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Exami0nation, evaluation and statistical analysis of human femoral anthropometry in Turkish population

Dr. Işık Tuncer
Department of Anatomy, Meram Faculty of Medicine, Necmettin Erbakan University, Meram, Konya, Turkey

Abstract
Aim: Morphological measurements are important parameters that used for evaluating on various structures. Femur participates in hip joint with its proximal part and in knee joint with its distal part. It has a significant value on surgical operations and prosthesis applications of these joints. It is also important for carrying the body weight and moving. On this basis we aimed to measure femur morphometrically and evaluate those measurements.
Material and Method: This study was conducted in the Anatomy Department of Meram Faculty of Medicine, Necmettin Erbakan University. 78 bones (37 right, 41 left) was measured in proximal end; Lesser trochanter and caput femoris (FHLT), greater trochanter (GTLT), condylus medialis (LTCM), condylus lateralis (LTCL), and caput femoris and condylus lateralis with (FHCL), condylus medialis with (FHCM). And in distal end height of medial condylus CMH), height of lateral condylus (CLH), inter- condyles height (ICH) and circumference of distal part (DC) were measured with tape measure and calipers. Data was evaluated statistically and student-t and Pearson correlation coefficient tests were applied.
Results: As a result femoral morphometric measurements were shown in different races (right-left). LTCL and FHCL were found to be higher in left femur than in right femur in our study (LTCL; right femur: 42.25±9.01cm, left femur: 43.52±6.34 cm, FHCL; right femur: 49.20±12.05 cm, left femur: 53.41±10.24cm).
Conclusion: Anthropometric measurements for adult femur in people from Central Anatolian of Turkey are covered in the study. Data obtained from this study may be helpful in pathologies that affect femur and hip joints and in forensic science field, also shares a demographic data.

Keywords: Femur, anthropometry, anatomy, adult.

1. Introduction

The longest and strongest bone in human body is the femur. It carries the weight of the body and transfers it to lower parts via hip joints. Its intracapsuler heads are in the shape of a half sphere and make joint with hips on the left and right. Femur neck is about 5 cm and it was 125˚ with its shaft.

The quadrangular greater trochanter and conical lesser trochanter are located at the neck-shaft joint. When the human body is in anatomical position femoral shafts are obliquely positioned. Shafts both seem cylindrical, triangular. Distal end of femur has two big articular condyles [1].

Three dimensional descriptions of condyles of femur are still needed and not very well defined. A representative knee joint geometry is usually expected which requires an approximation of the irregular joint geometry while taking into account interspecimen variations in joint modeling. Femoral condyles in the saggittal aspect were examined by many researchers. A comprehensive data may be seen in the study of Nuno and Ahmed [2, 3]. The widest one is the study of Zoghi *et al*. [4]. They used model profiles consisted two and three circular arcs to mathematically reconstruct the saggital profiles of the medial and lateral condyles, respectively, from the measurements of four specimens. Iwaki *et al*. [5] also studied saggittal profiles of condyles via circles gauges og magnetic resonanges images from 24 cadaveric knees. Nuno and Ahmed [3] reported the profiles of the femoral condyles with the measurements of 12 distal femurs in their latest study. In their study they reported that medial and lateral condyles may be adequately described by two-circular arcs in the femorotibial contact region (includes posterior and distal parts of the condyles). Preciseness of such a description was determined to be lower than 0.2 mm in terms of the difference between the experimental data and the fitted two-circular –arc representation. But, this study was limited to two the description of one representative sagittal plane for each condyle. The frontal profile of condyles of femur was not covered very well like its saggittal profile. Kurosawa *et al*. [6] explained frontal profiles of by using a circular arc on 10 samples.

The race, sex and environmental factors affect shapes and structures of bones. Nurzenki *et al*. showed that life conditions also affect the geometric indices of bone strength in the proximal femur [7].

Femur head offset and vertical offset are important parts for the range of motion and abductor muscle strength after total hip arthroplasty [8]. Hip prostheses are produced according to data obtained from Europe populations [9, 10]. So wrong size hip prostheses may have effects. Surgical operations are applied mostly for to fix anatomical reduction a stable fracture fixation that supports bone reunion and allows early mobilization. Good contour fit bone and plate is needed to develop strong bone construction [11]. Morphometric study of proximal part of the femur was conducted in different populations and communities [12]. And the study showed that femoral morphometry had regional features and social differences.

We aimed to study the morphometric characteristics of the proximal and distal parts of femur in the Central Anatolian population in Turkey and to establish a regional database for prosthesis design and medical applications.

Material and Method

This study was conducted in Meram Faculty of Medicine, The Department of Anatomy in Necmettin Erbakan University in 2017. It has been approved by ethical committee of Necmettin Erbakan University according to Copenhagen criteria (2016/214). First bones were examined by inspection. Measurements were performed on 78 bones (right:37, left:41) without gross anomaly. For the purpose of accuracy all measurements were performed by the same person. 10 parameters for proximal and distal parts were recorded (Fig 1,2,3,4,5,6). Measuring tape and millimetric callipers were used. Parameters and measurements were:

Proximal femur,

Distance from the head of the femur to the lesser trochanter of the femur (FHLT).

Distance from the tip of the greater trochanter of the femur to the lesser

trochanter of the femur (GTLT).

Distance from the lesser trochanter of the femur to the medial condyle (LTCM).

Distance from the lesser trochanter of the femur to the lateral condyle (LTCL).

Distance from the head of the femur to the lateral condyle (FHCL).

Distance from the head of the femur to the medial condyle (FHCM).

Distal femur,

Medial condyle height: Maximal height of medial condyle (CMH).

Lateral condyle height: Maximal height of lateral condyle (CLH).

Inter-condyles height: Maximal height of between condyles (ICH).

Distal circumference: Maximal circumference of distal part of the femur (DC).

Measurements were recorded on computer. Mean and standard deviation values were calculated. SPSS for Windows 10.00 were used for statistical analysis. For comparison according to lateralization student-t test and also Pearson correlation test were performed.

Fig 1: Anterior view of the left femur

Fig 2: Anterior view of the left femur (continued)

Fig 3: Anterior view of the left femur (continued)

Fig 4: Anterior view of the left femur (continued)

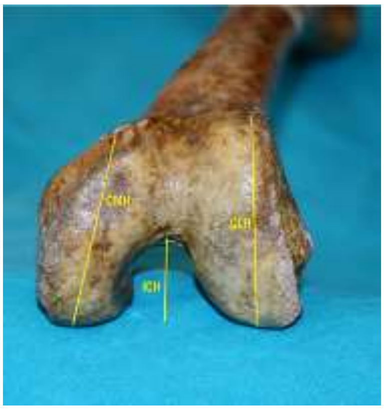

Fig 5: inferior view of the left femur (continued)

Fig 6: Anterior view of the left femur (continued)

Results

In this study 37 right and 41 left, totally 78 femur bones have been evaluated morphometrically. The statistical comparison of the results obtained by measuring femur samples was shown in Table 1. Significant statistical differences were found between these measurements ($p<0.05$). Right and left side comparison values of femoral morphometrical measurements were shown in Table 2. All values except LTCL and FHCL were found to be higher in right femur.

Pearson correlation test was performed to test the significance of correlations and their relation with parameters. Correlation coefficients numbers between femoral measurements were shown in Table 3.

Table 1: Measurements of femur-parameters 78 bones (37 right, 41 left) (cm)

Parameter	N	Mean	SD	Minimum	Maximum
FHLT	78	12.80	3.68	12.00	13.68
GTLT	78	9.95	5.56	8.92	10.81
LTCM	78	32.54	3.95	30.86	33.70
LTCL	78	42.78	10.41	41.70	44.56
FHCL	78	48.39	8.86	46.10	55.28
FHCM	78	45.28	9.50	43.80	49.78
CMH	78	25.97	5.28	15.00	37.20
CLH	78	38.94	18.78	18.80	75.70
ICH	78	23.39	3.73	13.70	32.90
DC	78	184.10	6.24	80.00	300.00

Table 2: Comparison of measured parameters on femur according to lateralization (right-left) (mean, SD, n: 37 right, n: 41 left) (cm)

Parameter	N	Right Mean ± SD	Left Mean ± SD	p
FHLT	78	13.25 ± 2.28	12.61 ± 4.61	< 0.001
GTLT	78	10.22 ± 5.38	9.52 ± 6.21	< 0.001
LTCM	78	33.11 ± 4.15	32.92 ± 8.14	< 0.001
LTCL	78	42.25 ± 9.01	43.52 ± 6.34	< 0.001
FHCL	78	49.20 ± 12.05	53.41 ± 10.24	< 0.001
FHCM	78	47.67 ± 5.52	45.41 ± 4.25	< 0.001
CMH	78	26.42 ± 5.38	25.58 ± 5.23	< 0.001
CLH	78	41.58 ± 20.17	36.63 ± 17.39	< 0.001
ICH	78	23.78 ± 4.12	23.04 ± 3.38	< 0.001
DC	78	197.10 ± 5.28	172.90 ± 6.82	< 0.001

Table 3: Correlation efficients (r) between the femoral anthropometric measurements

Parameter	FHLT	GTLT	LTCM	LTCL	FHCL	FHCM	CMH	CLH	ICH	DC
FHLT										
GTLT	,038									
LTCM	,045	,230*			-					
LTCL	,609*	,220	,186							
FHCL	322	-,880*	,204	,938						
FHCM	,323*	-,751*	,312*	,312	-855					
CMH	,220	,631*	,428*	-444*	-,191	,390*				
CLH	,072	,349*	,030	-,356*	-,524*	,524*	,516			
ICH	,072	,602*	,202	-,521*	-,571*	,120	-,315*	,474		
DC	-,050	,868*	,062	-,870*	,508	,590*	,512	,312	,424	

$P<0.05$

Discussion

Different disorders may have effects on femur and hip joint. Anthropometric measurements are valuable assets diagnosis purposes, and also for approaches to some disorders. Values that obtained by measuring bone parts and racial variations and are of immerse value to anatomists, anthropologists and forensic experts.

The study of Lingamdenne *et al.* [1] reports that the maximum length and trochanter length has significant correlation with the proximal breadth, and the mid shaft parameters. According to study of Vaghefi *et al.* [13] the values were 44.99 cm and 40.81 cm in Iranian males and females respectively. And Ziylan *et al.* [14] showed the maximum length of femur as 42.8 cm on the left side and 41.6 cm on the right side in Turkish people. In Lingamdenne's study, it has been found that the maximum length of the femur to be 43.02 cm similar to the values reported in other south Indian studies: 44.62 cm as showed by Khan *et al,* [15] and 43.74 cm as reported by Pillai *et al* [16].

Some studies of proximal femur parameters which were conducted in Asian countries also as in Malay population [17]

Chinese population [18] and in Pakistani [19] population. Different studies like these also support the fact of regional difference in the parameters of proximal femur but the data obtained from Asian population is very close with the parameters obtained from Verma's study. Some studies often reported measurements that are related to increased risk of fracture include a longer hip axis, length of femur, a larger neck shaft angle and a larger femoral neck width [20].

Head measurements of the bone are important in pathologies of hip joint. These treats help to make proper implants for hip replacement surgeries. Best implant is the one that serves the patient best which will prevent postoperative complications and last longer [21].

Every year more than 80.000 hip joint replacement are being done in the world [22]. But there are differences in human anatomy in difference places, and these differences should be considered while designing prosthesis. Reddy *et al*. [23] told that a wrong application between femoral bone and stem probably will result in micromotion which may lead to thigh pain, osteolysis and aseptic loosening. In any case that the implant is big for the femur it may cause fractures, also highly undersized implant may fail to bond with bone [24].

Mahaisavaria *et al*. [12] used CT imaging technique and combined it with reverse engineering to collect data to analyze three dimensional inner and outer geometry of the proximal cadaveric femur [12]. On their study Deshmukh *et al*. covered the geometry of femur in the Vidarbha (central) region of India by using the mathematical approach [25].

There was a good correlation between anthropometric measurements and mathematical models. Siwach RC and Dahia S. used the parameters of femur in Indian cadavers, and compared them with Chinese and Hong Kong population [26]. Ho Jung Cho *et al*. studied on anatomic differences of femur in Korean subjects from Americans and Japanese [27]. He concluded that designing hip prosthesis for Asian population was necessary. In their study De Sousa E. *et al*. used Auto Cad 200 Software to evaluate variables of proximal femur in Brazilian Population then he compared the results with other study result from other regions [28]. Rawal *et al*. suggested that dimensions of cementless femoral stem for Indian population [29]. There was a difference with the rate of 16.8 % in Femur Head Offset (FHO) between Indian and Swiss population. This may have affect on soft tissue and rage of motion.

Braun *et al*. [30] said that accurate total hip arthroplasty with the Metha shortstem prosthesis (Braun Aesculap; Tuttlingen, Germany) depends on the correct indication and an accurate preoperative measurement of the femoral bone shape, and intraoperatively, that the bone quality, osteotomy and implant position of are of the particular importance.

Navigation helps with the selection of modular neck adapters for optimal free range of motion. The selection of adapters changes depending on the usage of navigation in the surgery. Applying the correct position of the osteotomy is related to the surgeon's experience and judgment and also the local anatomical conditions. The osteotomy may be determined intra-operatively by the positioning of the rasp. Right positioning of the osteotomy and right dorsolateral contact of the short stem shows the optimal implant position. Implant depth must be adjusted by considering the lateral circumference of the femoral neck rather than in relation to the calcar osteotomy. The loss of lateral support on valgus positioning is not wanted. Navigation usage affects the neck position.

A reduction in the dimensions of the proximal and distal femur studied that could be considered a symptom of calcium metabolic disturbances, calcium deficiency and osteoporotic causes in older subjects is also caused by increasing age [31]. Existing wrong notch measurements in the literature can maybe be explained by a few factors, also with an analysis of different populations. Also differences in measurement techniques should have an effect in these wrong results. Another difficulty in the measurements is that parts of measurement on the distal femur were not flat, so this also affects measurement results [31].

Conclusion

We covered the fracture and normal cases in individuals for morphometric evaluation of the proximal and distal femur.

The comparison is difficult due to not many studies exist in the field which standardize parameters for these treats.

Parameters show significant differences between populations. There are also big differences between male and female individuals, which we also showed in this study. Another factor to affect the results is the state of the bone, whether it is from a dry sample or from a cadaver. MRI is the key on our future studies, which will make your data stronger than before. We believe the results we had in this study shall assist for surgical interventions on proximal and distal parts of femur and for arthroplasty applications, with its contribution to analysis of bone.

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