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Radiogrammetric Analysis of the Proximal Portion of th Femur in Nigerian Population

Bob-Manuel IF, Didia BC and Udoaka AI
Department of Anatomy, Faculty of Basic Medical Sciences, College of Health Sciences, University of Port Harcourt.

Corresponding Author: Bob-Manuel IF
E-mail: itsbif@yahoo.com; +234 803 6724 965

ABSTRACT
Metric knowledge of the structural arrangement of the proximal os femora is an important tool in the design and development of implants of articulating bones of the coxal joint. The aim of this study was to provide baseline morphometric data of the upper extremity of the femur of Nigerian population. A total of 1,699 normal anteroposterior radiographs of the pelvis of Nigerians were used from Radiology Departments of selected hospitals in Nigeria. From the obtained radiographs, femoral neck axis length (FAL), femoral neck width (FW), femoral head width (HW), intertrochanteric width (TW), and femoral neck-femoral shaft angle (FNSA) were measured using goniometers and digital venier calipers. Results obtained showed that dissimilarities are present in the mean values of the measured parameters within and across populations. The mean±SEM value for FAL, FW, HW, TW, and FNSA are 108.30±0.47mm & 108.21±0.48mm, 37.75±0.22mm & 37.33±0.21mm, 53.87±0.24mm & 53.74±0.22mm, 75.56±0.42mm & 75.72±0.43mm, 134.01±0.32° & 133.84±0.30° and 103.77±0.36mm & 103.78±0.41mm, 34.83±0.17mm & 35.09±0.17mm, 49.90±0.19mm & 49.84±0.20mm 71.65±0.32 & 71.11±0.32mm, and 132.38±0.31° & 131.96±0.26° for male left & right sides and female left & right sides respectively . Also, highly significant ($p<0.01$) differences in all measured parameters between males and females with males having higher values was observed. However, no significant statistical difference was found between right and left sides. This study concludes that Nigerian morphometric dimensions of the proximal os femora clearly varies from western standard depicting that the dimensions of the orthopaedic implants of the os femora currently available do not match with the os femora of Nigerian as they were made and designed using Caucasian values. We recommend therefore that makers of orthopaedic implants and screws should take revolutionary steps in making femoral orthopaedic implants to suit Nigerian need.

Keywords: Proximal femoral morphometry, Orthopaedic implants and screws.

INTRODUCTION
Metric variability in features of the human bones clarifies and defines the national and ethnic physiognomy of populations showing and displaying extensive and significant differences[1-3]. Recorded research write-ups in radiologic, orthopaedic or bioanthropologic journals by numerous researchers on the radiogrammetry or osteometry of the structural configuration of the os femora have clearly elucidated differences in various human populations[4-7]. Variations in skeletal morphometric measurement are concomitant with two main factors (environmental factors- such as geography, diet, lifestyle and genetic factors) [2,3].

Several researchers have employed the use of radiograph in assessing the morphometry of os femora as it is important to design and develop orthopaedic implants, screws and prosthesis of the proximal portion of the femur[3,7-10]. Besides, the measurement of the shape and configuration of human bones guide clinicians, orthopaedic surgeons, and radiologic anatomists, in determining danger or threat factors for bone breakage or fracture[3,11].

Femoral metric structural parameters such as femoral neck axis length (FAL), femoral neck width (FW), femoral head width (HW), intertrochanteric width (TW), and femoral neck-femoral shaft angle (Collodiaphyseal angle) have been correlated with biomechanical strength of the proximal os femora[3]. Besides, these metric structural parameters have been reported as concomitant with the resistance of bone to impact[3,8,12,13], the highest metric values established in races linked with higher prevalence of coxal fracture. These morphometric parameters are vital and useful in development and design of femoral orthopaedic implants and screws[7,10]. Metric knowledge of the structural arrangement of the upper or proximal *os femora* is also an important tool in the design and development of implants for management of fractures of articulating bones in the coxal region especially in total hip arthroplasty. Blade plates, dynamic hip screws (DHS), ASNIS screws, and cancellous screws are the most common implants used in the management of

fractures of the proximal *os femora* by orthopaedic surgeons. Most of the implants are designed and manufactured by Europeans and North Americans based on the metric structure of the *os femora* of their respective populations. When undertaking total hip replacement, it is crucial that the dimensions of the femoral implants used should match the metric structure of the os femora[14-16]. Siwach and Dahiya[14] also noted the geometric differences within the Western implants and the Indian femora. Besides, Baharuddin *et al.*[10] reported that the use of implants designed based metric records of other populations on another poses potential dangers associated with morphology-implant mismatch. The use of such implants in other regions such as Nigerians may therefore not be appropriate; as such implants designed did not take into consideration the morphology of other population thereby increasing the chances of implant failure leading to non union, malunion and avascular necrosis. These implants do not match other populations due to anthropometric differences of the proximal os femora between the different ethnic groups. These implants could also affect the outcome of surgery with complications such as loosening, micromotion, stress shielding etc[10,17,18], therefore the dimensions of these implants need to be modified to suit the Nigerian population[19].

Hence, the aim of this study was to determine the morphometry of the proximal portion of the femur of Nigerian population and provide baseline data of the upper extremity of the femur. The data thus provided could be utilized in the design and development of orthopaedic implants and screws suited for Nigerian population, promoting discussion of obtained data with standard indigenous and imported implants and screws over and above aiding the anthropologic and forensic anatomist in decision making.

MATERIALS AND METHODS

This non-experimental, analytic scientific investigation was carried out in the Radiology Departments of University of Port Harcourt Teaching Hospital, Braithwaite Memorial Hospital, Olabisi Onabanjo University Teaching Hospital, Ladoke Akintola University of Technology Teaching Hospital, National Orthopedic Hospital Igbobi, Lagos; University of Jos Teaching Hospital, and University of Abuja Teaching Hospital after approval was taken from the Ethics and Research Committee of the University of Port Harcourt. One thousand, six hundred and ninety-nine (1699) {seven hundred and eighty-seven (787) males and nine hundred and twelve (912) were females. Standard anteroposterior (AP) radiographs of the hip joint/os femora reported normal with bio-data indicating adult Nigerian origin were used for this study. Pelvic radiographs showing incomplete proximal end of os femora, incomplete ossification, and deformity or disease; reported abnormal and bio data not indicating Nigerian origin were excluded in this study.

The angular [femoral neck shaft angle (FNSA)] and linear [femoral neck axis length (FNAL), femoral neck width (FNW), femoral head width (FHW), femoral intertrochanteric width (FIW)] morphometric landmarks of the proximal os femora (right and left sides) were measured from the obtained standard anteroposterior (AP) radiographs of males and females. To measure each parameter (metric landmark or canon), the radiographs were placed on the X-ray viewing box; parameters or metric landmark traced using pencil and measured using and digital venier calipers in millimeters (mm) for linear metric landmarks and goniometers in degrees (°) for angular metric landmarks. The definition of measurements of the metric landmarks or parameters studied was taken as clearly described by Calis *et al.*[20], Patton *et al.*[11], Irdesel and Ari[3], De Sousa *et al.*[7], Baharuddeen *et al.*[10].

All measurements were taken twice and the average recorded in millimetres for linear parameters and degree for angular parameters. Data collected for this study were analyzed with the help of Statistical Package for Social Science (SPSS) 16.0 version to establish baseline descriptive statistical data. Two tailed z -test was used to compare mean values to establish gender and side differences.

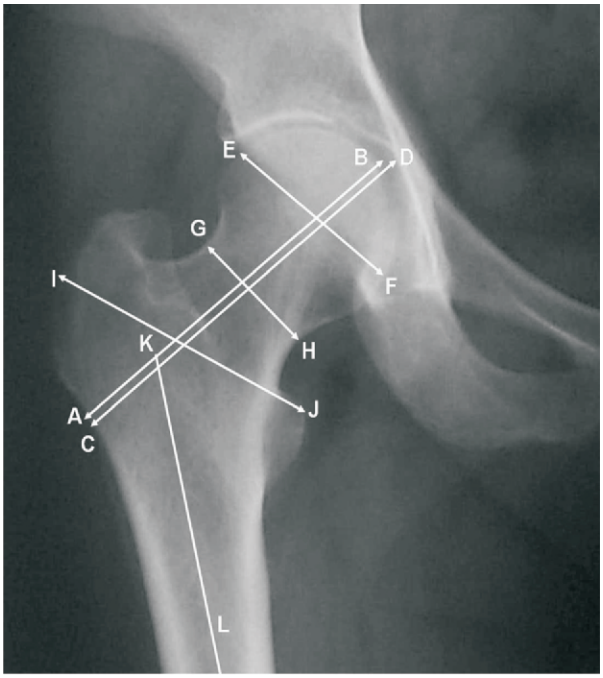

Figure 1: Definition of measured parameters from anteroposterior radiograph of the proximal portion of the femur.

RESULTS

The mean±SEM and standard deviation of the five measured parameters of the Nigerian population are shown in table 1. Statistical analysis of the obtained data showed highly significant differences in all measured parameters between males and females with males having higher values. However, no significant

statistical difference was found between right and left sides. Table 2 shows comparison of obtained data of the measured morphometric parameters of the proximal os femora with data from different studies.

Table 1: Statistical data of five measured morphometric parameters of the Nigerian population

PARAMETERS	SEX	SIDE	Mean ± SEM	SD	p value*	p value**
FNAL (mm)	MALE	LEFT	108.30±0.47	9.54	0.89	0.00
		RIGHT	108.21±0.48	9.59		
	FEMALE	LEFT	103.77±0.36	7.77	0.98	
FNW (mm)	MALE	LEFT	37.75±0.22	4.48	0.17	0.00
		RIGHT	37.33±0.21	4.12		
	FEMALE	LEFT	34.83±0.17	3.64	0.30	
		RIGHT	35.09±0.17	3.70		
FHW (mm)	MALE	LEFT	53.87±0.24	4.83	0.67	0.00
		RIGHT	53.74±0.22	4.27		
	FEMALE	LEFT	49.90±0.19	4.16	0.82	
		RIGHT	49.84±0.20	4.35		
FIW (mm)	MALE	LEFT	75.56±0.42	8.46	0.79	0.00
		RIGHT	75.72±0.43	8.59		
	FEMALE	LEFT	71.65±0.32	6.80	0.23	
		RIGHT	71.11±0.32	6.87		
FNSA (°)	MALE	LEFT	134.01±0.32	6.43	0.69	0.00
		RIGHT	133.84±0.30	5.84		
	FEMALE	LEFT	132.38±0.31	6.63	0.30	
		RIGHT	131.96±0.26	5.44		

(*: z-test analysis of means between femoral sides; **: z-test analysis of means between sexes

Table 2: Comparison of the measured angular parameters of the proximal os femora in different studies

Author, year & country	Sex	Side	MEASURED MORPHOMETRIC PARAMETERS				
			FNAL	FNW	FHW	FIW	FNSA
Pulkkinen et al, 2002 (Finland)	Females	NIL	9.00	2.90	4.30	5.20	
Calis et al., 2004 (TurKey)	NIL	Right	11.27	3.58	5.33	6.25	128.90
	NIL	Left	11.25	3.59	5.30	6.30	128.90
Irdesel and Ari, 2010 (Turkey)	Females	NIL	10.10	3.50	5.20	8.40	131.50
Baharudden et al, 2011 (Malaysia)	Females	NIL		2.89	3.89		132.00
	Males	NIL		2.60	4.36		129.00
De Sousa et al (2010), Brazil		Right		3.11	4.71		132.10
		Left		3.08	4.64		131.80
Tahir et al (2001), Nigeria	Males						136.70
	Females						126.65
Udoaka and Agi (2010), Nigeria	Males						132.00
	Females						130.20
Present study (Nigeria)	Females	Right	10.38	3.51	4.98	7.11	131.96
	Males	Right	10.82	3.73	5.37	7.57	133.84
	Females	Left	10.37	3.48	4.99	7.16	132.38
	Males	Left	10.83	3.78	5.39	7.56	134.01

DISCUSSION

The structural arrangement or configuration of the proximal portion of the *os femora* is an essential factor or canon in the design and development of orthopaedic implants of the *os femora* and prostheses of the coxal bone. Besides, it is essential in foretelling the likelihood and management of proximal fractures of the *os femora*. Radiogrammetric investigation of the proximal extremity of the *os femora* have revealed or elucidated that dissimilarities are present inter-populations and intra-populations; associated with variations in their genetic makeup, diet, geographical location and lifestyle[21].

Linear and angular morphometric parameters have been reported to vary in different population by numerous scientific investigators[3,6,7,11,22]. Comparing the means of the morphometric parameters obtain with the outcome of erstwhile workers on dissimilar and distinct population reveal variations values. Also our value of femoral neck shaft angle (FNSA) vary slightly but similar with the research outcome of Udoaka and Agi[22] on southern Nigerian population. This agrees with the conclusion made by Straeker *et al.*[23]. This team of investigators concluded or resolved that variations are extant among the parameters of the proximal os femora and insignificant in similar population but data from different populations vary significantly. From the aforesaid, it is worth emphasizing that inter-population and intra-population based differences are extant in the metric structural configuration of the *os femora.* Hence, utilizing or employing orthopaedic implants and screws designed by Caucasian manufacturers, presumably using femoral structural metric values of their population, won't be suitable for other population like ours. This study provides and documents comprehensive morphometric information or data of the proximal os femora requisite for the manufacture of local prostheses and orthopaedic implants that will meet the Nigerian need minimising repeated post-operation complication after fixation of proximal femoral fracture with orthopaedic implants currently used.

De Soua *et al.*[7], Strecker *et al.*[23], Tahir et al.[24] and Ziylan and Mushid[5] have reported the presence of statistically non-significant metric bilateral asymmetry of the *os femora* with the left os femora mostly larger than the right. In this current scientific radiogrammetric investigation, variations in the structural landmarks were observed between right and left femora but in no particular other; however, the left were mostly larger. This was not statistically significant in all measured parameters agrees with the findings of other aforementioned literatures.

In conclusion, Nigerian morphometric dimensions of the proximal os femora clearly varies from western standard depicting the dimensions of the orthopaedic implants of the os femora currently available do not match with the *os femora* of Nigerian as they were made and designed using Caucasian values. Also, we conclude that when studying the morphometry of the proximal femur of any population using either the left or right will suffice. We recommend therefore that biomedical engineers and makers of orthopaedic implants and screws should take revolutionary steps in making femoral orthopaedic implants to suit Nigerian needs.

REFERENCES

1. Hoaglund FT and Low WD. Anatomy of the femoral neck and head, with comparative data from Caucasians and Hong Kong chinese. *Clin. Orthop. Rel. Res.,* 1980; 152:10-6.
2. Schwartz AV, Kelsey JL, Maggi S, Tuttleman M, HO SC, Jonsson PV, Poor G, Sisson DE Castro JA, XU L, Matkin CC, Nelson LM and Heyse SP. International variation in the incidence of hip fractures: crossnational project on osteoporosis for the World Health Organization program for research on aging. *Osteoporos Int*, 1999; 9:242-253.
3. Irdesel J and Ari I. The proximal femoral morphometry of Turkey women on radiographs. *Eur J. Anat.,* 2006; 10 (1):21-26.
4. Steyn M, Iscan MY. Sex determination from the femur and tibia in South African Whites. *Forensic Sc Inter,* 1997; 90:111-9.
5. *Zuylan T and Murshid KA. An Analysis of Anatolian Human Femur Anthropometry. Turk J Med Sci., 2002; 32 231-235.*
6. Igigbi PS and Msamati BC. The femoral collodiaphyseal angle in Malawian adults. *Am. J. Orthop.,* 2002; 31(12):682-5
7. De Sousa EB, Fernandes RM, Mathias MB, Rodrigues MR, Ambram AJ and Babinski MA. Morphometric study of the proximal os femora extremity in Brazilians. *Int. J. Morphol.,* 2010; 28(3):835-40.
8. Karlsson KM, Sernbo I, Obrant, KJ, Redlund-Johnell I, Johnell O. Femoral neck geometry and radiographic signs of osteoporosis as predictors of hip fracture. *Bone,* 1996; 18:327-30.
9. Gnudi S, Ripamonti C, Lisi L, Fini M, Giardino R, Giavaresi G. Proximal femoral geometry to detect and distinguish femoral neck fractures from trochanteric fractures in postmenopausal women. *Osteoporos Int.,* 2002; 13:69-73.
10. Baharuddin MY, Kadir MRA, Zulkifly AH, Saat A, Aziz AA, Lee MM. Morphology study of the proximal os femora in Malay population. Int. J. Morphol., 2011; 29(4):1321-1325.
11. Patton MS, Duthie RA, Sutherland AG. Proximal femoral geometry and hip fractures. *Acta Orthop. Belg.,* 2006; 72:51-54.
12. Gregory JS, Testi D, Stewart A, Undrill PE, Reid M, Aspden RM. A method for assessment of the shape of the proximal os femora and its relationship to osteoporotic hip fracture. *Osteoporos Int.,* 2004; 15:5-11.
13. Pulkinen P, Partenen J, Jalovara P, Jamsa T. Combination of bone mineral density and upper femur geometry improves the prediction of hip

fractures. *Ostoeporos Int,* 2004; 15: 274-280
14. *Siwach RC, Dahiya S. Anthropometric study of proximal femur geometry and its clinical application. Indian Journal of Orthopaedic, 2003; 37(4): 247-251.*
15. *Noble PC, Jerry W, Alexander JW. The anatomical basis of femoral component design. Clin Orthop., 1988; 235: 148-165.*
16. Ravichandran D, Muthukumaravel N, Jaikumar R, Hirak Das, Rajendran M. Proximal femoral geometry in Indians and its clinical applications. *J Anat. Soc. India, 2011;* 60(1) 6-12.
17. Heinert G, Parker MJ. Intermedullary osteosynthesis of complex proximal femoral fractures with the Targon PF nail. *Injury, 2007;* 11:1294-1296.
18. Jiang LS, Shen L, Dia LY. Intermedullary fixation of subtrochanteric fractures with long proximal femoral nail or long gamma nail: technical notes and preliminary results. *Ann. Acad. Med. Singapore*, 2007; 10:821-826.
19. Abdul-Kadir MR, Hansen U, Klabunde R, Lucas D, Amis A. Finite element modeling of primary hip stem stability: the effect of interference fit. J. Biomech., 2008; 41(3):587-594.
20. Calis HV, Eryavuz M, Calis M. Comparison of femoral geometry among cases with and without hip fractures. Yonsei Med J, 2004; 45:901-907.
21. Faulkner KG, Cummings SR, Black D, Palermo L, Gluer CC, Genant HK. Simple measurement of femoral geometry predicts hip fracture: the study of osteoporotic fractures. *J Bone Miner Res.,* 1993; 10:1211-1217.
22. Udoaka AI, Agi CE. A Study of the Collo-Diaphyseal Angle in an Adult Population in Southern Nigeria. *Afr J Med Phy, Biomed Eng & Sc., 2010; 2: 67 – 70.*
23. Strecker W, Keppler P, Gebhard F, Kinzl L. Length and torsion of the lower limb. *Br J Bone Joint Surg.,* 1997; 79: 1019 -1023.
24. Tahir A, Hassan AW and Umar IM. A study of the colloidiaphyseal angle of the os femora in the North-Eastern Sub-Region of Nigeria. *Niger. J. Med.,* 2001; 10(1):34-36.