

A study of Upper End Length of Femur and Its Applied Significance

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Abstract:

Background & objectives: Upper end length of femur is the distance between fovea capitis of the femoral head and greater trochanter of the femur. The current study was carried out to obtain side-wise and sex-wise mean values of upper end length of femur and ascertain its application in forensic medicine, anthropology and clinical medicine. **Material & Methods:** The study sample consisted of 242 dry, human, adult femora [176 male (87 right, 89 left) and 66 female (32 right, 34 left)] from skeletal collections. Upper end length and maximum femoral length were measured. **Results:** Mean value of upper end length of femora in the study population was, 90.73 mm and 84.2 mm respectively for right male and female, and 91.7 mm and 85.2 mm respectively for left male and female. Higher value in males was statistically significant ($P < 0.001$) on both sides. Upper end length identified 5.74% of right male femora, 0.00% of right female femora, 3.37% of left male femora and 0.00% of left female femora. The correlation coefficient and regression equation to obtain maximum femoral length from upper end length were 0.770 & $117.235 + 3.570 * (\text{upper end length})$ for male bones and 0.858 & $74.236 + 4.253 * (\text{upper end length})$ for female bones. **Conclusions:** Upper end length of femur is a very useful tool for sexual identification & for estimation of femoral length. For a more anatomically accurate population specific prosthesis, other proximal femoral parameter also needs to be studied in the same population.

Keywords: upper end length of femur, proximal (upper) epiphyseal breadth, sex determination.

Introduction

The distance between the most superior point of fovea capitis of the femur and the greater trochanter of femur is described as the upper end length (proximal breadth, upper epiphyseal breadth) of femur^[1]. Upper end length is a useful tool in selecting the size of internal fixation device for the management of femoral neck fractures & intertrochanteric fracture. It would also be useful in determining the length of the femoral part of hip prosthesis.

Proximal femoral parameters in Indians are different from other populations and the dimensions of the currently available orthopaedic implants do not match those of the Indian femora^[2]. In order to obtain better biomechanical stability and avoid complications, the size and design of prosthesis should be selected in accordance with population specific values of parameters^[3,4]. Anthropological study of upper end length of

femur has been carried out by several workers in different populations^[5-11]. According to Krogman and Iscan^[12], standards of morphological and morphometric attributes in the skeleton may differ with the population samples involved and this is true with reference to dimensions and indices (average and range). As a general rule, standards should be used with reference to the group from which they are drawn and upon which they are based. These are not interchangeable.

The current study was carried out to establish mean values of femoral upper end length and to ascertain the role of upper end length in gender identification, determination of femur length and racial characteristics. Moreover, our work could also assist the biomechanists by providing data to design population specific implants and orthopaedic surgeons for selection of proper implant size.

Material and Method

The study sample consisted of 242 dry, human, adult femora [176 male (87 right, 89 left) and 66 female (32 right, 34 left)] which included 184 femora from the skeletal collection of the

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Department of Anatomy, M. P. Shah Medical College, Jamnagar, Gujarat [136 male (67 of right & 69 of left side) and 48 female (23 of right & 25 of left side)] & 58 femora from Anatomy department, P. D. U. Govt. Medical College, Rajkot, Gujarat [40 male (20right, 20left) & 18 female (9 right, 9 left)].

Upper end length of femur is the distance in the long axis of neck. It was measured by spreading calipers, the ends of caliper touching the margin of the head medially and the shaft below the greater trochanter laterally (a depression usually exists)^[5,11].

Maximum femoral length was measured by placing the femur on the osteometric board with its dorsal side upwards in such a manner that the medial condyle touches the short vertical wall; the moveable cross-piece touches the highest point of the head. Maximum vertical distance between upper end of head of femur and the lowest point on the femoral condyle was measured^[13].

Each bone was measured thrice and this measurement was repeated by two independent observers. The mean of these observations was taken as a final reading to nullify any intra and inter-observer errors. Data collected was tabulated and analyzed statistically sidewise & sexwise by demarking point (D.P.) analysis. The data was also analyzed to assess the correlation of upper end length with maximum femoral length. Regression equation was derived by linear regression methods to calculate the maximum femoral length from the upper end length. Statistical calculations were done by Epi Info- 7 software.

Result

The upper end length of right male femur varied from 76.00 mm to 110.00 mm (average: 90.73 mm & S.D.:6.02) and that of right female femur varied from 78.00 mm to 89.00 mm (average: 84.2 mm & S.D.:4.54). Mean value of upper end length was higher in males as compared to females. Calculated z-value and P value showed that differences in the mean upper end length in males and females were statistically highly significant with $P < 0.001$.

Table: 1 shows that with the demarking points, definite sexual classification in the male right bone (>97.84 mm) was 5.74 % (N=5) and in the female right bone (<72.67 mm) was 0.00% (Chart: 1).

The upper end length of left male femur varied from 75.00 mm to 110.00 mm (average: 91.7 mm & S.D.:6.22) and of left female femur varied from 80.00 mm to 89.00 mm (average: 85.2 mm & S.D.:4.38). Mean value of upper end length was higher in males as compared to females. Calculated z-value and P value showed that the difference in the mean upper end length in males and females was statistically highly significant with $P < 0.001$.

With the demarking points, definite sexual classification in male left bone (>98.34 mm) was 3.37 % (N=3) and in female left bone (<73 mm) was 0.00% (N=0). (Chart: 1)

Difference of the mean between right sided bone & left sided bone was statistically insignificant with $P > 0.05$ in both sexes.

Descriptive statistics and regression

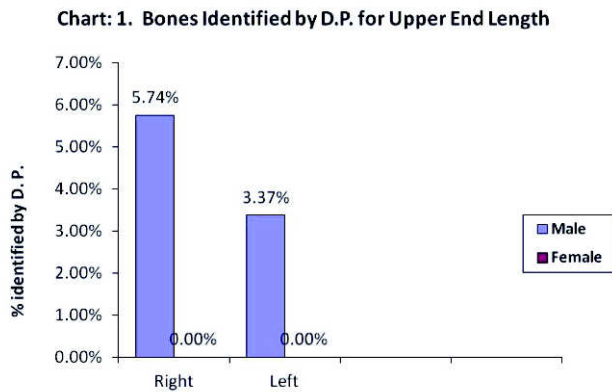
Table: 1 Statistical Values of Upper End Length (All dimensions in mm)

Statistical values	RIGHT		LEFT	
	Male (n=87)	Female (n=32)	Male (n=89)	Female (n=34)
Range	76-110	78-89	75-110	80-89
Mean	90.73	84.2	91.7	85.2
S.D.	6.02	4.54	6.22	4.38
z-value	6.33		6.46	
P value	$P < 0.001$		$P < 0.001$	
Calculated Range mean \pm 3S.D.	72.67-108.8	70.44-97.84	73-110.32	72.05-98.34
D.P	>97.84	<72.67	>98.34	<73
% & no. identified by D.P.	5.74% (no=5)	0.00% (no=0)	3.37% (no=3)	0.00% (no=0)

Table: 2 Descriptive and regression statistics for determination of maximum femoral length from upper end length

Gender	n	Upper End Length	Max. Femur Length	Correlation coefficient	Regression Equation	SEE
Male	176	Range: 75-110 Mean: 91.21 S.D.: 6.092	Range: 376 - 506 Mean: 442.80 S.D.: 26.188	0.770	117.235 + 3.570 * (upper end length)	10.443
Female	66	Range: 78-91 Mean: 84.72 S.D.: 4.176	Range: 398 - 473 Mean: 434.55 S.D.: 20.564	0.858	74.236 + 4.253 * (upper end length)	14.635

Max. femur Length: maximum femoral length



equation to obtain maximum femoral length from upper end length in males and females are shown in Table 2. In both the sexes, upper end length had a high degree of correlation with maximum femoral length (MFL) with the significance at the 0.01 level (2 tailed).

Derived regression equation to obtain maximum femoral length from upper end length for male bone is $117.235 + 3.570 * (\text{Upper end length})$ and for female bone is $74.236 + 4.253 * (\text{Upper end length})$.

Discussion

In a present study, calculated range (mean \pm 3S.D.) for right male bone was 72.67 mm to 108.8 mm and for right female bone it was 70.44 mm to 97.84 mm. With the help of these demarking points, right femur with upper end length more than >97.84 mm can be correctly classified as a male and right femur with upper end length less than <72.67 mm can be correctly classified as a female. However, if the upper end length of bone is between 72.67 mm and 97.84 mm, sexing was not possible due to overlapping

With the demarking points, definite sexual classification in male right bone (>97.84 mm) was

5.74 % (N=5) and in female right bone (<72.67 mm) was 0.00%

For left male bone calculated range was 73 mm to 110.32 mm and for left female bone it was 72.05mm to 98.34mm. So, left femur with upper end length more than >98.34 mm can be correctly classified as a male and left femur with neck length less than <73 mm can be correctly classified as a female. However, if the upper end length is between 73mm and 98.34mm, sexing was not possible due to overlapping. With the demarking points, definite sexual classification in male left bone (>98.34 mm) was 3.37 % (N=3) and in female left bone (<73 mm) was 0.00% (N=0).

Comparison of femoral upper end length of male between current study and other studies has been shown in table: 3. Mean upper end length value of male in present study was 90.73 mm (right) & 91.7 mm (left). In other studies, it varied from 85 mm to 94 mm. None of the earlier authors have studied the sexual dimorphism of upper end length of femur. Dimensionally the adult male: female ratio is about 100: 92, i.e. female measurements are about 92% of male measurements, this does not precisely hold for the entire living body^[11].

Generally male bones are longer and massive and this difference is reflected by the greater values of the mean upper end length in male on both the sides. Mean upper end length of male in present study population was lower than values reported in sample from the Amritsar^[5]; it corresponded with the values reported in the sample from Madras^[5] and was higher than the sample from Nagpur, Pune, Lucknow, Hyderabad and India^[5]. Values reported by Kate B. R. (1976)^[6] in Ceylonese, Formosa, Korea, Japan, China ,

Table: 3 Comparison of Upper end length

Population & Study	Neck Length (in mm)						
	Male			Female			
	Mean	S.D.	% Identified	Mean	S.D.	% Identified	
Kate B. R. (1970), India	88	-	-	78	-	-	
Kate B. R. (1970), Madras	89	-	-	76	-	-	
Kate B. R. (1970), Nagpur	86	-	-	78	-	-	
Kate B. R. (1970), Poona	87	-	-	79	-	-	
Kate B. R. (1970), Amritsar	94	-	-	86	-	-	
Kate B. R. (1970), Lucknow	88	-	-	78	-	-	
Kate B. R. (1970), Hyderabad	85	-	-	78	-	-	
Kate B. R. (1976), Ceylonese	Mean: 82, S.D.: 5.6						
Kate B. R. (1976), Formosa	Mean: 88						
Kate B. R. (1976), Korea	Mean: 90						
Kate B. R. (1976), Japan	Mean: 88						
Kate B. R. (1976), China	Mean: 79						
Kate B. R. (1976), Australia	Mean: 77						
Kate B. R. (1976), Andaman	Mean: 79						
Ziylan T., & Murshid	Rt.	Mean: 90.2, S.D.: 7.6					
K.A (2002), Anatolian	Lt.	Mean: 90.1, S.D.: 7					
Chandra M., (2011) South India		Mean: 79, S.D.: 5					
Present study	Rt.side (119)	90.73	6.02	5.74%	84.2	4.54	0.00%
(n=242)	Lt.side (123)	91.7	6.22	3.37%	85.2	4.38	0.00%

Australia & Andaman; work by Ziylan T., & Murshid K.A (2002)^[8] in Anatolian and by Chandra M. (2011)^[11] in South India did not mention sexwise mean values, but mean male upper end length of present study was similar to Korean^[6] & Anatolian^[8] population and was higher than the Ceylonese^[6], Formosan^[6], Japanese^[6], Chinese^[6], Australian^[6] Andamanise^[6] and South Indians^[11].

Table: 3 shows that mean upper end length in female in current study was 84.2 mm (right) & 85.2 mm (left). In other studies it varied from 78 mm to 86 mm.

Mean upper end length of female in present study population was higher than the values reported from the India^[5], Madras^[5], Nagpur^[5], Pune^[5], Lucknow^[5] & Hyderabad^[5] and it was similar to mean upper end length values from Amritsar^[5].

On comparing the studies which did not mention sexwise mean values, mean female upper end length of our study was higher than the mean values of, China^[6], Australia^[6], Andaman^[6] & South Indians^[11]; corresponding with the Ceylonese^[6] and lower than the Formosa^[6],

Korea^[6], Japan^[6] & Anatolian population^[8].

People from different racial backgrounds differ in various factors affecting bone morphology such as genetic constitution, diet, nutritional status, environment and physical activity. This could be the reason for the difference in values of upper end length in a different study population.

The correlation coefficient of upper end length and maximum femoral length (MFL) was 0.770 for the male and 0.858 for the female indicating a high degree of correlation between these parameters.

Table 4 shows comparison of correlation coefficient obtained in the present work with the work from other groups. Simmons et al (1990)^[7] has reported correlation coefficient of 0.606 (male) and 0.632 (female) in white race and of 0.592 (male) and 0.513 (female) in black race. Bidmos M. A. reported correlation coefficient for upper end length and maximum femoral length (MFL) of 0.610 (male) and 0.623 (female) respectively in South Africans of European Descent^[9] and of 0.653 (male) and 0.799 (female) respectively in the indigenous South Africans^[10]. Chandra M (2011)^[11]

reported correlation coefficient of 0.618 for upper breadth of femora in South India. Thus in the present study, correlation coefficient of femoral upper end length showed greater correlation than all other studies in both genders. (Table: 4).

Table: 4 also shows that in all the studies correlation coefficient was higher in males compared to females except in South Africans of European descent where correlation it was higher in females.

Table: 4 Comparison of correlation coefficient

Study		Correlation coefficient	
		Male	Female
Simmons (1990)	White	0.606	0.632
	Black	0.592	0.513
Bidmos M. A. (2005)	South African of European Descent	0.610	0.623
	indigenous South Africans	0.653	0.799
Chandra M. (2011), South Indian females		-	0.618
Present Study		0.770	0.858

Conclusion

The study may provide very useful information to forensic personnel, anthropologist, orthopaedics and bio-mechanists. Sex determination is relatively easy if the entire skeleton is available, pelvis and skull are the most reliable bones for this purpose[12]. However, in medico-legal cases one does not always have a complete pelvis or skull. Therefore it is important to be able to assess sex from the other parts of the skeleton also. This the first study reporting the sexual dimorphism of upper end length. Upper end length has strong correlations with maximum femoral length and it could be very useful tool in estimation of maximum femoral length when whole femur is not available. Mean upper end length values will help in designing population specific implants and for selection of proper implant size. However, for a more anatomically accurate population specific prosthesis, other proximal femoral parameters (e.g. head diameter, neck circumference...etc.) also needs to be studied in the same population.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this paper.

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