ORIGINAL ARTICLE

THE QUADRATE TUBERCLE: A MORPHOMETRIC STUDY

Tuberculum Quadratum: Morfometrik Bir Çalışma

Özcan GAYRETLİ[1], Ahmet ERTAŞ[2], Osman COŞKUN[1]

[1]Istanbul University
Istanbul Faculty of Medicine,
Department of Anatomy
[2]Istanbul University
Cerrahpasa Faculty of Medicine,
Department of Anatomy

ABSTRACT

Objective: Quadratus femoris muscle originates from ischial tuberosity and inserts into the quadrate tubercle of femur. Simply quadrate tubercle may be defined to be localized on the intertrochanteric crest. There are only a few more detailed descriptions of its localization. Consequently, we have aimed to describe the exact localization of the quadrate tubercle on femur.

Material and Methods: Morphometric measurements related to quadrate tubercle were performed on 144 adult dry human femurs. Afterwards proportional calculations between the measured morphometric measurements related to quadrate tubercle were made.

Results: Mean vertical distance between the most prominent points of greater and lesser trochanters was found as 63.1 mm. Mean vertical distance between the most prominent point of greater trochanter and origin of quadrate tubercle was measured as 21.8 mm. Mean vertical distance between the origin and end of quadrate tubercle was determined as 17.2 mm. Mean vertical distance between the end of quadrate tubercle and most prominent point of lesser trochanter was 24.3 mm. Mean length of femur was measured as 425.4 mm. The mean origin of quadrate tubercle was found in the upper 35% of the distance between the most prominent points of greater and lesser trochanters and the mean end of quadrate tubercle was found to be located in the upper 62% of the same distance.

Conclusion: As location of quadrate tubercle has not been discussed in detail yet, we believe that this study will be instructive for further anatomical dry bone and Magnetic Resonance Imaging studies.

Keywords: *Quadrate Tubercle; Intertrochanteric Crest; Quadratus Femoris Muscle*

Özcan GAYRETLİ, Dr.
(0000-0001-7958-3170)
Ahmet ERTAŞ, Dr.
(0000-0002-5518-4834)
Osman COŞKUN, Dr.
(0000-0002-0337-4927)

ÖZET

Amaç: Musculus quadratus femoris, tuber ischiadicum'dan başlar ve femur'daki tuberculum quadratum'a tutunur. Basit tanımlamayla, tuberculum quadratum, crista intertrochanterica'da bulunur. Tuberculum quadratum'un lokalizasyonu ile ilgili tanımlama, çok az kitap ya da makalede bulunmaktadır. Bu yüzden, bu çalışmada tuberculum quadratum'un os femoris'teki tam lokalizasyonunun tanımlanması amaçlandı.

Gereç ve Yöntemler: Tuberculum quadratum ile ilgili morfometrik ölçümler, 144 erişkin kuru insan femuru üzerinde gerçekleştirilmiştir. Daha sonra tuberculum quadratum ile ilişkili morfometrik ölçümlerin birbirlerine orantılı hesaplamaları yapılmıştır.

Bulgular: Trochanter major'un ve trochanter minor'un en çıkıntılı noktaları arasındaki vertikal uzaklık ortalama 63,1 mm bulunmuştur. Trochanter major'un en çıkıntılı noktası ve tuberculum quadratum'un başlangıcı arasındaki vertikal uzaklık ortalama 21,8 mm ölçülmüştür. Tuberculum quadratum'un başlangıcı ve bitişi arasındaki vertikal uzaklık ortalama 17,2 mm saptanmıştır. Tuberculum quadratum'un bitişi ve trochanter minor'un en çıkıntılı noktası arasındaki vertikal uzaklık ortalama 24,3 mm idi. Ortalama femur boyu uzunluğu 425,4 mm olarak ölçüldü. Tuberculum quadratum'un başlangıcı, trochanter major'un ve trochanter minor'un en çıkıntılı noktaları arasındaki ortalama vertikal uzaklığın üst %35'inde, tuberculum quadratum'un bitişi ise aynı uzaklığın ortalama üst %62'sinde yer alıyordu.

Sonuç: Tuberculum quadratum'un lokalizasyonu henüz detaylı olarak bildirilmediği için, saptadığımız morfometrik bulguların, bu oluşum ile ilgili gelecekte kuru kemiklerde yapılacak olan anatomik çalışmalar ve Manyetik Rezonans İnceleme çalışmaları için yol gösterici olacağını düşünmekteyiz.

Anahtar Kelimeler: *Tuberculum Quadratum; Crista İntertrochanterica; Musculus Quadratus Femoris*

İletişim:
Dr. Özcan GAYRETLİ
İstanbul Üniversitesi İstanbul Tıp Fakültesi, Anatomi Anabilim Dalı, Çapa Fatih 34093 İSTANBUL
Telefon: +90 533 550 6660
e-mail: gayretli@istanbul.edu.tr

Geliş tarihi/Received: 16.05.2021
Kabul tarihi/Accepted: 22.06.2021
DOI: 10.16919/bozoktip.938003

Bozok Tıp Derg 2021;11(3):x-x
Bozok Med J 2021;11(3):x-x

INTRODUCTION

The trochanters are the two large elevations on the femur, where its neck and body meet. The lesser trochanter is the rounded one which extends medially from the posteromedial side of uniting of the neck and body of femur and the greater trochanter is the laterally placed larger one that projects superoposteriorly from the junction of the femoral neck and body. At the posterior side of the femur, a prominent ridge, which is named as the intertrochanteric crest, units the trochanters (1).

Prasad et al. have reported that on the superior part of the intertrochanteric crest, there is a traction epiphysis which is named as the quadrate tubercle (QT) (2). Quadratus femoris muscle, which is a lateral rotator of the thigh, originates from the ischial tuberosity and inserts into the QT (2, 3). Consequently, QT occupies the space between the lesser trochanter and ischial tuberosity (ischiofemoral space)(3). Contrary to Prasad et al., McMinn has emphasized that the muscle itself does not form the tubercle (4). Thus, there is a contradiction about this subject. Last has added that QT is a bony accumulation at the epiphyseal junction (4). Frequently QT is highly prominent (2). The epiphyseal line of greater trochanter bisects the QT (5).

Related with the localization of QT, simply it is defined to be on the intertrochanteric crest (1). In 1919, Piersol named the QT as the tubercle for quadratus femoris and it was described as a slightly rounded prominence (QT) just near the junction of the posterior intertrochanteric crest and greater trochanter. Piersol added that occasionally a vertical line (quadrate line) served for quadratus femoris muscle instead of QT (6). Bergman and O'brien and Bui-Mansfield agreed that a vertical quadrate line (Linea quadrati) or a prominence (QT) could be found for insertion of quadratus femoris muscle (7, 8). Controversially Robinson reported that quadratus femoris muscle not only attached to the QT, but also it attached to the quadrate line (9). Searching up to date textbooks, we could not reach the definition of quadrate line (1,10). More detailed descriptions are found in very few articles and books (5, 10). Consequently, we have aimed to examine the exact localization of the QT. Up to now, only one morphometric study concerning the QT had been published in 1938, according to the literature we have reached. In fact, it is difficult to define that study as a morphometric one, as any certain morphometric data had not been given in that study. Sunderland had only identified some ratios in order to give a definition of localization of QT (5). Consequently, in order to define the localization of QT better, we have made some measurements related to QT and the neighbouring bony structures.

MATERIAL AND METHOD

Obtaining the ethics committee approval from İstanbul Faculty of Medicine Clinical Research Ethics Committee with the date 04.16.2021 and number 172629, in order to evaluate the QT of 85 left, 59 right; totally 144 adult human femurs which belong to the Departments of Anatomy in İstanbul Faculty of Medicine and Cerrahpaşa Faculty of Medicine, were examined. First of all, the presence of QT was investigated. Determining a QT in a femur, some measurements related to it were performed by digital callipers.

The vertical distance between the most prominent points of greater and lesser trochanters was measured. In order to determine the localization of QT, the vertical distance between the most prominent point of greater trochanter and superior border of the QT (origin of QT) on the intertrochanteric crest was measured. Then the vertical distance between the origin of QT and inferior border of the QT (end of QT) on the intertrochanteric crest was measured and this distance was recorded as the length of the QT. Moreover, the vertical distance between the end of the QT on the intertrochanteric crest and the most prominent point of lesser trochanter was measured for defining the localization of QT. All of the measured vertical distances are shown on proximal femur (Figure 1). Afterwards the vertical distance between the most prominent point of greater trochanter and the lower border of the lateral condyle of femur was measured as the length of femur (Figure 2). The minimum, maximum, standard deviation, and mean values of the above measurements were recorded.

In order to understand the dimensions and orientation of the QT better, proportional calculations between the measured parameters were made. We thought that we could identify the exact localization of QT by calculating the percentage of the vertical distance between the

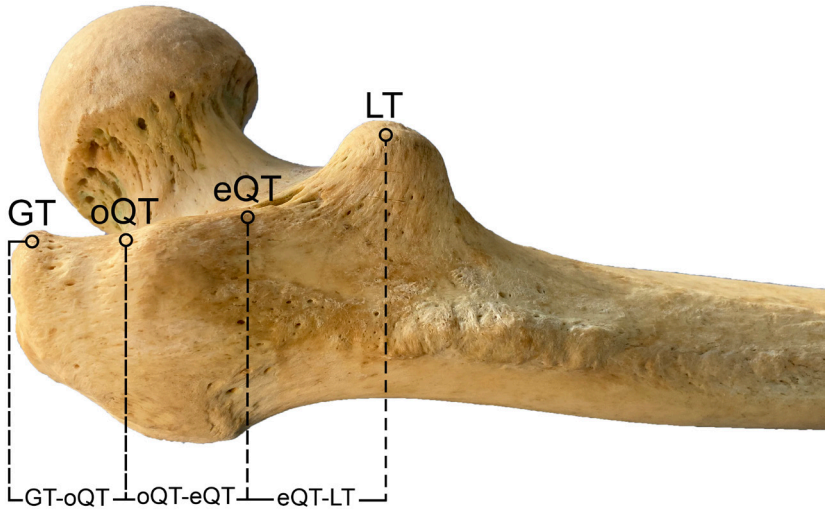
most prominent point of greater trochanter and origin of QT, on the total vertical distance between the most prominent points of greater and lesser trochanters. Moreover, we calculated the percentage of the vertical distance between the origin and end of QT, on the total vertical distance between the most prominent points of greater and lesser trochanters. Furthermore, we determined the percentage of the vertical distance between the end of QT and the most prominent point of lesser trochanter, on the total vertical distance between the most prominent points of greater and lesser trochanters. In order to define the localization of QT on the whole femur, we calculated the percentage of the total vertical distance between the most prominent points of greater and lesser trochanters, on the whole length of femur. As the femurs did not belong to the same individuals, we did not make a statistical comparison according to sides. Lastly, we dissected the gluteal and posterior thigh regions of one of our cadavers in order to show how the quadratus femoris muscle inserts to the QT (Figure 3).

RESULTS

The mean vertical distance between the most prominent points of greater and lesser trochanters was found as 63.1 mm. The mean vertical distance between the most prominent point of the greater trochanter and origin of the QT was measured as 21.8 mm. The mean vertical distance between the origin and end of the quadrate tubercle was determined as 17.2 mm. The mean vertical distance between the end of the quadrate tubercle and the most prominent point of lesser trochanter was found as 24.3 mm. The mean length of femur was measured as 425.4 mm. The minimum, maximum, standard deviation, and mean values of the above measurements are collected in Table 1.

The results concerning the proportional calculations between the measured parameters are collected in Table 2. According to these calculations, the mean origin of the tubercle was found to be in the upper 35% of the vertical distance between the most prominent points of the greater and lesser trochanters and the mean end of the QT was found to be located in the upper (35+27) 62% of the vertical distance between the most prominent points of the greater and lesser trochanters. In addition to these, it was found that the mean vertical distance between the most prominent points of greater and lesser trochanters formed the 14.8% of the length of femur.

Figure 1. The morphometric measurements related to the QT.

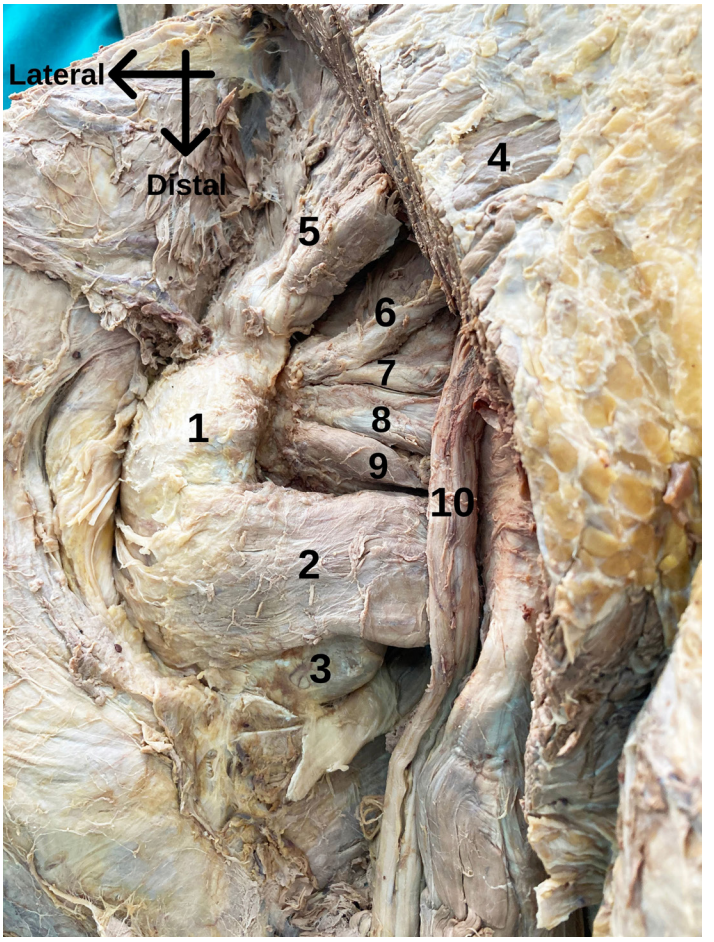


GT: The most prominent point of greater trochanter, LT; The most prominent point of lesser trochanter, oQT: Origin of quadrate tubercle, eQT: End of quadrate tubercle, GT-oQT: The vertical distance between the most prominent point of greater trochanter and origin of QT, oQT-eQT(Length of QT): The vertical distance between the origin and end of QT, eQT-LT: The vertical distance between the end of the quadrate tubercle and the most prominent point of lesser trochanter

Figure 2. Measurement of length of femur.

LF: Length of femur, **GT:** The most prominent point of greater trochanter, **oQT:** Origin of quadrate tubercle, **eQT:** End of quadrate tubercle, **LT;** The most prominent point of lesser trochanter

Figure 3. Insertion of quadratus femoris muscle to the QT and neighbouring structures.



1. Greater trochanter, **2.** Quadratus femoris muscle, **3.** Lesser trochanter, **4.** Gluteus maximus muscle, **5.** Gluteus medius muscle, **6.** Piriformis muscle, **7.** Superior gemellus muscle, **8.** Obturator internus muscle, **9.** Inferior gemellus muscle, **10.** Sciatic nerve

Table 1. The results of the morphometric measurements related to the QT.

Distance (mm)	Mean	Standard Deviation	Minimum	Maximum
GT-LT	63.1	7.6	45	84.1
GT-oQT	21.8	4.1	13.4	36.5
oQT-eQT	17.2	2.9	11.6	24.5
eQT-LT	24.3	4.7	12.6	35.5
LF	425.4	43.9	62.9	525.9

GT-LT: The vertical distance between the most prominent points of greater and lesser trochanters
GT-oQT: The vertical distance between the most prominent point of greater trochanter and origin of QT
oQT-eQT (Length of quadrate tubercle): The vertical distance between the origin and end of QT
eQT-LT: The vertical distance between the end of the quadrate tubercle and the most prominent point of lesser trochanter
LF (Length of femur): The vertical distance between the most prominent point of greater trochanter and the lower border of the lateral condyle of femur

Table 2. The results of the proportional calculations of the morphometric measurements related to the QT.

Proportional Calculations	Percentage (%)
GT-LT /LF	14.8
GT-oQT/ GT-LT	34.4
oQT-eQT/ GT-LT	27.2
eQT-LT/ GT-LT	38.4

GT-LT /LF: The vertical distance between the most prominent points of greater and lesser trochanters / Length of femur
GT-oQT/ GT-LT: The vertical distance between the most prominent point of greater trochanter and origin of QT / The vertical distance between the most prominent points of greater and lesser trochanters
oQT-eQT/ GT-LT: The vertical distance between the origin and end of QT / The vertical distance between the most prominent points of greater and lesser trochanters
eQT-LT/ GT-LT: The vertical distance between the end of the quadrate tubercle and the most prominent point of lesser trochanter / The vertical distance between the most prominent points of greater and lesser trochanters

DISCUSSION

Related to the localization of QT, different descriptions are found in the literature. Standring has reported that the QT is found a little above the centre of the intertrochanteric crest (10). Moore et al. has defined the QT to be found at the intertrochanteric crest, without giving a definite description (1). Prasad et al. have emphasized that QT is on the upper part of the intertrochanteric crest (2). The most detailed study about the QT belongs to Sunderland, which was performed in 1938. In order to give a description of localization of the QT, Sunderland examined 100 adult femora. He reported that the summit of the quadrate tubercle was located lateral to the intertrochanteric crest. He did not give the exact results of his measurements, but he reported that the QT was always found above the midpoint of the intertrochanteric crest. He added that the QT was located nearly at the junction of the upper one third and lower two thirds of the intertrochanteric crest (5). In the present study, the mean origin of the QT was found in the upper 35% of the distance between the most prominent points of the greater and lesser trochanters and the mean end of the QT was found to be located in the upper (35+27) 62% of the distance between the most prominent points of the greater and lesser trochanters. Consequently, our results are compatible with Sunderland's findings.

Moreover, in some researches aiming to describe a safe area for the neighbouring structures (e.g., superior gluteal nerve) according to gender, QT was investigated as a possible landmark, but it was reported that that there was not a statistically significant relationship between the QT and the superior gluteal nerve according to gender (11).

The angle between the proximal and distal ends of the femur or in other words, the angle between the axis of neck of femur and the transcondylar plane of femur, is the angle of femoral torsion(AFT). This angle can be visualized, viewing the femur superiorly. The mean values of this angle are 7° in males and 12° in females (1, 2). Pulling effect of the quadriceps femoris muscle can rotate the superior end of the femur laterally,

resulting with a contortion of the superior end, and an increasing of AFT. An extreme QT may be explained by a higher degree of AFT (2). Consequently, AFT positively correlates with the prominence of the tubercle AFT is used by the radiologists and the orthopaedic surgeons for not only diagnosis but also for evaluation of therapeutic interventions and follow-up of hip disorders (2). In the present study as we have wanted to focus on the QT itself, we have not made any measurements related to this angle. We aim to make a further study for evaluating the AFT.

Quadratus femoris muscle may be entrapped at the ischiofemoral space resulting in hip pain. This situation is named as the ischiofemoral impingement syndrome, and it can be diagnosed radiologically proving that the quadratus femoris muscle has oedema and the ischiofemoral space is reduced (3). As the quadratus femoris muscle attaches to the quadrate tubercle, probably this tubercle is important in determining the dimensions of the ischiofemoral space. In the present study, as we have studied on femurs only and we do not have the corresponding coxal bone, we have not investigated this space.

If we summarize the limitations of this study, one of them was the fact that we could not make a statistical comparison according to sides as the femurs were not kept as pairs. A second limitation was that we could not measure the AFT in order to investigate the relationship between this angle and QT. The third limitation was we could not determine detailed information about the ischiofemoral space.

Related to the quadratus femoris muscle, it has been reported that there have been only three cases having an injury of this muscle which have been diagnosed by MRI (8). The rarity of the injury of this muscle may be explained either by real low frequency of this pathological condition or the difficult diagnosis of this injury. In none of these three cases, there was a clinical suspicion of a possible injury of quadratus femoris muscle before MRI was applied. Consequently, MRI is said to be of critical importance for diagnosis of a quadratus femoris muscle injury as the tears of this muscle have characteristic findings on MRI. On axial T2-weighted fat-suppressed images, edema can be visualized at the space between the lesser trochanter and ischial tuberosity (at ischiofemoral space which is occupied by the quadratus femoris muscle). On sagittal T2-weighted or proton density fat-supressed images, edema can be visualized posterior to the lesser trochanter (8).

CONCLUSION

As the location and morphometric properties of the QT has not been discussed in detail yet, we believe that this study will be instructive especially for further anatomical lower limb studies. Moreover, as the radiologists have the chance to evaluate MRI findings related to the QT nowadays, we hope that the morphometric data obtained in this study may be helpful for their evaluation in future clinical studies.

Acknowledgements

We have not taken any grant or any other sources of support for our study. There is no conflict of interest.

REFERENCES

1. Moore KL, Dalley AF, Agur AMR. Clinically oriented Anatomy. 7th edition. Baltimore: MD: Lippincott Williams&Wilkins, 2014, p.1551.

2. Prasad R, Vettivel S, Isaac B., Jeyaseelan L., Chandi G. Angle of torsion of the femur and its correlates. Clin Anat 1996; 9:109-17.

3. Safran M, Ryu J. Ischiofemoral impingement of the hip; a novel approach to treatment. Knee Surg Sports Traumatol Arthrosc 2014; 22:781-5.

4. McMinn RMH. Last's Anatomy Regional and applied. 2020; Elsevier, Australia, Revised Ninth Edition 1998. PP:284. ISBN: 978-0-7295-43576

5. Sunderland S. The quadrate tubercle of femur. J Anat1938; 72(Pt 2):309-12.

6. Piersol G.A. editor. Human Anatomy. Seventh edition. J. B. Lippincott Company, Philadelphia& London 1919, p. 353.

7. Tubbs RS, Shoja MM, Loukas M editors. Haffner M, Conklin M. Bones of the lower limb. ch 13 in Bergman's Comprehensive Encyclopaedia of Human Anatomic Variation. John Wiley & Sons, 2016 p:90-1.

8. O'Brien SD, Bui-Mansfield LT. MRI of quadratus femoris muscle tear: another cause of hip pain. Am J Roentgenol 2007; 189: 1185-9.

9. Robinson A. editor. Cunningham's Textbook of Anatomy. Fifth edition. William Wood and Company, New York 1918, p: 418.

10. Standring S. Gray's Anatomy E-Book: The anatomical basis of clinical practice. Forty-second edition. Elsevier 2021, p.1362.

11. Lammy S. Anatomical course demarcating the safe area for the superior gluteal nerve. MJM 2009; 12(2): 23-6.