D S120 Scanner Rental) was used to scan the proximal part of the humerus, and the proximal ends of the scanned humerus were transferred to the computer and morphometric measurements were made with the software program. As a result of the measurements made: Average base length of the large tubercle 26±2.34 mm, average anterior height of the greater tubercle 30±2.50 mm, average posterior height of the greater tubercle 9.5±0.4 mm and average Widest sagittal length of the greater tubercle 28.75±2.02 mm. We think that the morphological and morphometry of the tuberculum majus, which is one of the formations at the proximal end of the humerus, will guide surgeons with anatomically designed implants in surgical applications.

Keywords: Greater tubercle, morphometry, morphology, proximal humerus, three-dimensional

Introduction

Proximal humerus fractures generally occur owing to low-energy trauma in elderly patients with osteoporosis or high-energy trauma in young patients [1,2].

While non-separated fractures may be treated conservatively, fractures with two or more displaced pieces require surgical care to achieve good functional outcomes [3]. The greater tuberosity of the humerus is susceptible to displacement fractures, which can affect the rotator cuff muscles and also cause subacromial impingement. Surgical intervention is usually required with displacements greater than 3- 5 mm [4].

All implants used in fracture care have the same goal: to hold the fracture in proper reduction until it heals and to provide enough stability for early movement. Isolated fractures of the greater tuberosity constitute 5% of proximal humeral fractures treated surgically [5]. Isolated fractures of the greater tuberosity occurs through different trauma mechanisms. As a result of falling or hyperabduction on the shoulder, the greater tubercle may form above the glenoid as impacted fractures caused by impaction of the acromion or degenerative rupture fractures as a result of anterior shoulder dislocation. In this mechanism, fracture occurs as a result of the greater tubercle impacting the glenoid or pulling the rotator cuff [6]. Some of these fractures are nondisplaced or minimally displaced and can be treated with conservative methods [7-9].

The surgical anatomical structure of the greater tubercle, which is one of the proximal humerus fractures, should be known for surgeons.

Anatomically, there are two protrusions on the outer side of Caput humeri. Greater tubercle (tuberculum majus) refers to the larger one on the back, while lesser tubercle (tuberculum minus) refers to the smaller one. There are foot print areas of the rotator cuff on the greater tubercle. They are marked with 3 straight orientations which are the supraspinatus muscle with the highest orientation and in anterior, the infraspinatus muscle in the middle, and the teres minor muscle with lowest orientation and in posterior. In these explanations, the shapes of the prints of the greater tubercle are defined as a simple geometrical shape [10, 11].

In our research, we assume that anatomical morphometric and morphological analysis of the greater tubercle will be useful in

*Coresponding Author: Merve Onder, Akdeniz University Medicine Faculty, Deparmant of Anatomy, Antalya, Türkiye. E-mail: merveonder@akdeniz.edu.tr

guiding both a more comprehensive approach during surgery and the implant designs that will be developed.

Material and Methods

In this study, we used 25 dry right and left humeral bones with undamaged proximal ends from Akdeniz University Faculty of Medicine's Department of Anatomy. Structures are named using classical anatomical descriptions.

The morphological structure of the greater tubercle formation at the proximal end of the humeri brought to the examination table was recorded independently by the two researchers. Morphometric measurement was made for the formation of the greater tubercle located at the proximal end of the humerus.

A 3D scanning device (Faro Focus 3D S120 Scanner Rental) was used to scan the proximal part of the humerus, and the proximal ends of the scanned humeri were transferred to the computer (Figure 1).

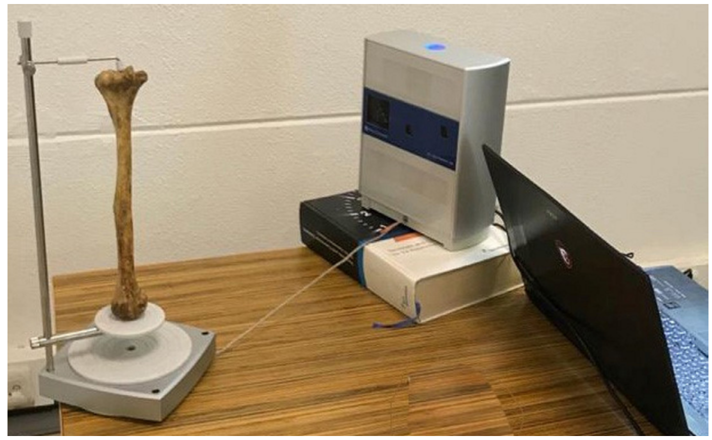

Figure 1. A 3D scanning device and the proximal ends of the scanned humeri

Morphometric measurements of the greater tubercle were provided by transferring 3D scanning data to the SolidWorks software program (Figure 2 a-b).

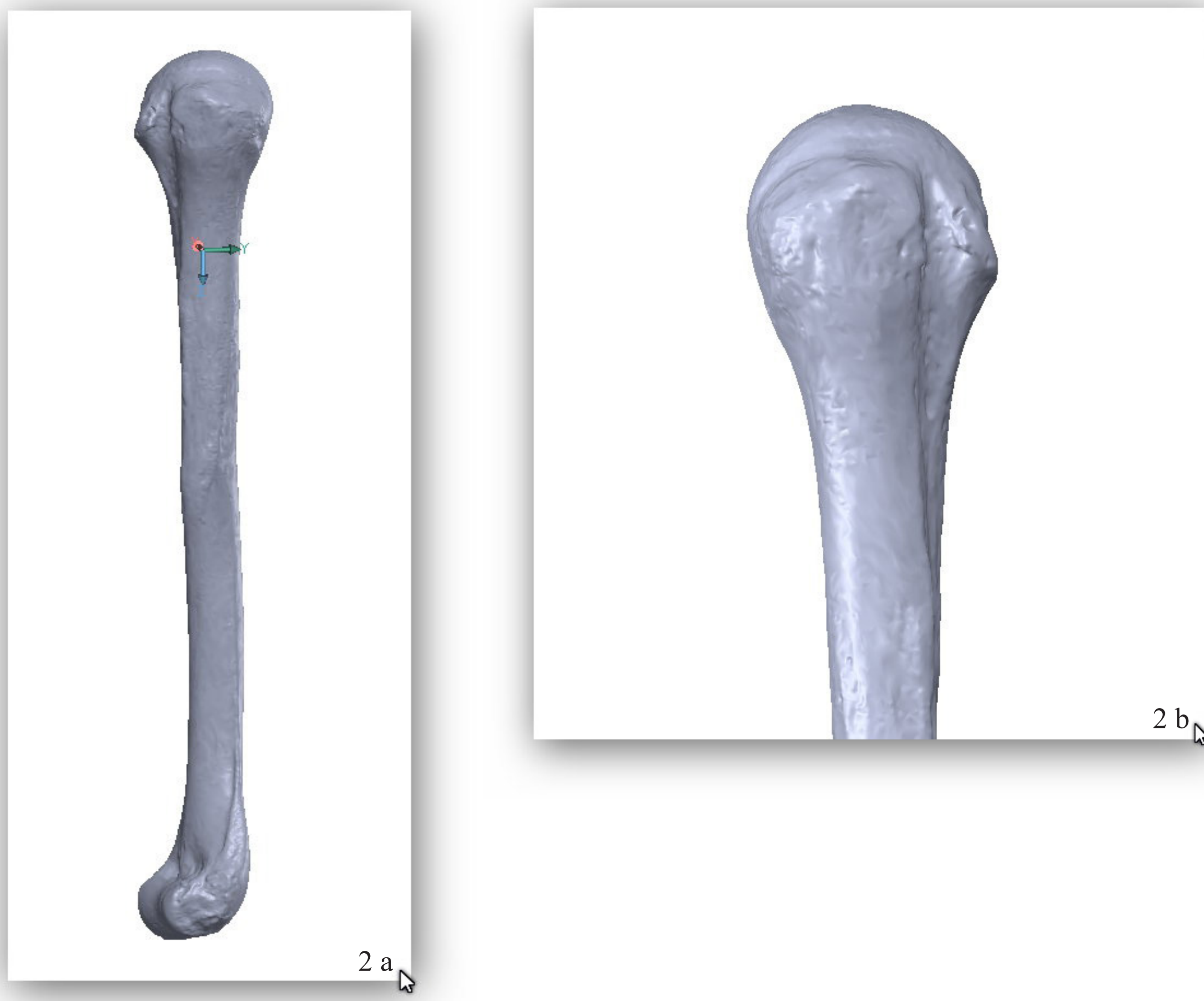

Figure 2. 3D scanning data to the SolidWorks software program

With the morphometric measurement of the greater tubercle, the length of the base, the length of the height, the length at its widest part, and its circumference were calculated (Figure 3 a-b).

Each observer repeated these measurements twice, and he calculated the intraclass correlation coefficient to evaluate the validity of the measurement in each group.

A 3D printer was also used to obtain the shape of the greater tubercle, which was then examined more closely (Figure 4).

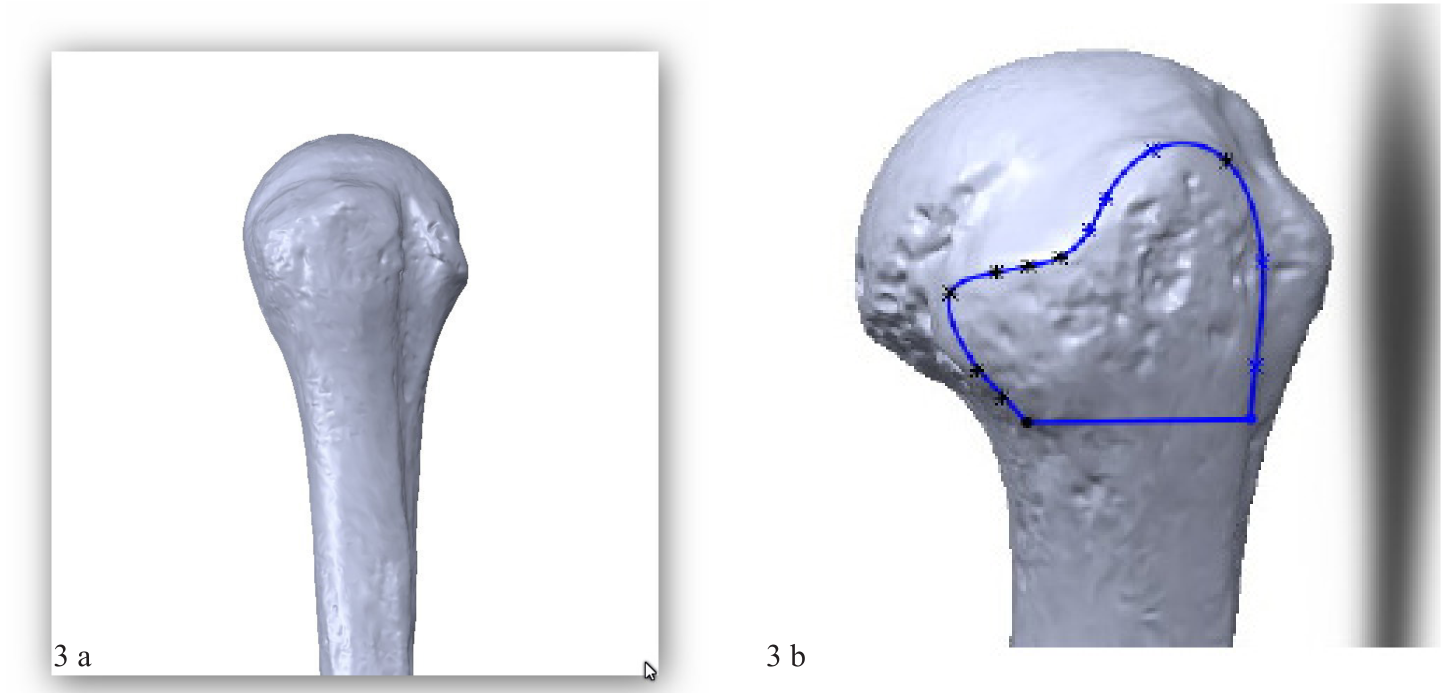

Figure 3. Limits for morphometric measurement of the greater tubercle

Figure 4. A 3D printer was also used to obtain the shape of the greater tubercle

Results

Two researchers recorded the observations regarding the morphological structure of the greater tubercle formation at the proximal end of the humeri. As a consequence, at the proximal end of all humeri, the greater tubercle was found on the outer and posterior sides of the caput humeri.

Many specimens had different forms of greater tubercles, with 28 being square-dichotomous (figure 5) and 22 being elliptical*trapezoidal (figure 6).

The greater tubercles with small area and diameter were square-dichotomous, while those with medium and large greater tubercle circumference and area were trapezoid-elliptical.

SolidWorks Professional programs were used to render morphometric measurements, and the findings are presented in (Table 1).

When the mean circumference of the greater tubercle on both sides was calculated, the circumference was measured to be 85.87 mm.

Table 1. Morphometric measurements of greater tubercle

	Left (n:25)		Right (n:25)	
	mean±SD	**(min-max)**	**mean±SD**	**median (min-max)**
Base length of the greater tubercle (mm)	26±2.34	(23.66-28.34)	20.86±2.46	(18.4-23.32)
Anterior height of the greater tubercle (mm)	30±2.50	(27.5-32.5)	22.46±2.07	(20.39-24.53)
Posterior height of the greater tubercle (mm)	9.5±0.4	(9.1-9.9)	9.7±0.3	(9.4-10)
Widest sagittal length of the greater tubercle (mm)	28.75±2.02	(26.73-30.77)	28.82±2.00	(26.82-30.82)

Figure 5. Square-dichotomous

Figure 6. Elliptical*trapezoidal

Discussion

In anatomic textbooks, the greater tubercle is marked by 3 flat impressions: the highest impression gives insertion tothe supraspinatus muscle; the middle, to the infraspinatus;and the lowest, to the teres minor. In these descriptions,the shapes of impressions of the greater tubercle have beensimply described as adjacent squares. However, in dry bone samples for anatomy practice or 3-dimensional (3D) computed tomography (CT) images, wesometimes encounter specimens that have a different shapeof the greater tubercle; the tubercle has another impression,in comparison with the conventional description in text-books [11, 12, 13]. In addition, Mochizuki et al previously reported thatthe infraspinatus inserted into the anterior edge of the greatertubercle and occupied a substantial area of the greatertubercle, which was in complete contrast to traditionalanatomic concepts of the insertions of the supraspinatus andinfraspinatus to the greater tubercle. On the basis of the study of Mochizuki et al, strangely enough, the border between the supraspinatus and the infraspinatus also delineated the area of the highest impression [14, 15]. Nozaki et al. hypothesizedthe consistent existence of this additional impression of thegreater tubercle of the humerus and that this impressionmight be related to the insertion of the infraspinatus tendonthat was newly described in Mochizuki's report [16]. The shapes of impressions ofthe greater tubercle have been simply described as adjacent squares, superior and middle impressions [16].

In our study, we observed the shapes of the greater tubercles by scanning proximal ends of a total of 50 humeri, 25 of which were right and 25 left, with a 3D printer. We discovered that 28 greater tubercles were square-matrix-like and 22 were elliptical*trapezoidal in our study. Despite the fact that the definitions in shape suit our analysis, Nozaki et al. did not include any numerical details [17]. Curtis et al. and Minagawa et al. also analyzed the supraspinatus and infraspinatus insertions on the basis of the concept that the greater tubercle was simply divided into three "facets" [18, 19]. We did not make a classification on facets. Kranioti et al. observed results that indicate the existence of shape differences between the sexes. In females, the greater tubercle is smoother, with its superior border less pronounced [20]. Furthermore, in the radiography of the proximal end of the humerus, Kranioti et al. selected 5 landmarks. The maximum curvature point of the greater tubercle is among the selected points [20]. We found that the lesser tubercle had a more square-rectangular shape in our dry bone analysis. Besides, we scanned the proximal end with a 3D scanner in our study. We did not make a classification on gender.

Nishida et al. measured the length of the greater tubercle in their study. The place of measurement is defined as; the length of the greater tubercle of the humerus was defined as its maximum width in the horizontal plane. They measured the Length of the greater tubercle of the humerus as 3.80 ± 0.45 cm in the absence of the subacromial spur and 4.01 ± 0.88 cm in the presence of the subacromial spur [21]. In our study, we measured the base length of the greater tubercle as an average of 20.86 ± 2.46 mm on the right and 26 ± 2.34 mm on the left. We think that the measurements we made are more accurate because they were made by the SolidWorks software in the computer environment.

In the study of Hromadka et al., the reference points of the greater tubercle were marked on the medial margin continuous with the intertubercular groove, on the lateral margin of the lesser tubercle, and in the "deepest" place of the intertubercular groove [22]. In our study, we determined the reference point like the work done by Hromadka et al.

Clinical Relevance: It will serve as a guide for the anatomical restorations that will be made in this area, as well as the implants that will be created for this purpose.

Conclusion

There is no difference between right and left greater tubercles in terms of the parameters we use (circumference, anterior and posterior heights, widest sagittal length and base length). We assume that the greater tubercles, which are the formations at the proximal end of the humerus, can instruct surgeons in surgical applications and anatomically designed implants.

Conflict of interests
No conflict of interest was declared by the authors.

Financial Disclosure
This study has received no financial support.

Ethical approval
Dry bone was used in the study

References

1. Boileau P, Pennigton SD. Common pitfalls in the management of proximal humeral fractures: how to avoid them. In: Boileau P, Walch G, Mole D, Favard L, Levigne C, Sirveaux F, et al, editors. Shoulder concepts 2008. Proximal humeral fractures and fracture sequelae. Montpellier: Sauramps Medical, 2008. p. 303-23.
2. Hepp P, Theopold J, Voigt C, et al. The surgical approach for locking plate osteosynthesis of displaced proximal humeral fractures influences the functional outcome. J Shoulder Elbow Surg. 2008;17:21-8.
3. Green A. Proximal humerus fractures. In: Norris TR, editor. Orthopaedic knowledge update: shoulder and elbow 2. 2nd ed. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2002. p. 209-17.
4. Rouleau DM, Mutch J, Laflamme GY. Surgical treatment of displaced greater tuberosity fractures of the humerus. J Am Acad Orthop Surg. 2016;24:46-56.
5. Gruson KI, Ruchelsman DE, Tejwani NC. Isolated tuberosity fractures of the proximal humeral: Current concepts. Injury. 2008;39:284-14.
6. Gumina S, Carbone S, Postacchini F. Occult fractures of the greater tuberosity of the humerus. Int Orthop. 2009;33:171-4.
7. Neer CS. Displaced proximal humeral fractures. Part 1. Classification and evaluation. J Bone Joint Surg (Am). 1970; 52:1077-11.
8. Platzer P, Kutscha-Lissberg F, Lehr S, et al. The influence of displacement on shoulder function in patients with minimally displaced fractures of the greater tuberosity. Injury. 2005;36:1185-4.
9. Williams GR, Wong KL. Two-part and three-part fractures: open reduction and internal fixation versus closed reduction and percutaneous pinning. Orthop Clin North Am. 2000;31:1-21.
10. Fick R. Obere Extremit€at. In: Handbuch der Anatomie und Mechanik der Gelenke unter Ber€ucksichtigung der bewegenden Muskeln. Jena: Gustav Fisher; 1904. p. 141-285.
11. Kopsch F. Die Lehre von den Muskeln. Myologia. In: Lehrbuch und Atlas der Anatomie des Menschen Abteilung 3: Muskeln, Gef€aße. Leipzig: Georg Thieme; 1933. p. 1-153.
12. Clemente C. Osteology, and muscles and fasciae of the upper limb. In: Gray’s anatomy. 30th American ed. Philadelphia: Lea & Febiger; 1985. p. 233-4.
13. Fick R. Obere Extremit€at. In: Handbuch der Anatomie und Mechanik der Gelenke unter Ber€ucksichtigung der bewegenden Muskeln. Jena: Gustav Fisher; 1904. p. 141-285.
14. Mochizuki T, Sugaya H, Uomizu M, et al. Humeral insertion of the supraspinatus and infraspinatus. Newanatomical findings regarding the footprint of the rotator cuff.J Bone Joint Surg Am. 2008;90:962 9.
15. Mochizuki T, Sugaya H, Uomizu M, et al. Humeral insertion of the supraspinatus and infraspinatus. Newanatomical findings regarding the footprint of the rotator cuff. Surgicaltechnique. J Bone Joint Surg Am. 2009;91(Suppl 2 Pt 1):1-7.
16. Nozaki T, Nimura A, Fujishiro H et al. The anatomic relationship between the morphology of the greater tubercle of the humerus and the insertion of the infraspinatus tendon. J Shoulder Elbow Surg. 2015;24:555-60.
17. Curtis AS, Burbank KM, Tierney JJ, et al. The insertional footprint of the rotator cuff: an anatomic study. Arthroscopy. 2006;22:609.e1.
18. Minagawa H, Itoi E, Konno N, et al. Humeral attachment of the supraspinatus and infraspinatus tendons: ananatomic study. Arthroscopy. 1998;14:302.
19. Kranioti EF, Bastir M, Sa´nchez-Meseguer A et al. A geometric-morphometric study of the cretan humerus for sex identification. Forensic Sci Int. 2009;189;111:e1–111.
20. Nishida N, Hayashi S, Kakizaki F, et al. Humeral head morphometry can predict the presence of subacromial spurs: measurements of dried bones from human shoulder girdles. Tokai J Exp Clin Med. 2019;44:9-14.
21. Hromádka R, Pokorný D, Popelka S, et al. Three-dimensional geometry of the proximal humerus and rotator cuff attachment and its utilization in shoulder arthroplasty Acta Chir Orthop Traumatol Cech. 2006;73:77-84.