Radiogrametric linear dimensions of the distal femur in Nigerian adults: forensic and clinical implications

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Abstract

Anatomical awareness of the bony components of the knee joint is important in forensic, medico-legal and clinical applications. The distal femur form part of the bony component of the knee joint and as such its morphological dimensions play a key role in establishing identity in forensics and in orthopedics. The study is aimed at providing reference data of some morphological dimensions of the distal third of femur of adult Nigerians using radiographic method. A total of 200 standard lateral radiographs (consisting of 100 males and 100 females) aged between 20-60 years were collected from the radiology departments of various teaching hospitals across Nigeria were used. From the obtained radiographs five parameters were measured using standard techniques. they include the Antero posterior width of femur, Half metaphyseal width of femur, length of anterior condyle of femur, length of posterior condyle of femur and Antero posterior width of condyle of femur. Analysis was done using SPSS 20.0 version; hence mean and standard deviation were obtained. Z-test was used to compare mean values at 0.05 significant levels. Measurements were taken in centimeters The index of sexual dimorphism was applied to ascertain level of gender difference. The results showed that males had higher mean values than females for all the linear parameters measured (p<0.05). There was also was no significant difference between sides of femur (p>0.05). Comparison with other race showed variations in mean values. The morphological differences in the linear dimensions of the distal femur between genders would be useful in gender and racial identification, in the choice of knee prosthesis for the Nigerian population and in clinical applications also since no significant bilateral difference was recorded the contralateral healthy side can be used for reconstructive procedures Thus it is recommended that anatomist, forensic anthropologist, radiologists, orthopedic surgeons and orthopedic manufacturing companies adopts these findings as a reference guide for adult Nigerians.

Keywords: distal femur, radiography, knee joint, sexual dimorphism, Nigerian adults

1. Introduction

The femur is the largest and heaviest bone in the skeleton and because of its strength and density it is frequently recovered in most forensic and archeological sites and therefore provides a good lead in the process of identification [1, 2]. One advantage the distal femur has in sexual identification is that where the shaft and proximal end are missing it can be relied on [3]. Distal femur anthropometry has been argued to play a role in sexual identification. It has been found that certain parameters of the distal femur, such as the femoral intercondylar notch differ between genders and are associated with both the volume and the incidence of anterior cruciate ligament rupture [5, 6]. However, this association has been questioned by other researchers [7, 8]. It is therefore important that other parameters be studied to see if they differ between sides aa well as gender.

Sexual and racial differences in the distal femur could lead to mismatched prosthesis if not taken into consideration. There is a debate about whether distinct designs of femoral component for men and women are needed based on morphology and size difference between genders [9, 10].

It is well known that Asian sub population are smaller with shorter stature compared to their Caucasian counterparts [11, 12] hence there is need for more studies on the African population with which comparism can be made. It follows therefore that these discrepancies may give rise to implant size mismatch with the resected bony surfaces of Nigerian patients since most of these prosthetic components are imported. Insignificant bilateral differences in limbs made it possible for the contralateral healthy side to be used for preoperative templating [13]. In the present study mean values of some linear parameters of the distal femur were measured and the presence of gender and side differences was studied.

2. Materials and methods

200 Normal lateral radiographs (100 males and 100 females) were used. The Radiographs were collected from the Radiology Department of some Teaching Hospitals across Nigeria by random selection.

Parameters that were measured are as follows:

Distal Femur

- Anterior posterior width of femur shaft
- Half-metaphyseal breadth of femur shaft
- Length of anterior condyle of femur
- Length of posterior condyle of femur
- Anterior posterior width of condyle of femur

For these measurements, a line is drawn on a lateral radiograph of the femur to connect the midpoints of the shaft at six and twelve centimeters from end (distal anatomic axis).

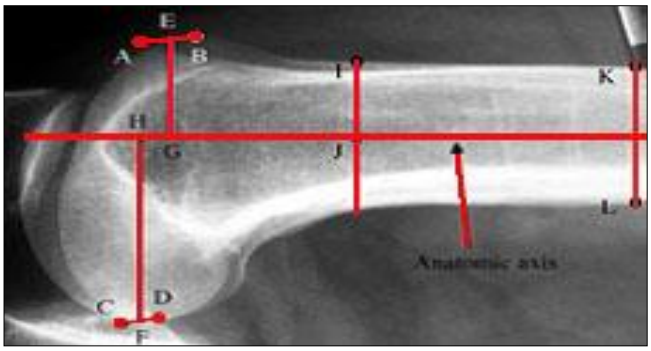

Fig 1: Determination of the Anatomical Axis and Points on Lateral Radiograph

Point AB is marked as tangents of the med. and lat. ant. condyles, respectively. Point CD is marked as tangents of the med. and lat. post. condyles. Points EF are midpoints of lines AB and CD respectively. Point GH are intersections of the anatomical axis and lines perpendicular from point EF respectively. Point IJ represents the distance from the anatomic axis to the anterior cortex and KL represents the distance from the ant. to post. cortices of the shaft. Points EG, FH, IJ, and KL are measured.

KL ----------Anterior posterior femoral shaft width
IJ----------Half metaphyseal width of the femur shaft
EG----------Length of anterior femoral condyle
FH----------Length of posterior condyle of femur
EG + FH----------Anterior posterior width of the condyle of femur

This method was modified after [10] Urabe *et al*. (2008).

The name, age (20-64) and sex of each subject on the x-ray together with the measured parameters were recorded.

S.P.S.S (Statistical Package for Social Sciences) 20.0 version was used for statistics. Data was presented as mean ±standard deviation. Students Z-test was used to test the difference between male and female values. The data was analyzed with statistical acceptance at p=0.05.

A probability level of p<0.05 (as been significant).

The index of sexual dimorphism was calculated as follows:

$$\text{Index of sexual dimorphism (ISD)} = \frac{\text{Mean value of male}}{\text{Mean value of female}} \times 100$$

This index indicates the level of difference between sees. Values close to hundred indicate low level of sexual difference and conversely the level of sexual difference increases with the increase of the distance from hundred [13] (Marin 2006).

3. Results

The Result is presented in Tables 1-5.

Table 1: Mean and standard deviation of parameters of distal femur and test of significance for right and left sides on radiographs of adult Nigerians

Parameters	Mean ±SD	Males (n=100)	Females (n=100)	Total (100)	*p*-value	Inference
		Right (50)	Left (50)			
Anterio posterior Width of femur shaft (cm)	M	3.64±0.28	3.61±0.27	3.63±0.28	(p>0.05)	Not significant
	F	3.45±029	3.42±030	3.44±0.29	(p>0.05)	Not significant
Half Metaphyseal width of femur shaft (cm)	M	2.23±0.20	2.20±0.19	2.22±0.20	(p>0.05)	Not significant
	F	2.02±0.19	2.00±0.18	2.00±0.20	(p>0.05)	Not significant
Length of Anterior Condyle of femur (cm)	M	3.40±0.33	3.43±0.34	3.42±0.32	(p>0.05)	Not significant
	F	3.20±0.35	3.23±0.36	3.22±0.34	(p>0.05)	Not significant
Length of Posterior Condyle of femur (cm)	M	4.60±0.27	4.62±028	4.61±0.28	(p>0.05)	Not significant
	F	450±0.31	454±0.32	452±0.32	(p>0.05)	Not significant

Observations from table 1 shows that when all the radiologic parameters were statistically analyzed to find mean and standard deviation and z test carried out, all parameters except the Lengths of Anterior condyle of Femur, Posterior condyle of Femur and Anteroposterior width of Femur were larger in the right than the left for both sexes. These differences were however not statistically significant (p>0.05) The Length of anterior condyle of femur was 3.34 ±0.34 for the left and 3.40 ±0.33 for the right with a total mean of 3.6 ±0.28 in males while in females it was 3.23 ±0.36 for the left and 3.20 ±0.35 for the right with a total mean of 3.44 ±0.29. The Length of posterior condyle of femur of femur was 4.62 ±0.28 for the left and 4.60 ±0.27 for the right with a total mean of 4.61 ±0.28 in males while in females it was 4.54 ±0.32 for the left and 4.50 ±0.31 for the right with a total mean of 4.52 ±0.32. Anteroposterior width of condyle was 8.04 ±0.29 for the left and 8.00 ±0.28 for the right with a mean total of 8.02 ±0.28. The differences were also not statistically related (p>0.05).

Table 2: Mean and standard deviation of parameters of distal femur on radiographs of adult Nigerians (males and females) and their test of significance

Parameters	Mean ±SD	Males (n=100)	Females (n=100)	*p*-value	Inference
		Male (100)	Female (100)		
Anterio posterior Width of femur shaft (cm)	R	3.64±0.28	3.45±0.29	(p<0.05)	Significant
	L	3.61±027	3.42±030	(p<0.05)	Significant
Half Metaphyseal width of femur shaft (cm)	R	2.23±0.20	2.02±0.19	(p<0.05)	Significant
	L	2.20±0.19	2.00±0.18	(p<0.05)	Significant
	R	3.40±0.33	3.20±0.35	(p<0.05)	Significant

Length of Anterior Condyle of femur (cm)	L	3.43±0.34	3.23±0.36	(p<0.05)	Significant
Length of Posterior Condyle of femur (cm)	R	4.60±0.27	4.50±0.31	(p<0.05)	Significant
	L	4.62±0.28	4.54±0.32	(p<0.05)	Significant
Anterior posterior width of condyle of femur (cm)	R	8.00±0.28	7.70±0.25	(p<0.05)	Significant
	L	8.04±0.25	7.76±026	(p<0.05)	Significant

In table 2 each morphologic measurement of the distal femur was significantly greater in males (p<0.05) for both right and left parameter

Table 3: Range of measured parameters on radiographs

Parameters	Sex	Right	Left	Total
Anterio posterior width of femur shaft	M	3.00-4.70cm	2.95-4.50cm	2.95-4.70cm
	F	2.80-4.20cm	2.76-4.10cm	2.76-4.20cm
Half metaphyseal width of femur shaft	M	1.60-2.60cm	1.58-2.52cm	1.58-2.60cm
	F	1.40-2.40cm	1.39-2.38cm	1.39-2.25cm
Length of anterior condyle of femur	M	3.00-4.45cm	3.10-4.50cm	3.00-4.50cm
	F	2.76-.3.96cm	2.80-4.00cm	2.76-4.00cm
Length of posterior condyle of femur	M	3.98-5.87cm	4.00-5.90cm	3.98-5.90cm
	F	3.48-5.00cm	3.50-5.10cm	3.48-5.10cm
Anterior posterior width of condyle of femur	M	6.78-10.0cm	6.80-10.10cm	6.78-10.10cm
	F	6.14-9.00cm	6.20-9.10cm	5.91-7.28cm

Table 4: Mean, SD, and the Index of Sexual Dimorphism (ISD) of the various parameters (on radiographs)

Parameters (CM)		Male (100)	Female (100)	Index of sexual dimorphism (ISD)
Anterior poster Width of femur shaft	R	3.64±0.28	3.45±0.29	105.5
	L	3.61±027	3.42±030	105.6
Half Metaphysical width of femur shaft	R	2.23±0.20	2.02±0.19	101.4
	L	2.20±0.19	2.00±0.18	110
Length of Anterior Condyle of femur	R	3.40±0.33	3.20±0.35	106.3
	L	3.43±0.34	3.23±0.36	106.2
Length of Posterior Condyle of femur	R	4.60±0.27	4.50±0.31	102.2
	L	4.62±0.28	4.54±0.32	102.6
Anterior posterior width of Condyle of femur	R	8.00±0.28	7.70±0.25	104.5
	L	8.04±0.25	7.76±026	104

Table 4 shows the mean, and the Index of sexual dimorphism (ISD) worked out by dividing the mean male value by the mean female value. Values greater than 100 indicate greater level of sexual difference between parameters. All parameters indicated values above 100 with the left half metaphyseal width of femur shaft showing the highest level of sexual difference at 110.

Table 5: Comparison of parameters of distal femur parameters on radiographs of adult Nigerians with data found on listed literature

Parameters	Present study		Caucasians		Japanese		Authors
	M	F	M	F	M	F	
Anterior posterior width of femur shaft (cm)	3.63±0.28	3.44±0.33	-	3.2±0.22	-	2.83±0.38	Urabe *et al* (2008)
Half metaphyseal width of femur shaft (cm)	2.22±0.20	2.0±0.20	-	1.81±0.14	-	1.44±0.15	Urabe *et al* (2008)
Length of anterior condyle of femur (cm)	3.42±0.32	3.22±0.34	-	2.57±0.36	-	1.94±0.26	Urabe *et al* (2008)
Length of posterior condyle of femur (cm)	4.61±0.28	4.52±0.32	-	4.51±0.34	-	4.29±0.38	Urabe *et al* (2008)
Anterior posterior width of condyle of femur (cm)	8.02±0.28	7.73±0.26	-	7.07±0.46	-	6.24±0.45	Urabe *et al* (2008)

The values of the parameters measured showed higher values from those of Caucasians and Asians (Japanese) recorded as seen in table 5 above

4. Discussion

The study was directed towards investigating the normal mean values of some selected parameters of the distal femur of Adult Nigerians. Analysis of the data from the radiographs studied shows that the mean Antero posterior width of the femur shaft, half metaphyseal width of femur shaft, length of anterior condyle of femur, length of posterior condyle of femur and the anterior posterior width of condyle of femur of Nigerian males and females (right) was 3.64 ± 0.28, 2.23 ±0.20, 3.40 ±0.33, 4.60 ±0.27, 8.00 ±0.28 and 3.45 ±0.29, 2.02 ±0.19, 3.20 ±0.35, 4.50 ±0.31, 7.70± 0.25 respectively. The left was 3.61 ± 0.27, 2.20 ±0.19, 3.43 ±0.34, 4.62 ±0.28, 8.04 ±0.29 and 3.42 ±0.30, 2.00 ±0.18, 3.23 ±0.36, 4.54 ±0.32, 7.76± 0.26 respectively. The Anteroposterior and half metaphyseal width of femur showed higher values on the right limb than observed for the left limb while higher values were observed on the left limb than the right limb for the length of anterior and posterior condyle of femur as well as anteroposterior width of femur condyle although this was not significantly related (p>0.05). There was a significant difference between the male and female values (p<0.05) in all linear parameters of the distal femur measured. This could be as a result of genetic makeup and inheritance which manifest as sexual dimorphism as reported by previous authors on most anthropometric parameters [14-16].

Sex identification in forensics and medico-legal cases is an important step towards establishing identity, especially from unknown human remains. The identity of the dead is an essential part of post mortem examination in cases of homicide, suicide, bomb blast, terrorist attacks, wars, airplane crashes, road accidents as well as natural disasters like tsunami, flood and earth quake [17]. One of the principle biological tracts to be established from skeletal remains is the sex of the individual [18]. Although one can say sex identification is more reliable if the complete skeleton is available, but in forensic cases, human skeletal remains are often incomplete or damaged [19]. The ability to determine sex from isolated and fragmental bones is of particular relevance and importance especially in cases where criminals mutilate their victims in attempt to make their identification difficult [20]. and also, in mass disasters as bones are usually commingled, charred and fragmented [21]. Hence these values of distal femur morphology would further help in process of sexual identification. One advantage of sexual identification using parameters of the distal femur is that where the shaft and proximal end are missing it can be relied on and because of the strength and density of the femur, it is frequently recovered in forensic and archeological fillings [21] as compared to the pelvis and skull and therefore relied on in the absence of the former. The use of radiography and other medical specialties to aid in investigating civil and criminal matters has increased as investigators realize how radiologic technology can yield information that otherwise is unavailable [22] (Reynold, 2010). Quantitative anatomy of the distal femur is important for the design of total joint replacement and internal fixation material. Recent studies emphasize on differences between genders and ethnic groups [23, 10].

The Index of sexual dimorphism is another reliable criterion for identifying sexual differences. It indicates the level of difference between sexes. Values close to hundred indicate low level of sexual difference and on the other hand the level of sexual difference increases with increase of the distance from hundred [13].

$$(\text{ISD}) = \frac{\text{Mean value of male}}{\text{Mean value of female}} \times 100$$

From the radiographic study, all sexually dimorphic parameter measured showed values greater than one hundred (100) indicating a high level of sexual difference. Anterior posterior width of femur shaft(cm), Half metaphyseal width of femur shaft(cm), Length of anterior condyle of femur(cm), Length of posterior condyle of femur(cm), anterior posterior width of condyle of femur, femoral condyle and Tibia condyle angle had the following index of sexual dimorphism 105.5 for the right and 105.6 for the left, 101.4 for the right and 110 for the left, 106.3 for the right and 106.2 for the left, 102.2 for the right and 102.6 for the left, 104.5 for the right and 104 for the left, 101.4 for the right and 101.5 for the left, 101.3 for the right 101.2 for the left respectively. With the length of anterior condyle of femur showing the highest level of sexual difference at 106.3. The accuracy of sex identification from unknown skeleton remains depends on the degree of sexual dimorphism [13]. The values of the linear parameters measured also showed significant differences from those recorded for Caucasians (p<0.05) and Asians (Japanese women (p<0.05) [10]. It showed higher values from those of Caucasians and Asians (Japanese) recorded. Anterior posterior width of femur for Nigerian women was 3.44 ±0.28 (cm) as against 3.20 ±0.22 and 2.83 ±0.38 for Caucasians and Asians (Japanese) respectively. Half metaphyseal width of femur shaft for Nigerian female was 2.00 ±0.20 as against 1.81 ±0.14 and 1.44 ±0.15 for Caucasians and Asians (Japanese) respectively. Length of anterior condyle of femur (cm) for Nigerian females was 3.22 ±0.34 as against 2.57 ±0.36 and 1.94 ±0.26 for Caucasians and Asians (Japanese) respectively. Length of posterior condyle of femur (cm) for Nigerian female was 4.52 ±0.32 as against 4.51 ±0.34 and 4.29 ±0.38 respectively for Caucasians and Japanese. Anterior posterior width of condyle of femur (cm) for Nigerian female was 7.73 ±0.28 as against 7.07 ±0.46 and 6.24 ±0.45 recorded for Caucasian and Japanese women.

5. Conclusion

The study has been able to establish mean values of these selected morphometric measurements of the distal femur using radiologic study, the Antero posterior width of femur, Half metaphyseal width of femur, length of anterior condyle of femur, length of posterior condyle of femur and Antero posterior width of condyle of femur are seen to be sexually dimorphic among Nigerians as in other population. It also corresponded with the sexual dimorphism index which indicates higher level of sexual difference with values farther from hundred (100). As such these parameters of the distal femur bone can be very useful in sexual identification and in providing distinct designs of femoral components for men and women based on morphology and size differences between genders where knee prosthesis are needed for the Nigerian population. The values obtained also corroborated some literatures [10]. There was also no significant relation between the right and left in all parameters measured a factor that would be useful in reconstructive surgery. Comparison with those of Asians and Caucasians show racial differences higher values were recorded in Nigerians compared with Caucasians and Asians, a useful fact in racial identification and in the design of distinct Knee prosthesis for the Nigerian population.

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