

## Study of Distal Femoral Anthropometry in the Population of Eastern Madhya Pradesh, India

Harsh Kumar Chawre<sup>1</sup>, Rajendra Singrolay<sup>2</sup>, Akhilesh Trivedi<sup>3</sup>, Furquan Alam<sup>4\*</sup>

<sup>1</sup>Assistant Professor, Department of Anatomy, Atal Bihari Vajpayee Medical College, Vidisha, Madhya Pradesh, India

<sup>2</sup>Associate Professor, Department of Anatomy, Government Medical College Ratlam, Madhya Pradesh, India

<sup>3</sup>Associate Professor, Department of Anatomy, Gajra Raja Medical College, Gwalior, Madhya Pradesh, India

<sup>4</sup>Assistant Professor, Department of Biochemistry, Government Medical College, Ratlam Madhya Pradesh, India

Received: 24-09-2021 / Revised: 03-10-2021 / Accepted: 25-12-2021

### Abstract

**Introduction:** The anatomy of the distal femur has important implications in total knee replacement, which aims to restore the morphology of the distal femur to as near normal as possible. **Material & Methods:** A total of One hundred ten (110) dry femurs of human Indian cadavers without any pathology, obtained from the Department of Anatomy, were utilised for this study. Medial and lateral condylars, anterior – posterior diameters, vertical diameters, transverse diameters, bicondylar width and Inter-condylar notch (width, height and depth) were measured. **Results:** The average Lateral condylar anteroposterior diameter (LCAPD) for the entire sample was 56.0 mm, average Medial condylar anteroposterior diameter (MCAPD) was 55.17mm, average Bicondylar width (BCW) was 68.01 mm, average Intercondylar notch width (IC\_ Wd) was 18.47mm and average Bicondylar angle (BCA) was 14.4°. **Conclusion:** The results of this study indicate that marked differences do exist in the dimensions between the femur of the Indian population and that of the populations of other regions of the world. For Indian population best fit prosthesis can be made with the help of the published data of distal femur.

**Keywords:** Lateral Condylar Anteroposterior Diameter (LCAPD), Medial Condylar Anteroposterior Diameter (MCAPD), Bicondylar Width (BCW), Intercondylar Notch Width (IC\_ Wd), Bicondylar Angle (BCA).

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

### Introduction

The lower end of the femur has lateral and medial condyles, separated posteriorly by the intercondylar notch. The anterior surfaces of the condyles are joined by an articular surface for the patella. The two condyles take part in the formation of the knee joint[1-3].

The anatomy of the distal femur has important implications in total knee replacement, which aims to restore the morphology of the distal femur to as near normal as possible[4]. The mismatch of femoral components, especially in the mediolateral dimension of female patients, was one of the main reasons for the need to design specific implants in order to reduce component overhang in female patients[5]. The main knee implants available in the market were based on anatomical studies performed in White individuals. In addition, the implants come in a limited number of sizes and require adaptations to their shape and kinematics[6].

It is well known that the Asian population has a smaller distal femoral and proximal tibia size than that of its Western counterpart[7-9]. Due to the comparatively smaller built and stature of the Asian population, many surgeons believe that imported implants, which are mainly designed from the morphometrics gained from the Western

population, may not be suitable for patients located in Asian countries[10].

The aim of the current study was therefore to determine the anthropometric measures of the distal femur amongst the population of Eastern Madhya Pradesh, using dried femurs.

The measurements obtained from this study will help in designing of implants and artificial joint components that will help in manufacturing prosthesis with ethnic specifications[6-11].

### Materials & methods

The measurement of different parameters pertaining to the study was carried out on 110 (50 right and 60 left) randomly selected, intact, dry, completely ossified femurs from subjects of unknown age, stature and sex from the Department of Anatomy, Atal Bihari Vajpayee Government Medical College, Vidisha, Madhya Pradesh, India.

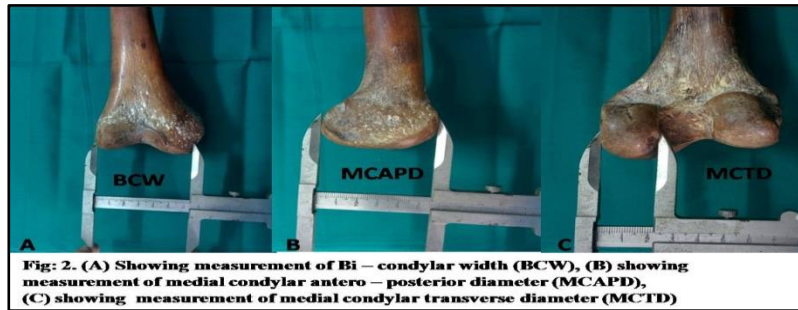
Only femora from skeletally mature individuals were used in this study. Age and sex of the source cadaver were not available. Femora that looked grossly deformed, those with previous fracture and post-mortem damage were excluded from this study. The following distances were then measured on the distal femur by use of Martins sliding Vernier callipers: the Medio-Lateral (M-L) width of the femoral condyles (Fig: 2A), widest Antero – Posterior (A-P) diameter of the medial and lateral femoral condyles (Fig 2B & 2C) and the width of the intercondylar notch as shown in (Fig: 3). The results obtained were then compared with results from other studied populations and the sizes of the femoral components of some widely used total knee replacement implants. The dimensions of the implants were obtained from the respective product monographs[4].

\*Correspondence

**Dr. Furquan Alam**

Assistant Professor, Department of Biochemistry, Government Medical College, Ratlam Madhya Pradesh, India.

E-mail: [falam\\_18@rediffmail.com](mailto:falam_18@rediffmail.com)



**Results**

The following parameters of the femur were measured for understanding the anthropometry and eventually designing a best fit femoral implant for total knee arthroplasty in Asian population.

- Lateral condylar anteroposterior diameter (LCAPD).
- Lateral condylar transverse diameter (LCTD).
- Lateral condylar vertical diameter (LCVD).
- Medial condylar anteroposterior diameter (MCAPD).
- Medial condylar transverse diameter (MCTD).
- Medial condylar vertical diameter (MCVD).
- Bicondylar width (BCW).
- Intercondylar notch height (IC\_ Ht).
- Intercondylar notch width (IC\_ Wd)

- Intercondylar notch depth (IC\_De).
- Bicondylar angle (BCA).

The average of all parameters for all samples was calculated separately. It was found to be 56.0 mm for Lateral condylar anteroposterior diameter (LCAPD), 25.25 mm for Lateral condylar transverse diameter (LCTD), 31.6 mm for Lateral condylar vertical diameter (LCVD), 55.17 mm for Medial condylar anteroposterior diameter (MCAPD), 23.61 mm for Medial condylar transverse diameter (MCTD), 30.56 mm for Medial condylar vertical diameter (MCVD), 68.01 mm for Bicondylar width (BCW), 24.3 mm Intercondylar notch height (IC\_ Ht), 18.47 mm for Intercondylar notch width (IC\_ Wd), 16.81mm for Intercondylar notch depth (IC\_De) and 14.4° for Bicondylar angle (BCA).

**Table 1: Summary of measured Parameters of both sides**

S. No.	Parameters	Side	Average		Range
1.	Lateral condylar anteroposterior diameter (LCAPD) (in mm)	Right	56.0	56.00	47 – 60
		Left	56.0		48 – 61
2.	Lateral condylar transverse diameter (LCTD) (in mm)	Right	27.0	25.25	21 – 36
		Left	23.5		21 – 30
3.	Lateral condylar vertical diameter (LCVD) (in mm)	Right	32.5	31.6	22 – 37
		Left	30.7		28 – 34
4.	Medial condylar anteroposterior diameter (MCAPD) (in mm)	Right	54.3	55.17	47 – 60
		Left	56.05		45 – 62
5.	Medial condylar transverse diameter (MCTD) (in mm)	Right	25.05	23.61	21 – 30
		Left	22.17		17 – 25
6.	Medial condylar vertical diameter (MCVD) (in mm)	Right	30.35	30.56	21 – 35
		Left	30.76		26 – 34

7.	Bicondylar width (BCW) (in mm)	Right	69.8	68.01	60 - 78
		Left	66.23		57 - 74
8.	Intercondylar notch height (IC_Ht) (in mm)	Right	23.1	24.3	19 - 26
		Left	25.5		21 - 26
9.	Intercondylar notch width (IC_Wd) (in mm)	Right	17.94	18.47	12 - 23
		Left	19.0		13 - 24
10.	Intercondylar notch depth (IC_De) (in mm)	Right	17.1	16.81	11 - 21
		Left	16.52		13 - 20
11.	Bicondylar angle (BCA) (in degree)	Right	14.3 <sup>o</sup>	14.4 <sup>o</sup>	10 <sup>o</sup> - 26 <sup>o</sup>
		Left	14.6 <sup>o</sup>		12 <sup>o</sup> - 17 <sup>o</sup>

### Discussion

The present study was undertaken to compare the differences in dimensions between femurs of Eastern Madhya Pradesh population and those of population from other regions, in order to solve the problem of a possible geometric mismatch between a selected implant and the dimensions of the hip joint of the study population concerned. In the present study, different morphometric parameters were recorded from dried bones. Most of the previous anatomical and

morphometric studies were conducted with indirect methods including radiography, computerized tomography, magnetic resonance imaging, and 3D modelling (Thienpont E et al. 2015[5]; Loures FB et al. 2016[6]; Hussain F et al. 2013[10]; Fan L et al. 2017[12]). Given the fact that cadaveric material is scarce, these methods offer the advantage of describing anatomy in large samples, since they can be performed in living subjects. However, the indirect methods have been found to be inaccurate.

**Table 2: Comparison of Parameters measurements from different studies**

Sr. No.	Parameters (in mm.)	Side	Present study	Biswas A et al. 2017[11]	Lakati KC et al. 2017[4]	Terzidis et al. 2012[13]
1.	LCAPD	Right	56.0	56.20	61.36	58.5
		Left	56.0	56.05	61.08	
2.	LCTD	Right	27.0	27.80	-	-
		Left	23.5	28.03	-	-
3.	LCVD	Right	32.5	32.51	-	-
		Left	30.7	33.05	-	-
4.	MCAPD	Right	54.30	52.97	57.98	58.7
		Left	56.05	54.74	58.05	
5.	MCTD	Right	25.05	25.48	-	-
		Left	22.17	27.28	-	-
6.	MCVD	Right	30.35	34.00	-	-
		Left	30.76	32.48	-	-
7.	BCW	Right	69.8	71.71	68.39	83.9
		Left	66.23	70.71	68.49	
8.	IC_Ht	Right	23.1	23.74	-	-
		Left	25.5	23.40	-	-
9.	IC_Wd	Right	17.94	20.86	23.00	20.5
		Left	19.0	19.43	23.06	
10.	IC_De	Right	17.1	20.86	-	25.9
		Left	16.52	21.26	-	

#### Lateral Condylar Anteroposterior Diameter (LCAPD)

Biswas A *et al.* 2017[11], worked on 70 dry femora and found the average LCAPD to be 56.20 mm of right side and 56.05 mm of left side. Lakati KC *et al.* 2017[4], had reported the average LCAPD in Kenyan population as 61.36mm and 61.08 mm of right and left side respectively. Terzidis *et al.* 2012[13], in their study on femoral condyles to determine gender wise differences have reported mean LCAPD were 58.5 mm. The average value in the present study is found to be 56.0 mm for both right and left side. Our results are similar to that found in the study of Biswas A *et al.* 2017[11] and Terzidis *et al.* 2012[13] while differ from Lakati KC *et al.* 2017[4].

#### Medial Condylar Anteroposterior Diameter (MCAPD)

It is another important parameter which is considered during prosthesis manufacture. In the present study, average value of MCAPD is found to be 54.30 mm of right side and 56.05 mm of left side. It is more when compared with the observations of Biswas A *et al.* 2017[11] (right side; 52.97 mm and left side; 54.74 mm), and less as compared to that of Lakati KC *et al.* 2017[4] (right side; 57.98mm and left side; 58.05). Terzidis *et al.* 2012[13], found the mean value of MCAPD 58.7 mm. So, here our study was not concurrent with previous studies considered.

#### Bicondylar Width (BCW)

In the present study, it is 69.8 mm and 66.23 mm of right and left side respectively, which is comparable with the values that was found in the study of Lakati KC *et al.* 2017[4] (right; 68.39 mm and left;

68.49) and is lesser as compared with that of Biswas A *et al.* 2017[11] (right; 71.71 mm and left; 70.71 mm). Terzidis *et al.* 2012[13] had observed it collectively as 83.9 mm.

#### Intercondylar Notch Width (IC Wd)

It is also essential to improve function and longevity of knee arthroplasty. In our study, we found average IC\_Wd as 17.94 mm and 19.0 mm of right and left side respectively. Biswas A *et al.* 2017[11] in their study showed that the average IC\_Wd was around 20.86 mm and 19.43 mm of right and left side respectively in West Bengal region. Lakati KC *et al.* 2017[4] who worked on distal femoral anthropometry in Kenyan population, recorded IC\_Wd as 23.00 mm and 23.06 mm of right and left side respectively. Terzidis *et al.* 2012[13], reported the mean value of IC\_Wd as 20.5 mm in Greek population.

#### Conclusion

The result of our current study indicates that marked differences do exist in the dimensions between the femur of the Indian population and that of the populations of other regions of the world. For Indian population best fit prosthesis can be made with the help of the published data of distal femur. These prostheses can also be used by other Asian countries as morphologically they are similar to Indian population. The results of the present study could be used as a guide

---

for future designs of the femoral prosthesis in Central Indian Population.

#### References

1. Pelvic Girdle, Gluteal region & Thigh, Standrings S, Borley NR, Collins P, eds. In: Gray's Anatomy 40th ed. Edinburgh: Churchill Living stone Elsevier; 2008: 1360 – 65.
2. The Lower Limb, Richard S. Snell, eds. In: Clinical Anatomy by Regions. 9th ed. Lippincott Williams & Wilkins; 2012: 439 – 444.
3. Lower limb, Chummy S. Sinnatamby, eds. In: Lasts Anatomy Regions And Applied 10th ed: Churchill Living stone Elsevier; 2011: 169 – 71.
4. K.C. Lakati, B.M. Ndeleva, C.K. Kibet, et. al. Anthropometry of The Distal Femur In A Kenyan Population And Its Correlation With Total Knee Replacement Implants, East African Orthopaedic Journal. 2017; 11: 67 – 72.
5. Emmanuel Thienpont, Roland Becker. Anthropometric measurements of the knee: time to make it fit. Knee Surg. Sports Traumatol Arthrosc. 2014; 22: 2889–90.
6. Fabrício Bolpato Louresa, Rogério Franco de Araújo Góesa, Idemar Monteiro da Palma, et. al. Anthropometric Study of The Knee And Its Correlation With The Size of Three Implants Available For Arthroplasty, Rev Bras Ortop. 2016;5 1(3): 282–89.
7. B. Yue, K. M. Varadarajan, S. Ai, et. al. Differences of knee anthropometry between Chinese and whitemen and women, The Journal of Arthroplasty. 2011; 26 (1):124–130.
8. F. B.Cheng, X. F. Ji, Y. Lai et al., Three dimensional morphometry of the knee to design the total knee arthroplasty for Chinese population, Knee. 2009; 16 (5): 341–347.
9. S. V. Vaidya, C. S. Ranawat, A. Aroojis, et. al. Anthropometric measurements to design total knee prostheses for the Indian population, The Journal of Arthroplasty.2000; 1(1): 79–85.
10. Fitdriyah Hussain, Mohammed Rafiq Abdul Kadir, Ahmad Hafiz Zulkifly, et.al. Anthropometric Measurements of The Human Distal Femur:A Study of The Adult Malay Population, Biomed Research International. 2013; 1: 01 – 05.
11. Ananya Biswas, Santanu Bhattacharya, A Morphometric and Radiological Study of The Distal End of Femur In West Bengal Population. Italian Journal of Anatomy and Embryology. 2017; 122 (1): 39-48.
12. Lin Fan, Tianyang Xu, Xifan Li, et. al. Morphologic Features of The Distal Femur and Tibia Plateau In Southeastern Chinese Population A Cross-Sectional Study, Medicine.2017; 96 (46): 01 – 05.
13. Ioannis Terzidis, Trifon Totlis, Efthymia Papathanasiou, Aristotelis Sideridis, et. al. Gender and Side-To-Side Differences of Femoral Condyles Morphology: Osteometric Data From 360 Caucasian Dried Femori, Anatomy Research International. 2012; 01: 01 – 07.

**Conflict of Interest: Nil Source of support: Nil**