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ORIGINAL ARTICLE

Radiographic Assessment of Proximal Femoral Morphology in Normal Nigerian Adults

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Abstract

Population-specific data on proximal femoral anatomy is crucial for optimizing orthopedic procedures like total hip arthroplasty, yet such data for Nigerian adults is scarce. This study aimed to assess key radiographic parameters of the proximal femur—neck-shaft angle (NSA), femoral head diameter (HD), and femoral horizontal offset (HO)—in normal Nigerian adults, focusing on gender and side differences.
Methods: A cross-sectional study of 100 hip radiographs (50 males, 50 females) of patients without history of lower extremity pathology was conducted. NSA, HD, and HO were measured bilaterally. Gender and side differences were analyzed using independent and paired t-tests ($p < 0.05$).
Results: The mean NSA was significantly higher in males (132.13°±3.65) than in females (129.45°±5.45; $p < 0.001$). Side-to-side comparison also showed a significant difference (Right:129.47°±4.27; Left:132.11°±4.87; $p < 0.001$). Males had a significantly larger HD (4.84±0.26cm) than females (4.58±0.40cm; $p < 0.001$), with a modest but significant side difference (Right:4.71±0.36cm; Left:4.59±0.43cm; $p = 0.03$). HO showed no significant gender difference (Males:3.82±0.29cm; Females:3.80±0.35cm; $p = 0.742$) or side-to-side variation (Right:3.81±0.32cm; Left:3.85±0.36cm; $p = 0.184$).
Conclusion: This study provides essential baseline data on proximal femoral anatomy in Nigerian adults. Notable gender differences were observed in NSA and HD, while HO appeared consistent across sexes and sides. These findings underscore the need for population-specific reference values to guide implant design, surgical planning, and orthopedic education in Nigeria.

Keywords: Anatomy; Hip; Femur; Neck-shaft angle; Head diameter; Horizontal offset

Introduction

The proximal femur—comprised of the femoral head, neck, and greater trochanter—is a complex three-dimensional structure featuring the primary compressive strut, a dense column of trabecular bone connecting head to shaft Stiehl, Jacobson, and Carrera 2007, and forming the femoral neck axis, a crucial parameter in hip arthroplasty Cornelissen et al. 2022. It also serves as the attachment site for multiple muscles, articulates with the acetabulum, and plays a critical role in weight-bearing and locomotion.

Variations in proximal femur morphology influence biomechanical function and susceptibility to disorders such as osteoarthritis and fracture Hafezji et al. 2024. Despite global recognition of its importance, specific normative radiographic data for Nigerian adults are lacking. Most published series focus on other ethnicities or regions, leaving a critical knowledge gap. The objective of this study was therefore to measure three key parameters—neck-shaft angle (NSA), head diameter (HD), and horizontal offset (HO)—in a cohort of Nigerian adults, and to establish reference values stratified by sex and laterality.

Materials and Methods

Study Design and Participants

We performed a cross-sectional observational study at the Radiology Department of Abubakar Tafawa Balewa University Teaching Hospital (ATBUTH), Bauchi. 100 consecutive adults (50 males, 50 females; age 18years) undergoing AP pelvic radiographs for non-lower limb indications were recruited. Exclusion criteria included prior hip pathology, trauma, surgery, systemic musculoskeletal disease, or contraindication to radiography.

Ethical Approval

The Human Research Ethics Committee of ATBUTH approved the protocol. All participants provided written informed consent after being informed of study purpose, procedures, risks, and benefits in accordance with the Declaration of Helsinki.

Radiographic Technique

Anteroposterior pelvic radiographs were obtained with participants supine, hips internally rotated 15°, focus-film distance 120cm, and beam perpendicular to the table Dávila-Parrilla et al. 2018.

Morphological Measurements

All measurements were made bilaterally by a single blinded investigator using digital calipers on the PACS workstation Roy et al. 2014:

- **Neck-shaft angle (NSA):** Angle between the femoral shaft axis and the head-neck axis.
- **Head diameter (HD):** Diameter of the best-fit circle around the femoral head.
- **Horizontal offset (HO):** Perpendicular distance from the center of the femoral head to the femoral shaft axis.

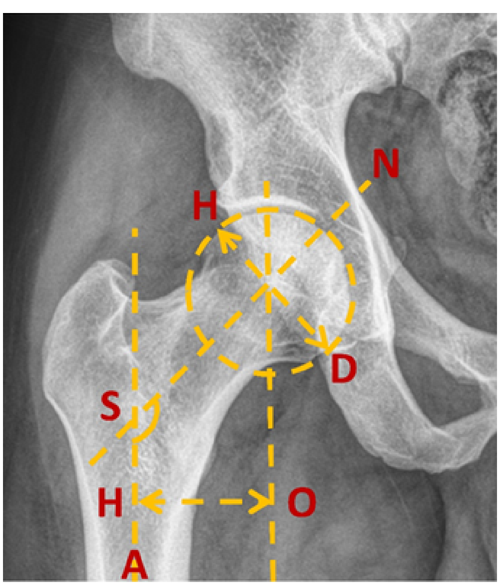

Figure 1. The proximal femoral parameters measured: NSA = Neck-shaft angle, HD = Head diameter, HO = Horizontal offset

Statistical Analysis

Data were analyzed in SPSS v27. Normality was assessed by Kolmogorov–Smirnov test. Independent-samples t-tests compared males vs. females; paired t-tests compared right vs. left sides. Significance was set at $p < 0.05$. Results are reported as mean±SD with 95% confidence intervals.

Results

Neck-Shaft Angle

Males exhibited a higher mean NSA (132.13°±3.65) than females (129.45°±5.45; $p < 0.001$) (Table 1). Side-to-side comparison showed the left NSA (132.11°±4.87) exceeded the right (129.47°±4.27; $p < 0.001$) (Table 2).

Head Diameter

HD was larger in males (4.84±0.26cm) than females (4.58±0.40cm; $p < 0.001$).(Table 1) Right vs. left HD difference was modest but significant (4.71±0.36cm vs. 4.59±0.43cm; $p = 0.03$).(Table 2)

Horizontal Offset

HO did not differ by sex (Males:3.82±0.29cm; Females:3.80±0.35cm; $p = 0.742$)(Table 1) nor side (Right:3.81±0.32cm; Left:3.85±0.36cm; $p = 0.184$).(Table 2)

Table 1. Independent-samples t-test for sex-based differences in proximal femur parameters

Variable	Male (Mean ± SD)	Female (Mean ± SD)	Mean Diff (95% CI)	t (df)	p-value
NSA (°)	132.13 ± 3.65	129.45 ± 5.34	2.67 (1.39, 3.95)	4.13 (98)	<0.001
HD (cm)	4.84 ± 0.26	4.58 ± 0.40	0.27 (0.13, 0.40)	3.91 (98)	<0.001
HO (cm)	3.82 ± 0.29	3.80 ± 0.35	0.02 (−0.11, 0.15)	0.33 (98)	0.742

NSA = Neck-Shaft Angle; HD = Head Diameter; HO = Horizontal Offset; SD = Standard Deviation; CI = Confidence Interval.

Table 2. Paired-samples t-test for side-to-side differences in proximal femur parameters

Variable	Right (Mean ± SD)	Left (Mean ± SD)	Mean Diff (95% CI)	t (df)	p-value
NSA (°)	129.47 ± 4.27	132.11 ± 4.87	−2.64 (−4.00, −1.29)	−3.87 (99)	<0.001
HD (cm)	4.71 ± 0.36	4.59 ± 0.43	0.12 (0.04, 0.19)	3.02 (99)	0.030
HO (cm)	3.81 ± 0.32	3.85 ± 0.36	−0.04 (−0.11, 0.02)	−1.34 (99)	0.184

NSA = Neck-Shaft Angle; HD = Head Diameter; HO = Horizontal Offset; SD = Standard Deviation; CI = Confidence Interval.

Discussion

The biomechanical goals of total hip arthroplasty are to create a stable anatomical articulation with an optimum range of movement, to restore normal biomechanics for muscular efficiency, and to equalize limb length Roy et al. 2014. This study holds significant implications for orthopedic practice and research, serving as a foundational step towards enhancing our understanding of proximal femur morphology within the Nigerian population. By elucidating radiographic parameters and establishing reference values, our findings will contribute to the development of evidence-based clinical guidelines, surgical techniques, and rehabilitation protocols tailored to the unique anatomical characteristics of Nigerian adults.

The neck–shaft angle (NSA) has several important clinical implications, particularly in adults. Accurate measurement is essential after hip injuries, especially for effective fixation in unstable fractures Sharma et al. 2018. A higher NSA is associated with increased risks of proximal femoral fractures, genu varum, and medial compartment knee arthritis Gnudi, Sitta, and Pignotti 2012; Im and Lim 2011; Walensky and O'Brien 1968; Altubasi, Hamzeh, and Madi 2020. Conversely, a lower NSA is linked to a higher incidence of greater trochanteric pain syndrome, Paget's disease, osteogenesis imperfecta, osteomyelitis, and osteoporosis Sharma et al. 2018; Jiang, Peng, and Al-Qwbani 2015; Fearon et al. 2012; Adibhatla, Satya, and Naidu 2019.

In the present study, the mean NSA was significantly greater in males (132.13° ± 3.65) than in females (129.45° ± 5.45), with a mean difference of 2.67° (95% CI: 1.39–3.95; $p < 0.001$). Likewise, side-to-side comparison revealed a significant difference (Right: 129.47° ± 4.27; Left: 132.11° ± 4.87; mean difference = –2.64°, 95% CI: –4.00 to –1.29; $p < 0.001$). Several Nigerian and international studies have reported similar sexual dimorphism in NSA **roy2014evaluation** ; Adekoya-Cole et al. 2016; Pathak, Maheshwari, and Ughareja 2016; Elbuken, Baykara, and Ozturk 2012, although some found no significant difference Ali et al. 2023; Boese et al. 2016 or even higher NSA in females Fischer et al. 2020, underscoring population-specific anatomical variation.

Femoral head diameter (HD) is another key parameter affecting implant fit and joint stability in hip arthroplasty. Males in our cohort exhibited a significantly larger mean HD (4.84 ± 0.26cm) compared to females (4.58 ± 0.40cm), mean difference = 0.27cm (95% CI: 0.13–0.40; $p < 0.001$). Side-to-side differences were also significant (Right: 4.71 ± 0.36cm; Left: 4.59 ± 0.43cm; mean difference = 0.12cm; 95% CI: 0.04–0.19; $p = 0.03$). This sexual dimorphism aligns with prior reports in Nigerian Ede et al. 2021, Indian Sharma et al. 2018, Malaysian Ede et al. 2021, Kenyan Ndeleva and Lakati 2017, and dry bone Nigerian samples Katchy et al. 2021. Differences in cartilage presence likely account for the slightly higher radiographic measures in vivo.

Femoral horizontal offset (HO) influences muscle tension, range of motion, and impingement risk Roy et al. 2014. In our study, mean HO did not differ significantly by sex (Males: 3.82 ± 0.29cm; Females: 3.80 ± 0.35cm; mean difference = 0.02cm; 95% CI: –0.11–0.15; $p = 0.742$) or side (Right: 3.81±0.32cm; Left: 3.85±0.36cm; mean difference = –0.04cm; 95% CI: –0.11–0.02; $p = 0.184$). These findings concur with radiographic Oommen 2024 and dry bone studies Roy et al. 2014.

Limitations of this study include its single-center design, absence of body mass index and activity level data, and reliance on two-dimensional radiographs, which preclude assessment of femoral neck version and three-dimensional morphology. While CT offers more precise volumetric measurements, plain radiography remains the most accessible modality in resource-limited settings.

Conclusion

This cross-sectional study establishes baseline radiographic values for NSA, HD and HO in Nigerian adults and confirms sexual dimorphism in NSA and HD, with minimal side-to-side differences. These population-specific reference values are essential to guide implant selection, surgical planning, and orthopedic education in Nigeria. Future multicenter studies employing three-dimensional imaging and incorporating demographic and anthropometric variables are warranted to expand normative databases and elucidate the influence of age, BMI, and activity level on the proximal femoral morphology.

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