Morphometric study of dry proximal femur of the Nepalese population: Implications for arthroplasty

Ajay Shah,[1] Niraj Pandey,[1] Sunil Shrestha[2]

ABSTRACT

INTRODUCTION

The femur, a major weight-bearing bone that influences the mechanical strength, consists of the head, neck, and trochanters. Understanding femur morphometry is critical for orthopaedic surgeries and implant design, necessitating local data for populations such as Nepal to reduce complications during procedures such as arthroplasty. Therefore, the primary objective of this study was to understand the morphometric parameters of the dry proximal femur within a Nepalese population.

MATERIAL AND METHODS

The present observational descriptive study was conducted on 56 dry femurs, and the neck length, vertical diameter of the head, and depth of fovea capitis were measured via a digital vernier calliper, and the neck shaft angle was measured via tpsDig2 software. The study was conducted in Bhairahawa, Nepal, after the approval of the Institutional Review Committee.

RESULTS

The anthropometric measurements of the neck shaft angle, neck length, vertical diameter of the head, and foveal capitis depth was found to be 114.1±4.42°, 35.52±2.57 mm, 41.63±3.53 mm and 2.17±0.89 mm, respectively. A statistically significant difference was found in the neck length (p<0.04) and neck shaft angle (p<0.0001).

CONCLUSION

There was a significant difference between the neck length and neck shaft angle. All the remaining parameters except the right neck length were greater in the vertical diameter of the head, foveal capitis depth and neck shaft angle. Therefore, to reduce complications, it is important to understand the morphometric parameters of the proximal femur in the Nepalese population prior to arthroplasty.

KEYWORDS

Fovea capitis, Neck shaft angle, Proximal femur, Total hip arthroplasty

AUTHORS' AFFILIATIONS

1. Department of Anatomy, Universal College of Medical Science, Bhairahawa, Nepal.
2. Department of Anatomy, National Medical College, Birgunj, Nepal.

https://doi.org/10.3126/jucms.v14i02.99585

For Correspondence
Mr. Ajay Shah
Department of Anatomy
Universal College of Medical Sciences
Bhairahawa, Nepal
Email: sahajay928@gmail.com

INTRODUCTION

The femur is one of the largest bones of the body having maximum weight-bearing caused by its typical geometric shape providing strength and stability. Morphometric parameters, such as the femoral head width, are related to the mechanical strength of the proximal femur.[1,2] The femoral neck measures approximately 5 cm in length, being thinnest in the middle and wider towards the sides, forming an average inclination angle of 135 degrees with the femoral shaft, ranging from 125 to 140 degrees in adultsallowing the femoral shaft to move freely away from the pelvis during movement.[3–5] The morphometric analysis of the proximal femur is crucial in clinical and scientific fields for understanding of fracture patterns and treatment modalities.[3,5–8] Fovea capitis femoris (FCF) is a distinct shallow depression anatomical structure located on the posteroinferior aspect of the femoral headmainly responsible for mechanical stability and vascular support of the femoral head.[9] The morphometry of the head of the femur varies among individuals of different nationalities.[2]

By 2050, the number of hip fractures in Asia is projected to rise from 1,124,060 in 2018 to 2,563,488, as reported by the 9th Asian Federation of Osteoporosis Society.[10] The varying diameters of the head and neck of the femur are crucial in orthopaedic surgery for prosthesis, implant design and nail application.[11,12] Therefore, due to anatomical and lifestyle differences from western populations, it is important to design implants using local data of Nepalese population and to ensure that surgeons understand the specific femur morphometry to minimize surgery complications.[6,7,10]

Therefore, the primary objective of this study was to understand the morphometric parameters of the dry proximal femur within a Nepalese population and understand its implication during arthroplasty.

MATERIAL AND METHODS

The present study is an observational descriptive study carried out on 56 dry femurs (28 right and 28 left, adopting convenience sampling) among the adult Nepalese population at the Department of Anatomy, Universal College of Medical Sciences, Bhairahawa, Nepal. The research received ethical approval (UCMS/IRC/065/26), and data collection was conducted from April to June 2026. All the femurs exhibited complete and normal anatomical characteristics exhibiting no any pathological or mechanical deformities at the proximal end.A digital Vernier calliper and digital images captured by an iPhone 14 camera [Apple Inc., Cupertino, California, USA] was used for the anthropometric measurement of dataand the angles were calculated via tpsDig2 software version 2.31. All the observations were conducted by one researcher to eliminate interobserver error and are presented in Figure 1. The acquired data were input into an MS Excel spreadsheet, and descriptive statistics and an unpaired t-test, were carried out via GraphPad Prism version 10, along with the presentation of relevant bar diagrams. A significance level below 0.05 was considered significant.

Figure 1. Measurement of the proximal femur. A: Neck length; B: Vertical diameter of the head; C: Depth of the fovea capitis femoris; D: Neck shaft angle via tpsDig2 software

RESULTS

An anthropometric investigation of the proximal femur was performed by measuring four critical parameters: neck length, vertical diameter of the femoral head, depth of foveal capitis, and neck-shaft angle on both the right and left sides. A single observer independently documented the results in two phases, and the mean was calculated. The mean recorded values for each parameter of the right and left sides of the proximal femur are provided in table 1, table 2, and figure 2.

Tables 1 and 2 present the minimum and maximum values, ranges, means, standard deviations, standard errors of the means, and p values of the morphological characteristics examined for the femur and neck shaft angles, respectively. The data distribution was found to be normal and independent sample t-test was used to compare the quantitative variables of the proximal end of the right and left femur. table 3 and figure 3 present the average descriptive statistics of the femurs, including the minimum, maximum, range, mean, standard deviation, and standard error of the mean.

Table 1. Anthropometric measurements of the proximal femur.

Parameter of Femur [mm]	Number	Min	Max	Range	Mean	Std. Deviation	Std. Error of Mean	*p* value
RNL	28	32.6	39	6.4	36.2	1.48	0.28	0.04*
LNL	28	28	42.9	14.9	34.8	3.2	0.60	
RVDH	28	32.8	47.2	14.4	41.8	3.49	0.66	0.65
LVDH	28	34.6	47	12.4	41.44	3.63	0.68	
RFD	28	0.4	4.3	3.9	2.15	1.01	0.191	0.83
LFD	28	1	3.8	2.8	2.2	0.77	0.146	

RNL: right neck length; LNL: left neck length; RVDH: right vertical diameter of head; LVDH: left vertical diameter of head; RFD: right foveal depth; LFD: left foveal depth

Table 2. Anthropometric measurement of the neck shaft angle of the femur.

Neck shaft angle of Femur [NSA]	Number	Min	Max	Range	Mean	Std. Deviation of Mean	Std. Error	p value
RNSA [°]	28	104	116	12	112	3.44	0.64	<0.0001*
LNSA [°]	28	109	126	17	117	3.89	0.73	

RNSA: Right neck shaft angle; LNSA: Left neck shaft angle

Table 3. Mean anthropometric measurements of the right and left femurs.

Parameter of Femur	Number	Min	Max	Range	Mean	Std. Deviation	Std. Error of Mean
NSA [°]	56	104	126	22	114.07	4.42	0.59
NL [mm]	56	28	42.9	14.9	35.52	2.57	0.34
VDH [mm]	56	32.8	47.20	14.40	41.63	3.53	7.38
FD [mm]	56	0.40	4.3	3.9	2.18	0.89	0.11

NL: Neck length; VDH: Vertical diameter of the head; FD: Foveal capability depth; NSA: Neck shaft angle

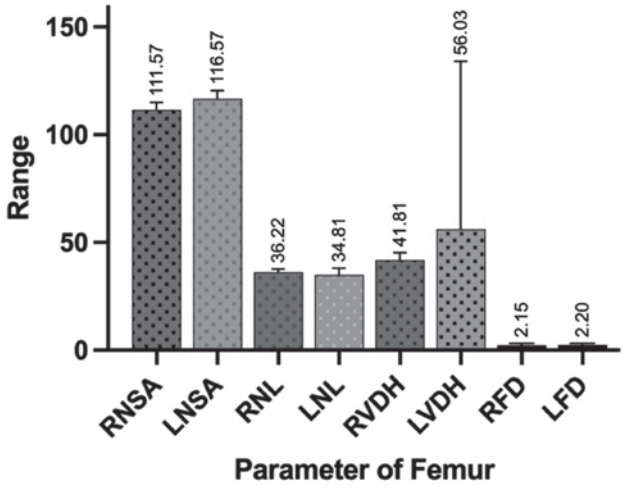

Figure 2. Mean anthropometric measurements of the right and left femurs

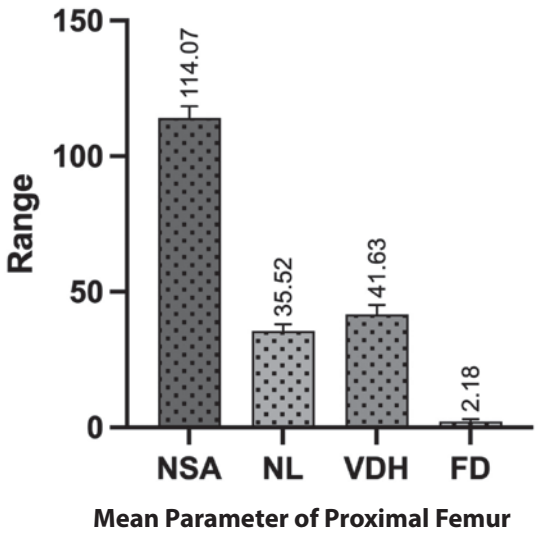

Figure 3. Mean anthropometric measurements of femurs

DISCUSSION

In the present study, 56 right and left dry proximal ends of the femur of the Nepalese population were studied, and the neck shaft angle (NSA) parameter was extensively studied by the scientific committee. In many studies, researchers have used goniometers, protectors and Xray's to measure the NSA, but our studies have used tpsDig2 software version 2.31 to measure the angle in photographs of 28 right and 28 left proximal femurs, as shown in Figure 1-D. The mean NSA was found to be 114.1±4.42°, and the right and left NSAs were 112±3.44° and 117±3.89°, respectively. The mean NSA was lower than that reported in the studies of George R et al.6 [2024,India, Dry bone, 124.11±6.37°], Kumar P et al.[13] [2024, India, Dry bone, 129.75±3.70o], Sharma V et al.[14] [2018, India, Dry bone, 126.98±2.5o], Adhikari RK et al.[15] [2017, Nepal, Dry Bone, 128.98±4.55°], and Adekoya-Cole et al.[16] [2016, Nigeria, X-ray, 130.77±6.03]. This variation may be due to racial differences and the use of tpsDig2 software.

The average neck length of the right and left femurs was studied with the help of a Vernier calliper and was found to be 35.52±2.57 mm. Compared with other studies, the average neck length was found to be greater than that reported by Adhikari RK et al.[15] [2017, Nepal, dry femur, 29.3±2.4 mm]; George R et al.[6] [2024, India, 101 dry bone, 21.75±3.81 to 32.03±5.58 mm]; and lower than that reported by Shanto RA et al.[2] [2022, Bangladesh, dry femur, 39.59±3.49 to 39.31±3.59]. The mean vertical diameter in the present study was 41.63±3.53 mm, which was approximately equal to that reported in the studies of Rashid S et al.[17] [2019, India, dry bone, 43.34±3.59 mm] and Kamdi A et al.[18] [2016, India, Cadaveric wet bone, range 42.32–45.42 mm range].

The depth of foveal capitis in the present study was 2.17±0.89 mm, which was lower than that reported in the studies of Yarar B et al.[8] [2020, 146 dry femurs, Turkey, 2.67±1.13], Roy T et al.[19] [2024, India, 297 dry femurs, 30.41.41 mm] and Golpinar Murat20 [2022, Turkey, 57 dry femurs, 2.71±1.09 mm]. Foveal capitis allows attachment to the ligamentum teres femoris and allows passage to blood vessels to supply the head. The depth of the fovea may vary because different vascular foramina are present at the attachment site of the ligamentum teres femoris. Foveal capitis and its morphometry also help in the positioning of the hip joint, with surgical and clinical implications.[19]

A study conducted by Contractor JB et al. on the proximal end of dry femurs in an Indian population revealed that significant variation is present at the proximal end, indicating that racial diversity should be considered during the selection of implants for THA.[21] According to Reddy et al., implant mismatch significantly increases the risk of intraoperative fractures and complications such as anterior thigh pain, improper load distribution, aseptic loosening and osteolysis. The existing implants are often designed for Western populations, which are relatively large and may misalign with other demographic racial groups. This highlights the necessity of creating implants tailored to the specific anthropometric and biomechanical data of different populations to reduce complications.[13,19]

Different studies from Nepal have also reported different anthropometric data for the proximal femur head, which differs from our study; therefore, it is important to consider the average anthropometric data of the related country so that the accurate size of the prosthesis received by the patients fits perfectly. Table 1 and Table 4 show the differences in the various parameters of the right and left proximal femurs and their comparisons with different parts of the world.

The major limitation of this study was that the bones selected were of unknown sex, as they were not documented in the records. Relying on the sex morphological features of the bone alone could not have resulted in a high degree of accuracy.

Table 4. Comparison of different morphological traits of the proximal femur between the current study and previous studies

Author, Year of study	Sample size	Country	RNSA [o]	LNSA [o]	RNL [mm]	LNL [mm]	RVDH [mm]	LVDH [mm]	RFD [mm]	LFD [mm]
Present study, Lumbini province, Nepal (2026)	56	Nepal	112±3.44	117±3.89	36.2±1.48	34.8±3.2	41.8±3.49	56±78.1	2.15±1.01	2.2±0.77
Machahari I et al[3] (2025)	50	Assam, India	129.22±5.22	129.17±5.71						
George R et al[6] (2024)	101	India	125.96±6.39	122.06±5.74	21.84±4.16	21.67±3.49	39.85±3.44	39.39±3.17		
Shanto RA et al[2] (2022)	150	Bangladesh					39.59±3.49	39.31±3.59		
Singh G et al[12] (2021)	100	North India	127.80+3.56	127.46+3.42						
Mukherjee B et al[5] (2021)	281	West Bengal, India	124.91±5.88	123.33±6.47						
Yarar B et al[8] (2020)	146	Turkey	134.46±6.48	129.87±6.47			46.43±3.24	45.72±3.35	2.70±1.14	2.66±1.14
Choudhary and Dhan[22] (2020)	82	Bihar, India	133.63±4.38	134.34±4.55						
Mukhia & Poudel[23] (2019)	75	Nepal	122.90±7.71	131.30±5.17						
Rashid S et al[17] (2019)	80	Jammu, India					43.51±3.48	43.16±3.74		
Kharbuja R et al[24] (2018)	102	Nepal			30.8±4.7	33.0±4.8				
Gullapalli and Inuganti[25] (2017)	110	Andhra Pradesh, India	119±17.15	123.00±10.80						
Adhikari Rk et al[15] (2017)	50	Nepal	129.84±5.22	128.12±3.66	30.6 ±1.9	28±2.1				
Shrestha et al[4] (2015)	100	Nepal	128.46±5.83	126.97±5.66						
Caetano et al[26] (2015)	87	Brazil	128.23±4.43	128.04±4.36						

CONCLUSION

The mean anthropometric measurements of the neck shaft angle, neck length, vertical diameter of the head, and foveal capitis depth was found to be 114.1±4.42 degrees, 35.52±2.57 mm, 41.63±3.53 mm and 2.17±0.89 mm, respectively. A statistically significant difference was found in the neck length and neck shaft angle.Therefore, it is important to consider the average anthropometric data of the proximal femur of related countries to ensure that the accurate size and reduces complications prior to total hip arthroplasty.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to staffs of Department of Anatomy for their valuable assistance during this research.

CONFLICT OF INTEREST

None

REFERENCES

1. Moosa SS, Khwaja M, Ahmed Hasham Shaikh S, Banu Siddiqui F, Rehan Hafiz Daimi S, Dadarao Hiware S, et al. Sexual dimorphic parameters of femur: a clinical

guide in orthopedics and forensic studies. J Med Life. 2021 Dec;14(6):762–8.

2. Shanto RA, Mannan S, Sumi SA, Russel TH. Morphometric Study of Fully Ossified Femoral Head Diameters in Bangladeshi Population. J Enam Med Coll. 2025 Apr 8;12(3).

3. Machahari I, Mitra S, Deka H, Das B, Das A. A Morphometric Study of the Femoral Angle of Anteversion and Neck Shaft Angle in Dry Bone Specimen. Int J Acad Med Pharm. 2025;7(6):598–602.

4. Shrestha A, Ranjit N, Shrestha R. Neck Shaft Angle of Non-articulated Femur Bones among Adults in Nepal. Med J Shree Birendra Hosp. 2016 May 13;14(2):1–4.

5. Mukherjee B, Sadhu A, Majumdar S. Evaluation of Neck–Shaft Angle of Dry Femora in the Gangetic Region of West Bengal. Natl J Clin Anat. 2021 Jul;10(3):148–54.

6. Resmi George, Nithin K Raju. Morphometry of proximal femur in South Indian Population. Asian J Med Sci. 2024 Mar 1;15(3):80–7.

7. Khanal L. Estimation of Total Length of Femur from its Proximal and Distal Segmental Measurements of Disarticulated Femur Bones of Nepalese Population using Regression Equation Method. J Clin Diagn Res. 2017;11(3):HC01–5.

8. Yarar B, Malas MA, Çizmeci G. The morphometry, localization, and shape types of the fovea capitis femoris, and their relationship with the femoral head parameters. Surg Radiol Anat. 2020 Oct;42(10):1243–54.

9. Gören H, Tuncel Çini N, Aydar Y. Evaluation of the Effects of Fovea Capitis Femoris Localization and Morphometry on the Femoral Head. Harran Üniversitesi Tıp Fakültesi Derg. 2025 Jun 27;22(2):344–50.

10. Pokharel B, Pant AR, Chaudhary P, Khanal GP. Morphometric Parameters of the Proximal Femur in Nepalese Population: A Cross-sectional Study. J BP Koirala Inst Health Sci. 2020 Dec 31;3(2):8–12.

11. Chowdhury MS, Naushaba H, Chowdhury AMM, Khan LF, Ara JG. Morphometric study of fully ossified head and neck diameter of the human left femur. J Dhaka Natl Med Coll Hosp. 2013 Aug 1;18(2):9–13.

12. Singh G, Dhindsa GS. Morphometry of Neck-Shaft Angle in Dried Adult Human Femora of North Indian Population. Asian J Pharm Clin Res. 2021 Sep 6;14(9) :136–8.

13. Kumar R, Kumar N, Kumar S, Kumar B, Sinha RR, Kumar A. Morphometric Study of Proximal Femur and Its Implications in Total Hip Arthroplasty. Eur J Cardiovasc Med EJCM. 2025;15(5):49–54.

14. Sharma V, Kumar K, Kalia V, Soni P. Evaluation of femoral neck-shaft angle in subHimalayan population of North West India using digital radiography and dry bone measurements. J Sci Soc. 2018;45(1):3.

15. Adhikari RK, Yadav B, Yadav SK, Singh AC. Comparative Study of Angle of Inclination and Neck Length of Dry Femur. J Nobel Med Coll. 2017 Aug 22;6(1):44–7.

16. Adekoya-Cole T, Akinmokun O, Soyebi K, Oguche O. Femoral neck shaft angles: A radiological anthropometry study. Niger Postgrad Med J. 2016;23(1):17.

17. Rashid S. Anatomical Study of Femoral Head Dimensions. Int J Adv Res. 2019 Aug 31;7(8):750–3.

18. Kamdi DA, R. Sherke DA, Krishnaiah DM, Chaitanya MK. Morphometric Parameters and Sex Determination of Clavicle In Telangana Region. IOSR J Dent Med Sci. 2014;13(10):01–5.

19. Roy T, Basu R, Das B, Mandal I, Langstastang A. Morphological and Morphometric Variations of Fovea Capitis Femoris: A Cross-sectional Study from Kolkata, West Bengal, India. Int J Anat Radiol Surg. 2024;13(5):AO14–8.

20. Gölpinar M. Morphometric and Morphological Evaluation of the Fovea Capitis Femoris. Med Rec. 2022 Sep 22;4(3):400–4.

21. B Contractor J, Umraniya B, Singh P. Morphometric analysis of proximal femur in Indian population and its implications in Total Hip Arthroplasty. Indian J Clin Anat Physiol. 2024 May 6;11(1):27–31.

22. Choudhary KK. Neck Shaft Angle of Femur and Its Clinical Implications. J Med Sci Clin Res. 2020 Jan 31;08(01).

23. Mukhia R, Mansur DI, Wahekar K. The Upper end of Tibia of Nepalese adults: A Morphometric study. J Health Allied Sci. 2020 Oct 16;10(2):78–81.

24. Kharbuja R, Adhikari RM, Shrestha A. Bicondylar Angle and its Relation with Length and Neck Length of Human Femur. J Lumbini Med Coll. 2018 May 24;6(1):17–20.

25. Gullapalli A, Inuganti AK. Morphometric Study of Femoral Neck Shaft Angle and Its Clinical Significance. Int J Anat Res. 2017 Aug 31;5(3.2):4261–4.

26. Caetano EB, Serafim AG, Padoveze EH. Study of the Collo-diaphyseal Angle of the Femur of Corpses in the Anatomy Department of the PUC-SP Medical School. Int J Morphol. 2007 Jun;25(2):285–8.