Original Communication

MORPHOMETRIC MEASUREMENTS OF QUADRATE TUBERCLE AND RELATED NEIGHBORING STRUCTURES ON DRY ADULT BONES

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ABSTRACT

Objectives There is only a little information about quadrate tubercle (QT) and its' clinical importance in anatomy textbooks and literature. This study aims to provide comprehensive morphometrical data about QT, related neighboring structures, and gender differences will also be investigated. Material and Methods A total number of 108 [(34 female/74 male) / (48 right/60 left)] adult femurs were morphometrically evaluated. Distances between QT to the greater trochanter (GT), lesser trochanter (LT), the femoral head (FH), and GT to LT measurements were taken to determine the position of QT. Data were analyzed using the SPSS (v 26.0) package software program. Results The distances between QT-GT; QT-LT; QT-FH; GT-LT parameters determined as 33.65±4.47, 28.52±3.43 (p=0.001); 40.89±4.62, 35.64±3.87 (p=0.001); 79.73±7.05, 70.18±5.66 (p=0.001); 67.53±5.20, 58.68±5.14 (p=0.001) mm in males and females, respectively. The cut-off points were calculated for gender determination as 62.80, 75.45, 30.75, 38.45 mm for GT-LT, QT-FH, QT-GT, QT-LT parameters, respectively. Conclusions In this study, a triangular safe area for arterial anastomoses was determined between QT-GT/ QT-LT/ GT-LT parameters at the proximal end of the femur. It can create a safe area that can be used in clinical applications when needed. Also, it has been shown that gender determination among the parameters has the highest confidence interval with the GT-LT parameter, while other QT-centered parameters have high predictive power and can be used for gender determination. To best our knowledge, this is the first study in the literature about QT precise distances and use for gender determination together.

Keywords: *Intertrochanteric crest, quadrate tubercle, quadratus muscle, femur proximal end*

RESUMEN

Objetivos: Hay poca información sobre el tubérculo cuadrado (QT) y su importancia clínica en los libros de texto y la literatura de Anatomía. Este estudio tiene como objetivo proporcionar datos morfométricos completos sobre QT, también se investigarán las estructuras vecinas relacionadas y las diferencias de género. Material y Métodos: Se evaluaron morfométricamente un total de 108 [(34 hembras/74 machos) / (48 derechos/60 izquierdos)] fémures adultos. Se tomaron las distancias entre el QT y el trocánter mayor (GT), el trocánter menor (LT), la cabeza femoral (FH) y GT a LT para determinar la posición del QT. Los datos se analizaron usando el paquete de software SPSS (v 26.0). Resultados: Las distancias entre QT-GT; QT-LT; QT-FH; Parámetros GT-LT determinados como 33,65±4,47, 28,52±3,43 (p=0,001); 40,89±4,62, 35,64±3,87 (p=0,001); 79,73±7,05, 70,18±5,66 (p=0,001); 67,53±5,20, 58,68±5,14 (p=0,001) mm en machos y hembras, respectivamente. Los puntos de corte se calcularon para la determinación del sexo como 62,80, 75,45, 30,75, 38,45 mm para los parámetros GT-LT, QT-FH, QT-GT, QT-LT, respectivamente. Conclusiones: En este estudio se determinó un área segura triangular para anastomosis arteriales entre los parámetros QT-GT/QT-LT/GT-LT en el extremo proximal del fémur. Puede crear un área segura que se puede utilizar en aplicaciones clínicas cuando sea necesario. Además, se ha demostrado que la determinación de género entre los parámetros tiene el intervalo de confianza más alto con el parámetro GT-LT, mientras que otros parámetros centrados en QT tienen un alto poder predictivo y pueden usarse para la determinación de género. Según nuestro conocimiento, este es el primer estudio en la literatura sobre las distancias precisas de QT y su uso para la determinación de género en conjunto.

Palabras clave: *Cresta intertrocantérica, extremo proximal del femur, músculo cuadrado, tubérculo cuadrado*

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INTRODUCTION

The proximal end of the femur has the head, neck, greater and lesser trochanters. The greater trochanter (GT) is large and quadrangular, projecting up from the junction of the neck and shaft. The lesser trochanter (LT) is a conical posteromedial projection of the shaft at the posteroinferior aspect of its junction with the neck. The intertrochanteric crest, a smooth and prominent ridge at the junction of the posterior surface of the neck with the shaft, descends medially from the posterosuperior angle of the greater trochanter to the lesser trochanter. A little above its center is a low, rounded quadrate tubercle (QT) (Standring et al., 2008). The QT is the insertion point of the quadratus femoris muscle (QFM). The QFM is one of the external rotators of the thigh and it is lay quadrilateral between the lateral border of ischial tuberosity to QT and the line below. This line is defined as "quadrate line" (Woodburne and Burkel, 1988) or "linea quadrata" (Gray et al., 1977).

There is only a little information about QT and its' clinical importance in anatomy textbooks. In the literature, only Sunderland (1938) conducted a study about QT and some describing ratio data about its' position at the proximal end of femur included. Even though some information about QT and its' positions have been given in Sunderland's study, there is no morphometric data had been provided. Recently, Gayretli et al. (2021) conducted a morphometric study about QT but in their study genders are unknown.

For clinical practice, some studies focused on QT and QFM in the literature. Lammy (2009) used QT to determine a safe area for the superior gluteal nerve. The ischiofemoral impingement is defined as the entrapment of QFM between LT and ischial tuberosity (Hernando et al., 2016). The QFM itself has clinically important especially for ischiofemoral impingement syndrome management (Tosun et al., 2012; Sussman et al., 2013; Safran and Ryu, 2014; Hernando et al., 2016).

This study aims to provide comprehensive morphometrical data about QT, related neighboring structures, and gender differences will also be investigated. To the best of our knowledge, no study in the literature has been conducted about QT morphometrical analyses in terms of genders.

MATERIAL AND METHODS

The study was designed in the order of morphometric anatomy and enrolled in the anatomy department. The dry bones in the study belong to the laboratory of the Department of Anatomy.

Ethical approval was not obtained because any living human or animal participants were included in this study. The research was carried out in accordance with the Helsinki Declaration of 1964, and all subsequent revisions.

The study included bilateral femurs from 40 adult males and 20 adult females from the bone collection. Bones with pathologies, impaired integrity proximal end of femur structures were excluded from the study.

Figure 1- Shows measurement methods of quadrate tubercle and related neighboring structures. Dashed circle(outside): Quadrate tubercle, Dashed circle (inside): Centre of quadrate tubercle. 1: Quadrate tubercle center to Greater trochanter most prominent (QT-GT), 2: Quadrate tubercle center to lesser trochanter most prominent (QT-LT), 3: Most prominent of greater trochanter to lesser trochanter (GT-LT), 4: Quadrate tubercle center to femoral head horizontal most prominent (QT-FH)

Distances between QT to GT, LT, FH, and GT to LT measurements were taken to determine the position of QT. In measurements, the center of the tubercle (QT), most prominent points of the trochanters (GT, LT) and most horizontal prominent of the femoral head (FH) has been used (Figure 1). The GT Measurements were made using a manual sliding caliper with an error of ±0.01 mm and were taken twice at different times by a single observer, with mean values taken and noted.

Data were analyzed using the IBM SPSS Statistics for Macintosh (v 26.0. Armonk, NY: IBM Corp) package software program. The student's 2-tailed t-test was used to determine the difference between two independent groups. ROC curve analysis was used to determine cut-points. The level of error was 0.05.

RESULTS

A total number of 108 [(34 female/74 male) / (48 right/60 left)] adult femurs were morpho-metrically evaluated while 12 femurs were excluded in this study. Maximum, minimum, and total mean values of measured parameters are shown in Table 1.

The results obtained from the study conducted to determine the differences between the genders are shown in Table 2. According to this table, it was determined that each parameter was statistically significantly smaller in females than in males (p=0.001, Table 2).

The only parameter in which a statistically significant difference was observed between the sides was determined as QT-FH (p=0.001, Table 3).

	QT-GT	QT-LT	GT-LT	QT-FH
Minimum	20.70	28.30	47.00	56.10
Maximum	45.50	55.20	81.90	101.10
Mean	32.04	39.24	64.74	76.72
SD	4.80	5.02	6.67	7.98

Table 1- Total mean values of parameters- Data has been given in millimeters. QT Quadrate tubercle, GT Greater trochanter, LT Lesser trochanter, FH Femoral head, SD Standard deviation

	Gender	N	Mean±SD	Results
QT-GT	M	74	33.65±4.47	t=6.529
	F	34	28.52±3.43	**p=0.001***
QT-LT	M	74	40.89±4.62	t=5.756
	F	34	35.64±3.87	**p=0.001***
GT-LT	M	74	67.53±5.20	t=8.105
	F	34	58.68±5.14	**p=0.001***
QT-FH	M	74	79.73±7.05	t=6.930
	F	34	70.18±5.66	**p=0.001***

Table 2- Comparisons of mean values between genders. Data has been given in millimetrers. * Indicates statistically significant at p<0.05, QT Quadrate tubercle, GT Greater trochanter, LT Lesser trochanter, FH Femoral head, SD Standard deviation, M Male, F Female

The cut-points and confidence intervals obtained as a result of the ROC analysis performed to test the gender determination of the parameters are shown in Graphic 1 and Table 4.

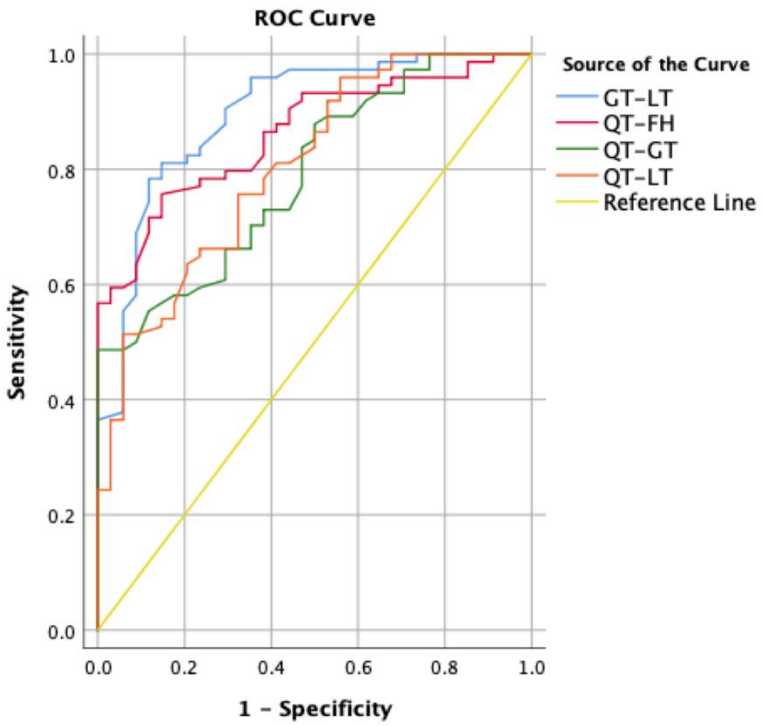
The cut-off point for the GT-LT parameter was determined as 62.80 mm. From the measurement of this parameter, it was seen that gender determination could be performed with the highest ratio among the parameters measured with a confidence interval of 83% to 96%.

The cut-off point for the QT-FH parameter was determined as 75.45 mm. From the measurement of this parameter, it was seen that

the second-highest rate for gender determination among the parameters measured with a confidence interval of 80% to 93% could be determined.
The cut-off point for the QT-GT parameter is 30.75 mm. From the measurement of this parameter, it was seen that gender determination could be performed between 71% and 88% confidence interval.
The cut-off point for the QT-LT parameter was determined as 38.45 mm. From the measurement of this parameter, it has been seen that gender determination can be performed between 72% and 89% confidence interval (Table 4).

	Side	N	Mean±SD	Results
QT-GT	R	48	31.31±4.44	t=1.410
	L	60	32.62±5.03	p=0.16
QT-LT	R	48	39.58±5.69	t=0.621
	L	60	38.96±4.44	p=0.537
GT-LT	R	48	64.59±6.95	t=0.212
	L	60	64.87±6.49	p=0.833
QT-FH	R	48	73.33±7.79	t=4.252
	L	60	79.44±7.10	**p=0.001***

Table 3- Comparisons of mean values between sides. Data has been given in millimeters. * Indicates statistically significant at p<0.05, QT Quadrate tubercle, GT Greater trochanter, LT Lesser trochanter, FH Femoral head, SD Standard deviation, M Male, F Female



Graphic 1- Shows area under the curve (ROC) analyses of parameters. QT: Quadrate tubercle, GT: Greater trochanter, LT: Lesser trochanter, FH: Femoral head

Test Result Variable(s)	Area	Std. Error	Sig.	95% ConfidenceInterval		Cut-Off Point
				LowerBound	UpperBound	
QT-GT	79%	0.04	0.001	71%	88%	30.75
QT-LT	80%	0.04	0.001	72%	89%	38.45
GT-LT	90%	0.03	0.001	83%	96%	62.80
QT-FH	86%	0.03	0.001	80%	93%	75.45

Table 4- Displays theresults of areaunderthe ROC curveanalyses of parameters. QT Quadrate tubercle, GT Greater trochanter, LT Lesser trochanter, FH Femoral head

DISCUSSION

The lateral rotator muscles of the femur are ordered from top to bottom as the piriformis, gemellus superior, obturator internus, gemellus inferior, obturator externus, and QFM. The insertion tendons of these muscles are located between GT and QT. In our study, the distance between QT-GT was determined as 33.65±4.47, 28.52±3.43 mm in males and females, respectively. These obtained data can be used to determine the range covered by the insertion tendons of the lateral rotators. There are also two arterial anastomoses behind the proximal end of the femur. One of these is the trochanteric anastomosis lies near the trochanteric fossa of the femur and is an anastomosis between the ascending branch of the medial circumflex femoral artery and descending branches of the superior and inferior gluteal arteries (Standring et al., 2008). The trochanteric fossa is the place at the medial side of the intertrochanteric crest between GT and QT. And, this measured parameter is also may use to determine the position of trochanteric anastomosis. Gautier et al. (2000), in their cadaver study, determined that the deep branch of the medial femoral circumflex artery extends from the proximal edge of the quadratus femoris to the greater trochanter. This course also corresponds to the QT-GT interval.

The QFM inserts to QT and quadrate line which is on the intertrochanteric crest between QT and LT. In our study, the distance between QT-LT was determined as 40.89±4.62, 35.64±3.87 mm in males and females, respectively. This measured parameter might be useful for QFM insertion line width and gender differences in clinical practice. Also, the other arterial anastomosis of the proximal end of the femur is the cruciate anastomosis lies at the level of the lesser trochanter, near the lower edge of the femoral attachment of quadratus femoris and is an anastomosis between the transverse branches of the medial and lateral circumflex femoral arteries, a descending branch of the inferior gluteal artery and an ascending branch from the first perforating artery (Standring et al., 2008). Grose et al. (2008), in their study to determine the anastomosis site of the inferior gluteal artery and the medial femoral circumflex artery, determined that the anastomosis area was in the obturator externus tendon connection region and a branch defined as the quadratus branch descended over the quadratus femoris. So, this measured parameter is might be useful for clinical practice to determine the exact position of the cruciate anastomosis. Also, it can be useful for ischiofemoral impingement management. Because the measured parameter gives a piece of information about how much space is normally should be between QT and LT.

In our study, the distance between QT-FH was determined as 79.73±7.05, 70.18±5.66 mm in males and females, respectively. The lateral circumflex femoral artery and the first perforating artery from the profunda may also contribute to the trochanteric anastomosis, creating an extra-capsular 'arterial ring of the femoral neck' (Crock, 1996). Branches from this ring, the retinacular vessels, pierce the capsule and ascend along the femoral neck to give the main blood supply to the head of the femur (Standring et al., 2008). Zhao et al. (2017), stated that the superior retinacular arteries enter the femoral neck between the greater and quadrate tubercle lines. The measured parameter might be contributed to an understanding of retinacular artery positions, especially the superior one.

The insertions of the lateral rotators of the femur and the trochanteric and cruciate arterial anastomoses are located between GT and LT. In our study, the distance between GT-LT was determined as 67.53±5.20, 58.68±5.14 mm in males and females, respectively. Gayretli et al.

(2021) determined this distance as 63.1 mm. It is seen that the mean values in our study are higher in males and lower than this value in females. They took the origin and endpoints of QT as a basis while making their measurements. The fact that our measurements were made based on the QT center may explain the difference. For this reason, the only parameter that can be compared from the parameters used in their study is the GT-LT parameter.

According to the gender determination data, it was observed that the GT-LT parameter could predict the highest confidence interval in the gender determination from dry bones. This parameter also forms one side of Purkait's triangle (Purkait, 2005). In addition, it was determined that QT-centered GT, LT, FH distance data, which were not used before in anthropological measurements, can be used in anthropological or forensic studies with high confidence intervals for gender determination.

In this study, a triangular area was determined behind the proximal end of the femur. This triangle we created consists of QT-GT/QT-LT/GT-LT parameters. The main purpose of this is to determine the clinical safe area for arterial anastomoses. It can create a safe area that can be used in clinical applications when needed. It is thought that these data can be used especially when arterial anastomosis sites are to be avoided. In this study, it has been shown that gender determination among the parameters has the highest confidence interval with the GT-LT parameter, while other QT-centered parameters have high predictive power and can be used for gender determination for the first time in the literature.

Conflict of interest

The author declares that there is no conflict of interest

Funding

The study has no sponsorship

Ethical approval

Ethical approval was not an obligation by our institution because any living human or animal participants were included in this study. The research was carried out in accordance with the Helsinki Declaration of 1964 and all subsequent revisions

Informed consent

It was not necessary for this type of study

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