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Anatomical Diversity in Femur bones: Understanding the Morphological Variability for Surgical and Prosthetic Applications

Diversidad Anatómica en Huesos Fémur: Comprensión de la Variabilidad Morfológica para Aplicaciones Quirúrgicas y Protésicas

Sajith Edirisinghe; Dulmini De Silva; Harsha Dissanayake; Surangi Yasawardene; Movini Devmini; Shanaka Pathmaperuma & Nawodha De Zoysa

EDIRISINGHE, S. ; DE SILVA, D.; DISSANAYAKE, H.; YASAWARDENE, S.; DEVMINI, M.; PATHMAPERUMA, S. & DE ZOYSA, N. Anatomical diversity in femur bones: Understanding the morphological variability for surgical and prosthetic applications. *Int. J. Morphol., 42(1)*:162-165, 2024.

SUMMARY: The femur, the body's longest bone, plays a critical role in orthopaedics and radiology. Understanding its anatomy, particularly the neck-shaft angle (NSA), is vital for diagnosing bone issues and designing hip implants. While some Asian populations' femur measurements have been studied, there is a research gap concerning Sri Lankans. This study aimed to fill this gap by examining the proximal femur's anatomy in the Sri Lankan population. We analysed 45 adult human femurs (26 right, 19 left) of unknown sex, ethically sourced from the University of Sri Jayewardenepura. Femurs with fractures or pathologies were excluded. Precise measurements were recorded using digital vernier callipers, with millimetre accuracy. Parameters included mean femoral length, vertical and transverse femoral head diameters, neck axis and neck length. Each measurement was taken three times to minimize subjectivity. Right femurs had a mean length of 42.8 mm (SD±2.64), while left femurs measured 43.53 mm (SD±3.27). Mean NSA was 125.78º (SD±4.45) for left femurs and 127.59º (SD±2.06) for right. Mean femoral head diameters were 4.09mm (SD±0.30) (right) and 4.12mm(SD±0.31) (left). Mean anterior neck lengths of the right and left were 2.61(SD±0.54) and 2.71(SD±0.50) respectively. Comparing our findings with other Asian populations highlighted significant variations in femur measurements. These discrepancies emphasize the need for population-specific data for orthopaedic interventions and raise questions about the suitability of imported prosthetics. Differences in femur length, neck length, and NSA between sides suggest potential challenges in using implants designed for one side on the other. This study underscores the necessity of population-specific data in orthopaedics, as femur measurements differ even among Asian populations. Further research and statistical analysis are essential for tailoring orthopaedic solutions to individual populations. The findings also suggest a potential need for locally manufactured prosthetics to better suit the Sri Lankan population.

KEY WORDS: Femur; Femur head; Femur neck.

INTRODUCTION

The longest bone in the human body is the femur, also known as the thigh bone. It is primarily composed of a long shaft that extends proximally to connect with the neck and medially to form a rounded head, which articulates with the acetabulum. At the point where the greater and lesser trochanters meet, the shaft extends distally. Towards the lower end of the shaft, there are two large condyles. When a person is in a standing position, the shaft descends in a downward and medial direction. In adult males, the neck of the femur forms an angle of approximately 125º with the shaft (Sinnatamby, 2011).This angle is known by many names, including neck-shaft angle (NSA), caput-collum diaphyseal angle (CDA), diaphyseal-femoral neck angle, angle of inclination and , cervico diaphyseal angle and collum diaphyseal angle (Sharma *et al*., 2018).

Hip joint dislocation and fractures of the femur's neck are frequently encountered cases in clinical practice. Understanding the various dimensions of the femur's head and neck is crucial in the field of orthopaedic surgery and radiology. These measurements play a pivotal role in identifying bone abnormalities and estimating a person's age (Chowdhury *et al*., 2012). Additionally, the morphological characteristics of the proximal femur hold significant importance when it comes to designing and crafting implants for total hip replacement procedures (Jiang *et al*., 2007). Ensuring a precise geometric match between the femoral component and the underlying bone is indispensable for achieving a robust and long-lasting fixation (Umer *et al*., 2010).

Hence, acquiring a comprehensive understanding of

Department of Anatomy, Faculty of Medical Sciences, University of Sri Jayawardenapura, Gangodawila, Sri Lanka.

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the proximal femur's anatomy and its critical measurements becomes imperative. Nevertheless, the current press-fit femoral stems often fail to achieve an optimal fit within the bone's inner surface, particularly in Asian populations. This disparity arises because previous studies primarily centred on the Caucasian demographic (Umer *et al*., 2010). While some studies have investigated proximal femur morphometry in Asian populations such as Indian, Chinese, and Nepalese, there is still a notable gap in research concerning the Sri Lankan population. This study was undertaken to address this gap and to establish a basis for comparing the obtained measurements with those from other Asian countries.

MATERIAL AND METHOD

This study involved the examination of 45 adult human femurs, comprising both right (26) and left (19) limbs, of unknown sex. These femurs were obtained following ethical review from the Ethics review Committee of the Faculty of Medical Sciences, University of Sri Jayawardenapura. The data collection took place at the Department of Anatomy, Faculty of Medical Sciences, University of Sri Jayewardenepura, Sri Lanka, during the period of 2013-2014. Any femur displaying fractures or pathological abnormalities, such as tumours, deformities, or trauma, was excluded from the study. Precise measurements of the proximal femoral geometry were taken using a graded digital vernier calliper, with measurements recorded in millimetres up to two decimal points for accuracy.

Fig. 1. Measuring the maximum femoral length.

Fig. 2. Measuring the vertical diameter of the femoral head.

The femoral parameters were measured as follows:

Maximum femoral length. The distance between the highest point of femur head to the lowest point of the medial condyle was measured using an osteometric board (Fig. 1).

Vertical diameter of femoral head. The Vernier calliper was utilized to measure the vertical diameter of the femoral head (Fig. 2). This measurement was taken perpendicular to the long axis of the femoral neck, representing the straight distance from the highest point to the lowest point of the femoral head within a vertical plane.

Transverse diameter of femoral head. The Vernier calliper was employed perpendicular to the long axis of the femoral neck to measure the horizontal diameter of the femoral head. This measurement represents the maximum distance across the femoral head within the horizontal plane. Subjective variation was avoided by measuring each parameter three times and the mean of the readings obtained were recorded.

Axis of the neck. The axis of the neck was assessed by a coloured string dividing the anterior surface of the neck into two equal parts. In the mid-sagittal plane overlying the anterior surface, the axis of the shaft was determined using the same-coloured string. The angle was measured using a goniometer.

The length of the neck. Measured along the long axis of the neck, anteriorly and posteriorly using the vernier callipers. Anteriorly it was measured in between the base of the head and the midpoint of the intertrochanteric line (Fig. 3). Whereas posteriorly the length was determined, between the base of the head and midpoint of intertrochanteric crest. Further, the width of the neck of the femur was calculated using the vernier callipers at the narrowest part of the neck. The results obtained was computerised and statistically analysed with SPSS 15.0.

Fig. 3. Measuring the anterior neck length.

RESULTS

Out of the 40 adult femurs, 22 were right sided and 18 were left sided. The mean length of the right ones was 42.8 (SD±2.64) while that of the left ones was 43.53 (SD±3.27) (Table I). The mean length of the left femur bones was slightly greater than the right. **(Tables I and II)**

In our study the mean NSA values obtained for left and right were, 125.78(SD±4.45) and 127.59(SD±2.06) respectively (Table II). When considering another important diameter, the vertical diameter of the femoral head, the result of ours was 4.09(SD±0.30) on the right and 4.12(SD±0.31) on the left. The mean anterior neck lengths of the right and left were 2.61(SD±0.54) and 2.71(SD±0.50) respectively.

Table I. Statistical measurements of femoral dimensions.

	Right					Left				
	Frequency	Mean	SD	Mini	Max	Frequency	Mean	SD	Mini	Max
ML	22	42.80	2.64	37.20	48.50	18	43.53	3.27	37.20	48.70
TDS	22	2.51	0.25	2.22	3.25	18	2.55	0.27	2.13	3.11

Table II. Statistical measurements of dimensions of the femoral head.

	Right					Left				
	Frequency	Mean	SD	Mini	Max	Frequency	Mean	SD	Mini	Max
VDN	22	2.91	0.29	2.42	3.46	18	2.83	0.26	2.36	3.45
VDH	22	4.09	0.30	3.57	4.55	18	4.12	0.31	3.57	4.65
ANL	22	2.61	0.54	1.80	3.60	18	2.71	0.50	1.80	4.00
PNL	22	3.97	0.38	3.40	4.80	18	3.94	0.45	3.10	4.60
NSA	22	127.59	2.06	123	131	18	125.78	4.45	114	132

ML-maximum femoral length. TDS- Transverse diameter of femoral shaft. VDN- vertical minimum diameter of the femoral neck. VDH- Vertical diameter of the femoral head. ANL- Anterior Neck Length. PNL- Posterior Neck Length. NSA- Neck Shaft Angle

DISCUSSION

Our retrospective study, utilizing 40 adult human femurs from anatomical archives, primarily aimed to determine proximal femur morphometry values in the Sri Lankan population for comparison with existing data. The slight variance in mean femur length between the right and left sides underscores the potential mismatch between implants designed for one side and their suitability for the other.

In a Hong Kong study, males had a mean femoral length of 45.1 cm, and females had 43.7 cm (Hoaglund & Low, 1980), both exceeding Sri Lankan values(Right-42.8(SD±2.64), Left-43.53(SD±3.27)). Conversely, a study in Nepal reported a lower mean length of 42.0 ± 2.81 cm, indicating regional variations in body proportions (Mukhia *et al*., 2019).

The Nepalese study found angles of 122º±7.71 and 131.3º±5.17 for right and left femurs (Mukhia *et al*., 2019), while a Pakistani study recorded 130.3º±6.1 (Umer *et al*., 2010). These figures differed from our study (Right-125.78(SD±4.45), Left-127.59(SD±2.06)) , even within the same Asian population, highlighting potential limb-specific differences.

The measurement of the diameter of the femoral head holds great importance in hip joint replacement procedures, a surgery frequently performed in healthcare facilities. (Kluess *et al*., 2007). In a Brazilian study, the mean femoral head diameter was 4.65 cm (de Sousa *et al*., 2010), significantly larger than our findings. Similarly, in Chinese research, it measured 4.54±3.21 cm (Lin *et al*., 2014), and in an Indian study, the right femoral head diameter was 4.26±3.25 cm, while the left was 4.23±3.69 cm (Verma *et al*., 2017). These variations in a critical measurement for prosthetic femoral head fitting raise questions about the appropriateness of imported prosthetics. These findings prompt discussions on the effectiveness of foreign prosthetics and the justification for locally manufactured prosthetics in Sri Lanka.

CONCLUSION

Based on the aforementioned observations, it can be concluded that while body proportions may exhibit similarities with neighbouring countries, femur measurements show distinct differences. Therefore, it is imperative to undertake additional studies and gather statistical data to optimize patient care and treatment outcomes.

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RESUMEN: El fémur, el hueso más largo del cuerpo, desempeña un papel fundamental en ortopedia y radiología. Comprender su anatomía, en particular el ángulo cuello-diáfisis (NSA), es vital para diagnosticar problemas óseos y diseñar implantes de cadera. Si bien se han estudiado las medidas del fémur de algunas poblaciones asiáticas, existe un vacío en la investigación sobre los habitantes de Sri Lanka. Este estudio tuvo como objetivo examinar la anatomía del fémur proximal en la población de Sri Lanka. Analizamos 45 fémures humanos adultos (26 derechos, 19 izquierdos) de sexo desconocido, obtenidos éticamente de la Universidad de Sri Jayewardenepura. Se excluyeron fémures con fracturas o patologías. Se registraron mediciones precisas utilizando calibradores vernier digitales, con precisión milimétrica. Los parámetros incluyeron la longitud femoral media, los diámetros vertical y transversal de la cabeza femoral, el eje del cuello y la longitud del cuello. Cada medición se tomó tres veces para minimizar la subjetividad. Los fémures derechos tuvieron una longitud media de 42,8 mm (DE ± 2,64), mientras que los fémures izquierdos midieron 43,53 mm (DE ± 3,27). La NSA media fue de 125,78º (DE±4,45) para el fémur izquierdo y de 127,59º (DE±2,06) para el derecho. Los diámetros medios de la cabeza femoral fueron 4,09 mm (DE ± 0,30) (derecha) y 4,12 mm (DE ± 0,31) (izquierda). Las longitudes medias del cuello anterior de la derecha y la izquierda fueron 2,61 (DE ± 0,54) y 2,71 (DE ± 0,50) respectivamente. La comparación de nuestros hallazgos con otras poblaciones asiáticas destacó variaciones significativas en las medidas del fémur. Estas discrepancias enfatizan la necesidad de datos específicos de la población para las intervenciones ortopédicas y plantean dudas sobre la idoneidad de las prótesis importadas. Las diferencias en la longitud del fémur, la longitud del cuello y la NSA entre lados sugieren posibles desafíos al utilizar implantes diseñados para un lado en el otro. Este estudio subraya la necesidad de datos específicos de la población en ortopedia, ya que las mediciones del fémur difieren incluso entre las poblaciones asiáticas. Es esencial realizar más investigaciones y análisis estadísticos para adaptar las soluciones ortopédicas a poblaciones individuales. Los hallazgos también sugieren una posible necesidad de prótesis fabricadas localmente para adaptarse mejor a la población de Sri Lanka.

PALABRAS CLAVE: Fémur; Cabeza de fémur; Cuello de fémur.

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Corresponding author
E.A.T Sajith Edirisinghe
Department of Anatomy
Faculty of Medical Sciences
University of Sri Jayawardenapura
Gangodawila
SRI LANKA

E-mail: edirisinghe@sjp.ac.lk