ORIGINAL ARTICLE

Morphometry of the Distal Femur in a South-South Nigerian Population

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ABSTRACT

Introduction: Variations exist in the anatomical profiles of the knee among individuals and populations. This study aimed to assess the morphometry of the distal femur in a South-south Nigerian population. **Methods:** Fifty-one adult femurs were used in this study. The mediolateral width of the femoral condyles, the anteroposterior length of the medial and lateral condyles, and the width of the intercondylar notch were measured with the sliding caliper, while the femur length was measured with the osteometric board and the aspect ratio was calculated. T-test and Pearson's correlation were employed using SPSS 23. P-value< 0.05 was considered significant. **Results:** There was no significant side difference in all the parameters studied, p>0.05, except in the mediolateral width of the condyles and the aspect ratio in which the left was significantly greater than the right side, p=0.002 and p=0.003 respectively. Pearson's correlation between the anteroposterior length of the medial condyle and full length of the femur showed that the correlation coefficient was 0.61; p<0.001. Pearson's correlation between the anteroposterior length of the lateral condyle and full femur length showed r= 0.72; p<0.001, while between the intercondylar notch width and the full length of the femur, r= 0.33; p=018. **Conclusion:** A side difference exists in the mediolateral width of the condyles and the aspect ratio, but no side difference in the anteroposterior length of the medial and lateral condyles and width of the intercondylar notch. This will provide a guide in the replacement of the femur component during the total knee replacement procedure.

Keywords: Forensic anthropology, Femur, Knee Arthroplasty, Nigeria, Orthopedics

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INTRODUCTION

The femur is rated as the longest and strongest bone in the body, and the morphology of its distal or lower end is built as a bearing surface to transmit weight to the tibia (1). The lower end of the femur possesses two condyles, lateral and medial, separated by an intercondylar notch. Sinnatamby (2) stated that 'a centre of ossification for the lower end of femur appears at the end of the ninth foetal month and its presence is acceptable medico-legal evidence of maturity'.

Morphometric anatomy of the distal femur in relation to gender, side (3) and ethnicity or population (4) has been studied. Population or ethnic variations exist in the morphometry of biological structures (5). Therefore, accurate anatomic data of the distal femur are crucial to the design of the femoral component of a total knee joint replacement (3). Some studies have shown variations in shape of the knee among the Caucasian populations (6,7), which most existing total knee arthroplasty (TKA) implant designs are based (8). Asian based studies have also received much attention in the literature and comparison to existing implants which are Caucasians (7,9,10,11). Black Africans have not received such attention (12). In view of variations in anatomical profiles among individuals, and indeed populations, the conventional prosthetic knee components will not fit well into other indigenous people of the world.

Among the various studies on the morphometry of the distal femur that have been recorded in the literature include those that employed direct measurement of dried femurs (3,13,14), measurements from radiographs (14), measurements during surgical operation of the knee (15) and Computer tomography (CT) scan (16). Among these are those from Asia (14, 16,17), Europe (3), America (15) and Africa (13). No study has been credited to the Nigerian population in the literature. The purpose of this study was to determine the morphometric anatomy of the distal femur of some Nigerians and to compare the results with those of previous studies across the world. The population-specific data will be of significance in solving the problem of frequent unfit femur component of the total knee replacement prostheses.

MATERIALS AND METHODS

The study was a descriptive type of the quantitative design and utilized all the femurs in the bone collection. Fifty-one dried adult femurs, left and right, were obtained from the Human Anatomy museum of the Delta State University, Abraka, South-South, Nigeria. The actual age and sex of the bones were not known. Grossly deformed and fractured femurs were excluded from the study. The Faculty Research and Ethics Committee approved the research (REC/FBMS/DELSU/19/62); this is without prejudice to the Declaration of Helsinki (18).

The bones, which were of adults of unknown sex, were grossly examined to select only those with complete diaphyseal-epiphyseal fusion, absence of fracture and other morphological deformities. The right bones were then separated from those on the right according to standard anatomical procedure. The parameters of the femur measured were: the full femur length (FL), mediolateral width (MLW) of the condyles, anteroposterior length (APL) of the medial condyle, APL of the lateral condyle and the width of the intercondylar notch, according to Figures 1-5 respectively. The FL was measured in centimetre, using the osteometric board as shown in Figure 1, while measurements of the distal femur dimensions were done in millimetre (and later converted to the centimetre), using the sliding caliper (Mitutoyo, Japan) as shown in Figures 2-5. The aspect ratio (AR) of the femur was calculated as: MLW/APL of the lateral condyle. All measurements were taken twice and the average recorded, to reduce the error of measurements.

Figure 1: Measurement of full length of femur

Figure 2: Measurement of mediolateral width

Figure 3: Measurement of anterioposterior length of medial condyle

Figure 4: Measurement of anterioposterior length of lateral condyle

Figure 5: Measurement of width of intercondylar notch

Data were analysed with the aid of IBM SPSS Statistics version 23. Independent samples t-test was used to determine significant side difference. Pearson's correlation was used to determine the level of relationship between two different parameters. P-value was accepted statistically significant if ≤ 0.05.

RESULTS

Results showed that a total of 51 femurs (29 right and 22 left) were used in the study. Table I showed the comparison of parameters on both sides. There was no significant side difference in all the parameters studied (p>0.05) except in MLW of the condyles and AR in which the left was significantly greater than the right side (p=0.002 and p=0.003 respectively). Table II showed the comparison of the mean dimensions of the present study with those of previous studies.

Pearson's correlation between the APL of the medial condyle and FL showed strong, positive and significant correlation (r= 0.61; p<0.001). Also Pearson's correlation between the APL of the lateral condyle and FL showed strong, positive and significant correlation (r= 0.72; p<0.001). However, Pearson's correlation between intercondylar notch width and FL was poor, positive and significant (r=0.33; p=0.018).

Table I: Comparison of parameters studied between right and left sides.

Parameter	Data	N	Mean	SD	t	df	P-value
Full length of femur (cm)	Right side	29	47.43	2.65	-0.169	49	0.867
	Left side	22	47.56	2.77			
	Combined	51	47.49	2.68	-	-	-
Total width of condyles (cm)	Right side	29	7.06	0.80	-3.195	49	0.002
	Left side	22	7.70	0.57			
	Combined	51	7.34	0.78	-	-	-
APL of medial condyle (cm)	Right side	29	6.20	0.42	0.215	49	0.831
	Left side	22	6.18	0.43			
	Combined	51	6.19	0.42	-	-	-
APL of lateral condyle (cm)	Right side	29	6.33	0.49	-0.133	49	0.895
	Left side	22	6.35	0.41			
	Combined	51	6.34	0.45	-	-	-
Width of intercondyler notch (cm)	Right side	29	2.42	0.28	0.564	49	0.576
	Left side	22	2.36	0.47			
	Combined	51	2.39	0.37	-	-	-
MLW/APL lateral condyle	Right side	29	1.12	0.13	-3.38	49	0.003
	Left side	22	1.21	0.06			
	Combined	51	1.16	0.12	-	-	-

APL= Anteroposterior length; MLW= mediolateral width; SD= Standard deviation; df= Degree of freedom.

DISCUSSION

In a Kenyan study (13), the MLW was reported to be similar on both sides contrary to the result of the present study that showed significant side difference. Biswas and Bhattacharya (14) also reported that there was no significant side difference in MLW in a study in West Bengal population.

On the mean FL, APL of the medial and lateral condyles,

Table II: Comparison of mean dimensions of the distal femur of the present study and other populations

Dimension (mm)	Data	Population/ Mean					
		West Bengal (India) (5)Biswas et al., 2017	Gujarat (India) (13) Zalawadia., 2017	Andhra Pradesh (India) (14) Neelima et al., 2016.	Iranian (15) Moghtadaei et al., 2016	Greek (3) Terzidis et al., 2012	Present study (Nigerian)
Mediolateral width of condyles	Total	-	-	-	-	-	73.36± 7.75
	Right	71.71±4.50	74.53±2.34 (M)	-	-	88.6±0.42 (M)	70.58± 8.04
	Left	70.71±5.25	67.09±2.11(F)	-	-	78.5±0.30 (F)	77.04± 5.68
APL of medial condyle	Total	-	-	-	-	-	61.92 ± 4.21
	Right	52.97±3.77	57.49±2.34 (M)	57.83± 0.69	-	61.1±0.34(M)	62.03± 4.21
	Left	54.74±3.85	53.91± 2.05 (F)	-	-	55.9±0.29 (F)	61.77± 4.30
APL of lateral condyle	Total			-	-	-	63.41± 4.50
	Right	56.20±3.36	59.02±2.69 (M)	58.0± 0.51	63.35± 3.1(M)	61.1±0.33 (M)	63.34± 4.88
	Left	56.05±4.29	54.82±2.34 (F)	-	56.53±2.98 (F)	55.4±0.21(F)	63.51± 4.05
Width of intercondyler notch	Total			-	-	-	23.91± 3.71
	Right	20.86±2.52	21.11±2.02 (M)	22.83± 0.41	21.76± 3.0 (M)	22.0±0.18 (M)	24.16± 2.82
	Left	19.45±2.57	19.35±2.52 (F)	-	17.37±2.5 (F)	18.7±0.10 (F)	23.56± 4.68
MLW/APL	Total	-	-	-	-	-	11.60± 1.16
	Right	-	-	-	-	-	11.19± 1.32
	Left	-	-	-	-	-	12.13± 0.61
Method used		Dry femur	Dry femur	Dry femur	CT scan	Dry femur	Dry femur

M= Males; F= Females; APL= Anteroposterior length; MLW= Mediolateral.

there were no significant side differences. Similar findings were reported by Biswas and Bhattacharya (14), Terzidis et al. (3) and Dargel et al. (19). Furthermore, Lakati et al. (13) found that there was no significant side difference in the APL of the lateral condyle. On the mean AR, the left side was significantly greater than the right, indicating the same shape of implants cannot be used on both sides.

On mean dimensions, all the parameters in the present study were greater than those reported for Kenyan population by Lakati et al. (13). Similarly, the MLW and APL of the lateral condyle, and the AR in the current study were greater than those reported in studies in Malaysia, Southeast Asia, by Hussain et al. (16), using a CT scan and Ewe et al. (17), in a distal femur resection. In another previous study in India, South Asia, by Shah et al. (20), the mean value of femoral MLW, APL and femoral AR were less than those of the present study. In another prior study in West Bengal, East India, South Asia, by Biswas and Bhattacharya (14), the mean values of lateral and medial femoral APLs, and MLW from direct measurements were less than those observed in the present study, but the mean intercondylar notch width and value of AR calculated from table values were greater than those of the present study. However, the value of MLW obtained by radiology in Biswas and Bhattacharya (14) was greater than those of the current study.

Similarly, in other previous studies on Caucasians, specifically the Greece, by Terzidis et al. (3), the mean values of MLW, medial and lateral APL, and intercondylar width were less than those observed in the current study, the value of the AR is greater in their study compared to that of the present study. The variation of distal femur dimensions among populations and ethnic groups could be ascribed to genetic, geographic, environmental and even anthropometric factors.

On the relationship between FL and distal femur dimensions, the correlation with the medial and lateral condyle APLs, and the intercondylar width were positive and significant. This implies that the mean dimensions of these parameters increase as the FL and indeed the height of the person increase. In a previous study by Lakati et al. (13), they also reported strong positive significant correlation between FL and condylar APL. Contrary to the present study in which negative correlation was observed between FL and intercondylar notch, Lakati et al. (13) reported that there was no correlation. The difference in population and factors likely to affect anthropometric measurements could have been responsible for the variation.

The knowledge of the morphometry of the distal femur is very important, especially as compared to those of other populations or ethnic groups across the world. The ethnic groups have varied morphology and dimensions of distal femur. Asians, American, Europeans and Africans have different morphology and dimensions. Nevertheless, the prosthetic components for total knee replacements presently in use are based mainly on the morphometry of the Europeans and Americans (21). In addition, there are also TKA implants that are designed for Asian patients that provide a better fit for the Asian knees (22). Furthermore, a statistically significant difference in the anatomy and morphology relating to the size and shape of the knee joint crucial to TKA has been observed between geographical regions (12). These conventional components of knee prostheses will not make a good fit with the anatomical profile of other populations (23) and in indeed Nigerians, as this will lead to the problem of undersizing or oversizing of femoral components in total knee replacement.

Variation of morphometry of distal femur in the current study with other populations is also important in forensic anthropology as it can only be applied to the Nigerian population. This study is limited in the sense that the sex and the actual age of the subjects are not known and further study which focused on sex and age is encouraged.

CONCLUSION

There are no significant side differences in all the femoral parameters studied, except the MLW and intercondylar width that showed that the left side was significantly greater than the right. A significant positive correlation exists between the FL, and medial and lateral condylar APLs, and intercondylar width. There is a negative correlation between FL and AR. The results of this study are important in choosing the correct distal femoral prosthetic components in total knee arthroplasty. It is also important in forensic anthropology during human identification and in population variation studies.

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REFERENCES

1. Tubbs RS. Pelvic girdle, gluteal region and thigh. In: Standring S, editor. Gray's anatomy. The anatomical basis of clinical practice. London, United Kingdom: Elsevier; 2016.
2. Sinnatamby CS. Last's Anatomy. Regional and applied. 12th ed. London: Elsevier Ltd; 2011.
3. Terzidis I, Totlis T, Papathanasiou E, Sideridis A, Vlasis K, Natsis. Gender and Side-to-Side Differences of Femoral Condyles Morphology: Osteometric Data from 360 Caucasian Dried Femori. Anat Res Int. 2012;2012:6. Available from: https://new.hindawi.com/journals/ari/2012/

679658/.
4. Urabe K, Mahoney OM, Mabuchi K, Itoman M. Morphologic differences of the distal femur between Caucasian and Japanese women. Journal Orthopaed Surg. 2008;16(3):312–15.
5. Murlimanju BV, Purushothama C, Srivastava A, Kumar CG, Krishnamurthy A, Blossom V, et al. Anatomical morphometry of the tibial plateau in South Indian population. Ital J Anat Embryol. 2016;121(3):258-64.
6. Bellemans J, Carpentier K, Vandenneucker H, Vanlauwe J, Victor J. The John Insall Award. Both morphotype and gender influence the shape of the knee in patients undergoing TKA. Clin Orthop Relat Res. 2010;468:29–36.
7. Hitt K, Shurman JR, Greene K, McCarthy J, Moskal J, Hoeman T, et al. Anthropometric measurements of the human knee: correlation to the sizing of current knee arthroplasty systems. J Bone Joint Surg Am. 2003;85 (Suppl 4):115–22.
8. Zalawadia AZ, Parekh DH, Patel SM. Morphometric study of lower end of dry Femur in Gujarat Region and its Clinical implication. Int J Anat Res. 2017;5(4.2):4595-9.
9. Cheng FB, Ji XF, Lai Y, Feng JC, Zheng WX, Sun YF, et al. Three dimensional morphometry of the knee to design the total knee arthroplasty for Chinese population. Knee. 2009;16:341–7.
10. Ho WP, Cheng CK, Liau JJ. Morphometrical measurements of resected surface of femurs in Chinese knees: correlation to the sizing of current femoral implants. Knee. 2006;13:12–4.
11. Uehara K, Kadoya Y, Kobayashi A, Ohashi H, Yamano Y. Anthropometry of the proximal tibia to design a total knee prosthesis for the Japanese population. J Arthroplasty. 2002;17:1028–32.
12. Kim TK, Philips M, Bhandari M, Watson J, Malhotra R. What differences in morphologic features of the knee exist among patients of different races? A systematic review. Clin Orthop Related Research, 2017;475:170-82.
13. Lakati KC, Ndeleva BM, Kibet CK, Odhiambo SM, Sokobe BM. Anthropometry of the distal femur in a Kenyan population and its correlation with total knee replacement implants. East Afri Orthopaedic J. 2017;11:67-72.
14. Biswas A, Bhattacharya S. A morphometric and radiological study of the distal end of femur in West Bengal population. Italian J Anat Embryol. 2017;122(1):39-48.
15. Loures FB, Gyes RFA, Palma IM, Labronici PJ, Granjeiro JM, Olej B. Anthropometric study of the knee and its correlation with the size of three implants available for arthroplasty. Rev Bras ortop. 2016;51(3):282–9.
16. Hussain F, Kadir MRA, Zulkifly AH, Sa’at A, Aziz AA, Hossain MG. Anthropometric Measurements of the Human Distal Femur: A Study of the Adult Malay Population. BioMed Research International. 2013;2013: Available from: https://www.hindawi.com/journals/bmri/2013/175056/
17. Ewe TW, Ang HL, Chee EK, Ng WM. An Analysis of the Relationship between the Morphometry of the Distal Femur, and Total Knee Arthroplasty Implant Design. Malaysian Orthopaedic J. 2009;3(2):24-8.
18. World Medical Association. World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects. Bull World Health Organ. 2001;79:373-4.
19. Dargel, J, Schmidt-Wiethoff R, Fischer S, Mader K, Koebke J, Schneider T. Femoral bone tunnel placement using the transtibial tunnel or the anteromedial portal in ACL reconstruction: a radiographic evaluation. Knee Surg Sports Traumatol Arthrosc. 2009;17:220-7.
20. Shah DS, Ghyar R, Ravi B, Hegde C, Shetty V. Morphological Measurements of Knee Joints in Indian Population: Comparison to Current Knee Prostheses. Open Journal of Rheumatology and Autoimmune Diseases. 2014;4:75-85.
21. Abdulhamit M, Kadir IY, Turan BK. Wider femoral and mediolaterally narrower tibial components are required for total knee arthroplasty in Turkish patients. Knee Surg sports Traumathol Arthrosc. 2019;27:215521-66.
22. Hosaka K, Saito S, Ishii T, Mori S, Sumino T, Tokuhashi Y. Asian-Specific total knee system: 5-14 year follow-up study. BMC Musculoskel Disord. 2011; 12:251. Available from: http://www.biomedcentral.com/1471-2474/12/251.
23. Gupta C, Kumar J, Kalthur SG, D'souza AS. A morphometric study of the proximal end of the tibia in South Indian population with its clinical implications. Saudi J Sports Med. 2015;15:166-9.