



Morphometric description of greater & lesser tubercles at proximal humerus: An Anatomical study

Susmita Saha^{1*}, Sanya Khurana², Prachi Saffar Aneja³, Paras Kumar⁴, Nisha Pahal⁵, Vikash Bhoria⁶

^{1*}Professor, Department of Anatomy, Faculty of Medicine & Health Sciences, SGT Medical College, Budhera, Gurugram – 122505, India

²Postgraduate Student, Department of Anatomy, Faculty of Medicine & Health Sciences, SGT Medical College, Budhera, Gurugram – 122505, India

³Professor & Head, Department of Anatomy, Faculty of Medicine & Health Sciences, SGT Medical College, Budhera, Gurugram – 122505, India.

⁴Tutor, Department of Anatomy, PGIMS, Rohtak, Haryana, India

⁵Postgraduate Student, Department of Anatomy, Faculty of Medicine & Health Sciences, SGT Medical College, Budhera, Gurugram – 122505, India

⁶Postgraduate Student, Department of Anatomy, Faculty of Medicine & Health Sciences, SGT Medical College, Budhera, Gurugram – 122505, India

***Corresponding Author: Dr Susmita Saha**

**Faculty of Medicine & Health Sciences, SGT Medical College, Gurugram, Haryana*

Email: drsusmita.sh@gmail.com

| Article History | Abstract |
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| Received- 02. 12. 2023 Revised- 14. 01. 2024 Acceptance- 10. 02. 2024 | <p>Background: Humerus, a typical long bone of arm forms shoulder joint at its proximal end and elbow joint at its distal end. Greater and lesser tubercles are two bony protrusions present on its proximal end with intertubercular sulcus (Bicipital groove). These tubercles are very much prone to fractures & also many other pathological conditions of shoulder joint which is termed as the most mobile joint. So, the main aim of our current study was to estimate the morphometry of greater and lesser tubercles of proximal humerus among North Indian Population group.</p> <p>Materials and Methods: This present study was conducted on 100 adult dry humerii of both sexes obtained from bone bank, Department of Anatomy, FMHS, SGT University, Gurugram, Haryana, India over a span of one year. Detailed Morphometry of Greater and lesser tubercles like length and width along with some bony distances were measured using digital vernier calliper on both sided bones.</p> <p>Results: The mean value with standard deviation for length and width of greater tubercle was 30.88±1.78 mm & 6.53±1.56 mm respectively & length and width of lesser tubercle was 16.29±1.30 mm & 4.35±1.85mm respectively on right side which was comparatively more than the left side. But distance from head to lesser tubercle was comparatively more on both sides than distance from greater tubercle.</p> <p>Conclusion: The morphometry of Greater and lesser tubercles of humerus among North Indian population will be a great help for the surgeons for the management of proximal humeral fractures & associated abnormalities.</p> |

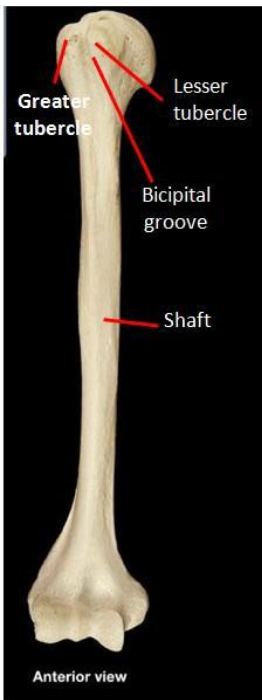
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| CC License CC-BY-NC-SA 4.0 | <i>Key words: Greater tubercle; lesser tubercle; morphometry; proximal humerus; fractures; shoulder joint</i> |
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Introduction

Humerus, a typical long bone present as only bone of the arm forming the main skeleton of the arm. It articulates with glenoid cavity at its proximal end to form shoulder joint which is the most mobile joint of the body^{1,2}. In its distal end, it articulates with the forearm bones radius & ulna to form the cubital articulation^{3,4}. As a typical long bone, humerus posses two end with a shaft. But proximal part of the bone is more vulnerable to fracture due to trauma especially in elderly decades; on the other side, in younger age group fracture may occur due to high energy trauma^{5,6}. The proximal end of humerus consists of spherical to rounded head, two bony protrusions; greater & lesser tubercles, anatomical & surgical necks along with intertubercular sulcus^{4,5}. Out of which, greater tubercle or tuberosity is more prone to displacement fracture, which may lead to subacromial impingement syndrome (SAIS)⁷. It occurs because of involvement of rotator cuff tendon over the top of the humerus. In severe displacement of greater tubercle, surgical intervention has to be performed for the management of impingement syndrome⁷. This surgical anatomical bony landmark is bigger in size & present at the external part of upper end of humerus; the other one is smaller in size named lesser tubercle present at the anterior side of proximal end of humerus^{8,9}. In between the two tubercles, there is intertubercular groove or Bicipital groove which is also a part of proximal end of humerus¹⁰. Most of the conventional textbooks mention presence of three muscular impressions at the upper surface of greater tubercle for the attachment of rotator cuff tendons (supraspinatus, infraspinatus & teres minor)^{11, 12}. Out of which supraspinatus is the most common tendon to get impinged upon supraspinatus outlet leading to impingement syndrome¹³. It has been also mentioned that, sclerotic changes of greater tubercle may lead to rotator cuff tear; one of the major cause for the occurrence of impingement syndrome¹⁴. Not only impingement syndrome, it has been also observed by the clinicians especially orthopaedicians that, proximal humeral fractures are mostly associated with involvement of greater tubercle¹⁵. Lesser tubercle fracture is quite uncommon & seems to respond well to conservative rehabilitation¹⁶ which can be easily diagnosed by plain radiographic or MRI scans¹⁷. Keeping this in mind, the present osteo morphometry on greater & lesser tubercles of humerus have been conducted among North Indian population group which will be a great help for the clinicians especially surgeons to decide the treatment and for further management.

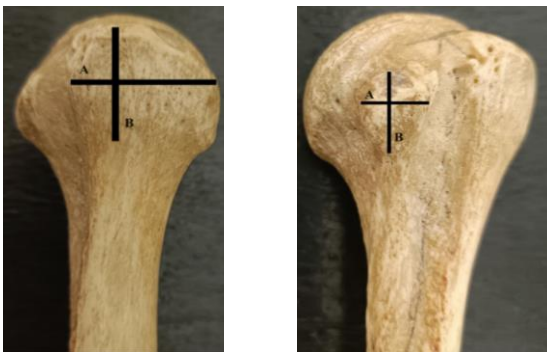
Materials & methods

In the current observational study, morphometric evaluation of both greater & lesser tubercles of humerus were performed on 100 adult dry humerii of both sexes from bone bank of department of Anatomy, FMHS, SGT university Gurugram over a span of one year. All the humerii were examined & generalized anatomical descriptions were recorded. Broken, damaged humerii were excluded from the study. The information of study materials were anonymised as coded so as to delinked from any identity source (ICMR guideline: National Ethical guidelines for biomedical & health Research involving Human participants, ICMR, 2017 section 5, Box 5.2)¹⁹. Morphometric parameters were measured by the help of a digital Vernier calliper. Measurements were taken twice & the average was taken to reduce bias error. The following measurements were taken for the study:



Table/ Fig 1: Anterior view of humerus showing the parts of proximal humerus including greater tubercle, lesser tubercle & intertubercular sulcus/ Bicipital groove

- Length of the greater tubercle along its full extent from anterior most to posterior most part
- Width of the greater tubercle at its maximum point
- Length of the lesser tubercle along its full extent
- Maximum transverse diameter as width of lesser tubercle
- Distance of greater tubercle from the centre of the head of humerus
- Distance of lesser tubercle from the centre of the head



Table/ Fig 2: length(A) & width(B) of greater tubercle & lesser tubercle have been marked by black lines in 1st & 2nd figures respectively



Table/ Fig 3: Morphometry is showing the Distance from head to Greater tubercle



Table/ Fig 4: image is exhibiting the distance from head to lesser tubercle

Measurements were calculated in mm & data was analyzed using SPSS latest version 21.0 & maximum, minimum, mean with standard deviation were calculated.

Results & observations

Out of 100 dry humerii, 57 belonged to right side & 43 belonged to left side. The maximum, minimum, mean with standard deviation according to the side of humerus has been presented in Table/ Fig 5. The values were more on the right side compared to left.

| Side of the bone | Bony landmarks | Parameters | Maximum (in mm) | Minimum (in mm) | Mean with standard deviation (in mm) |
|------------------|------------------|------------|-----------------|-----------------|--------------------------------------|
| Right | Greater tubercle | Length | 38.13 | 28.03 | 30.88± 1.78 |
| | | Width | 8.27 | 5.92 | 6.53± 1.56 |
| | Lesser tubercle | Length | 18.28 | 13.19 | 13.29± 1.40 |
| | | Width | 5.04 | 3.68 | 4.31±1.72 |
| Left | Greater tubercle | Length | 35.27 | 24.63 | 29.86± 1.84 |
| | | Width | 7.28 | 6.02 | 6.93± 1.41 |
| | Lesser tubercle | Length | 16.24 | 11.17 | 12.23± 1.75 |
| | | Width | 5.98 | 3.74 | 4.35±1.85 |

Table/ Fig 5: The maximum, minimum, mean with standard deviation of various parameters of greater & lesser tubercle on both sides of humerii have been displayed

Various morphometric distances have been evaluated from the head of the humerus to both the tubercles on both sided humerii which has been displayed in Table/ Fig 6. Apart from mean value with standard deviation t value was also calculated for various distances measured.

| Side of the bone | Parameters | Mean with standard deviation (in mm) | t- value |
|------------------|------------|--------------------------------------|----------|
| Head to GT (mm) | Right | 22.09 ± 5.21 | 28.03 |
| | Left | 21.23 ± 2.44 | 5.92 |
| Head to LT (mm) | Right | 28.26 ± 3.33 | 14.16 |
| | Left | 25.98 ± 2.63 | 3.74 |

Table/ Fig 6: Mean value with standard deviation for distances of both the tubercles from head of humerus have been presented

Discussion

At the outer side of head of the humerus, two bony protrusions greater & lesser tubercles have been described. There are muscular impressions on the upper surface of both the tubercles. Between the two, greater tubercle

has been marked with upper, middle & lower impression because of the attachment of supraspinatus, infraspinatus & teres minor tendons respectively²⁰. It was also mentioned that the shapes of all the impressions are simple geometrical shapes. Mochizuki et al. reported that, among the three muscular impressions, infraspinatus inserted onto the anterior edge & accommodated a substantial area²¹. In another study, Nozaki et al. has described an additional impression at the top of the greater tubercle²². But, Merve et al. In 2021, have conducted morphometric & morphologic anatomical evaluation on greater tubercle by 3- D printer & concluded that, the impressions for impressions of rotator cuff tendons were elliptical as well as trapezoidal²⁰. Not only greater tubercle, they have also observed the lesser tubercle as square rectangular shaped. As a surgical anatomical landmark, morphometry & morphology of greater tubercle plays an important role for the surgeons in the management of proximal humeral fractures^{23, 24}. Nishida et al. measured the length of greater tubercle & which was maximum in the horizontal plane²⁵. They concluded, the length as 3.80 ± 0.45 cm. But in contrast to study performed by Merve et al. the average length of greater tubercle was 20.86 ± 2.46 mm on the right side and 26 ± 2.34 mm of the left side²⁰. In another study conducted on greater tubercle by Nozaki et al. through 3 D image but the dimension of the impression on it have been described instead of the length & width²⁶. An additional impression for infraspinatus tendon was also mentioned in their study. They analyzed the humeri with rotator cuff tendons through micro computed tomography to evaluate the positional relationship of lateral impression of humerus with infraspinatus tendon. But for the subacromial impingement syndrome, greater tuberosity of humerus is very much susceptible to displacement fracture⁷. It can easily affect the rotator cuff tendon specially supraspinatus tendon. Fractures only on greater tuberosity account 5% among all proximal humeral fractures which can occur because of various trauma mechanisms²⁷. This can lead to hyper abduction of shoulder where tubercle may displace above the glenoid cavity of scapula and get impacted under acromion process. In this scenario also, rotator cuff may get pulled leading to impingement syndrome. Minimum treatment may be needed in case of minimal displacement but surgical interventions are usually required with displacements greater than 3 to 5 mm²⁷.

Conclusions

Tubercles at proximal humerus can influence the stability & biomechanics of shoulder joint. So, it is expected that, data of our detailed anatomical morphometric study on tubercles at proximal humerus will be a great help for the clinicians especially orthopaedic surgeons while performing surgical interventions as a treatment of proximal humeral fractures. This will also serve as a data base for the North Indian population group.

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