A study of obliquity of femoral shaft in Eastern Indian population

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ABSTRACT

In the erect posture, femur is not absolute vertical, being separated above from its fellow by a considerable interval, which corresponds to the breadth of the pelvis, and inclines gradually medially and downward, so as to approach its fellow, for the purpose of bringing the knee joints near the line of gravity of the body. In the present study obliquity of femoral shaft measured in 127 dry femora. Mean obliquity of femoral shaft for 62 left sided femora found 8.431º with standard deviation of 2.361º whereas for 65 right sided femora were found to be 7.708º with standard deviation of 2.425º. When total 127 femora considered, mean bicondylar angle of 8.061 ± 2.412º was obtained. Though statistically insignificant, mean bicondylar angle determined on left side was higher than that on the right side.

Keywords: Femur, femoral obliquity, bicondylar angle, condylo-diaphysial angle, bipedalism.

INTRODUCTION

Femur is the beautifully shaped longest and strongest bone in the skeleton that occupies approximately a quarter of the human stature. The femur transmits weight from the ileum to the upper end of the tibia. Support of the weight of the body on vertically opposed ends of the two largest bones in human body is obviously an unstable arrangement.

Although, throughout the primate series, femur shows less divergence from the basic mammalian pattern than do some other bones, it experienced specific adaptations and morphological changes as a consequence of its central role in bipedal posture and locomotion. Body weight load started to be borne by the femur contributing these changes.[1,2]

In the erect posture, femur is not absolute vertical, being separated above from its fellow by a considerable interval, which corresponds to the breadth of the pelvis, and inclines gradually downward and medial ward, so as to approach its fellow, for the purpose of bringing the knee joints near the line of gravity of the body.[3] It is assumed that the plane of the femoral condyles i.e. the bicondylar plane in normal locomotion will be horizontal to the ground.[4] But one striking character of the lower end of femur is the relative lengths of the medial and lateral condyles.[5] These being unequal, causes an inclination of the shaft from the vertical. Resultant angle formed by the long axis of the femur with the vertical to the bicondylar plane is termed as the bicondylar angle or the angle of obliquity of shaft of femur or condylo-diaphysial angle. This obliquity of femoral shaft is one of the significant changes that occurred due to bipedalism.[6]

Femoral bicondylar angle proves to be an epigenetic functional feature, which develops during early childhood growth. In the human newborn, the femoral diaphysis is vertical. The bicondylar angle starts at 0° at birth and then increases progressively with growth to reach adult values. As the child starts walking, the femoral obliquity angle develops between 1 and 7 years of age, and this obliquity does not develop in non-walking children.[7-9]

AIMS AND OBJECTIVES

1. To study the angle of femoral obliquity from the available dry femora in the Medical Colleges of Kolkata.
2. To generate anthropometric data for designing knee prosthesis.
3. To compare the generated data with the previous workers in the field.

MATERIAL AND METHODS

Total 127 dry femora irrespective of age and undetermined sex available in the department of Anatomy of the five Government Medical Colleges of Kolkata were taken for the study. Those broken and / or deformed were discarded. The bones with complete morphological features were studied.

For measuring bi-condylar angle the following method were adopted. Each femur was placed with posterior surface of femoral condyles and greater trochanter touching on a white sheet of paper fixed on an osteometric board. Distal surface of the femoral condyles were kept such a way so that both the condyles touch

Table-1: Frequency distribution of bicondylar angle in left sided femora. n = 62

Bicondylar angle (º)	Frequency in numbers	(%) of total
3.00 - 5.99	9	14.52%
6.00 - 8.99	27	43.55%
9.00 -11.99	21	33.87%
≥ 12.00	5	8.06%
Total	62	100.00%

Table-2: Frequency distribution of bicondylar angle in right sided femora. n = 65

Bicondylar angle (º)	Frequency in numbers	(%) of total
3.00 - 5.99	17	26.15%
6.00 - 8.99	24	36.92%
9.00 -11.99	21	32.31%
≥ 12.00	3	4.62%
Total	65	100.00%

one of the vertical plates of the osteometric board (Fig.1). Plane of vertical plate of the osteometric board represented transverse axis of the knee joint, was drawn as a horizontal line (XY) on the white sheet of paper placed on the osteometric board (Fig. 2).

Using Martin's Sliding Caliper transverse diameter of the shaft at two places, that is first at the junction of upper ¾ and lower ¼ (A) of the standard maximum length of the femur and then the second transverse diameter was taken just below the lesser trochenter (B). By joining mid-point of these two shaft diameters (A and B) and extending it up to the horizontal plane of transverse axis of knee joint (XY), long axis of shaft of the femur (CE) was obtained. A perpendicular (CD) was drawn from the point of intersection (C) of the long axis of the shaft on the transverse axis (XY) of the knee (Fig. 2). The angle formed by the long axis of the shaft and the vertical drawn on transverse plane (<ECD) represents the bicondylar angle or angle of obliquity, which is also known as condylo-diaphysial angle. The bicondylar angle thus obtained, measured using protractor and recorded for computation. This procedure was repeated for each of the study samples.[10]

RESULTS

Out of 127 femur used for the study 62 were of left side and 65 were of right side. From the frequency distribution table for the left sided femora it was observed that bicondylar angle of 27(43.55%) fell between 6.00º and 8.99º. Bicondylar angle of 21(33.87%) left sided femora measured in the range of 9.00º to 11.99º. Thus out of 62 left sided femora 48 (77%) were between 6.00º and 11.99º (Table-1).

Bicondylar angle of 24(36.92%) femora on the right side fell between 6.00º and 8.99º. Bicondylar angle of 21(32.31%) right sided femora measured in the range of 9.00º to 11.99º. Of the 65 right sided femora 45(69%) turned out to be in the range of 6.00º–11.99º (Table-2).

Mean bicondylar angle for left sided femora was 8.431º with standard deviation of 2.361º. Similarly, mean bicondylar angle for right sided femora was found to be 7.708º with standard deviation of 2.425º. When total 127 femora considered, mean bicondylar angle of 8.061 ± 2.412º was obtained (Table-3). Mean bicondylar angle of the femur of left side were thus higher than that on the right side. We put the measurements to statistical analysis to determine whether these differences were statically significant. Using SPSS software student's t-test applied to the values to obtain t = 0.045 in d f = 125

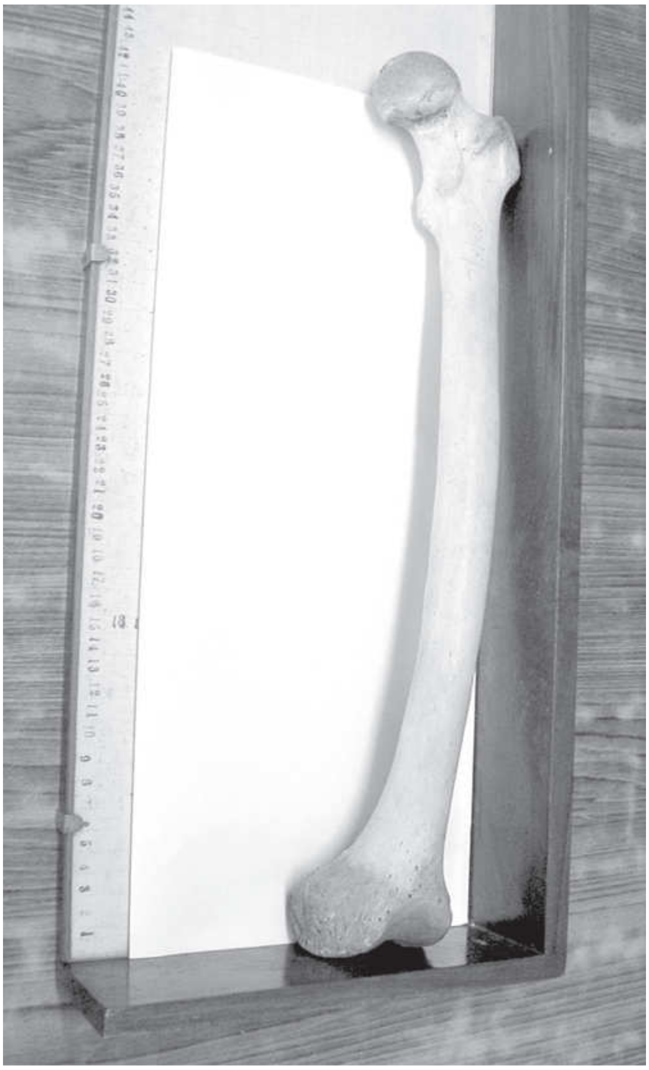

Fig. 1. Femur placed on osteometric board for taking measurements

Table-3: Comparison between bicondylar angles of left and right side. n = 127

Sidedness	Number of femora studied	Mean bicondylar angle (º)	Standard Deviation
Left	62	8.431	2.361
Right	65	7.708	2.425
Total	127	8.061	2.412

t = 0.045 d f = 125 P > 0.05

has a P > 0.05. Outcome left-right difference was not statistically significant.

DISCUSSION

In standing, the femoral shafts are oblique and their heads are separated by the pelvic width. The shafts converge downwards and medially to the knees and almost touch: they lie below the hip joints[3]. There have been several definition and methods used for measuring this obliquity of femoral shaft or bicondylar angle.

Clark[11] used available incomplete femora and studied the angle of inclination on the axial line extending from the centre of the preserved part of the shaft to the mid point of the anterior end of the inter-condylar notch. This way he got bicondylar angle at least 7º in English thigh bones. Kern and Straus[12] gave opinion of similar nature (7.5º ± 0.27º) as they used high point of inter condylar notch as a reference point. Walmsley[13] defined the anatomical axis of the femur to be a line passing through as many possible of the centre points between the edges of the shaft and through the mid condylar point and bicondylar angle to be that angle between this axis and the vertical on the infra-condylar plane. Heiple and Lovejoy[10] modified the method of Walmsley.[13] They defined long axis of shaft of femur as a line connecting the mid-point of the shaft just below the lesser trochanter with the mid-point of the shaft at a position 25% of the standard maximum length of the femur from its distal end. They have shown that the axis obtained by their method hardly deviate from the axis obtained from Walmsley's method, which was more complicated to measure. Moreover, these researchers found that the modified method was not affected by the asymmetry of the upper and lower ends of the femur and also avoided the ambiguity which might be introduced by medial or lateral bowing. Most of the successive researchers considered this method as standard. So, for the present study of measuring bicondylar angle, the method of Heiple and Lovejoy[10] were adopted.

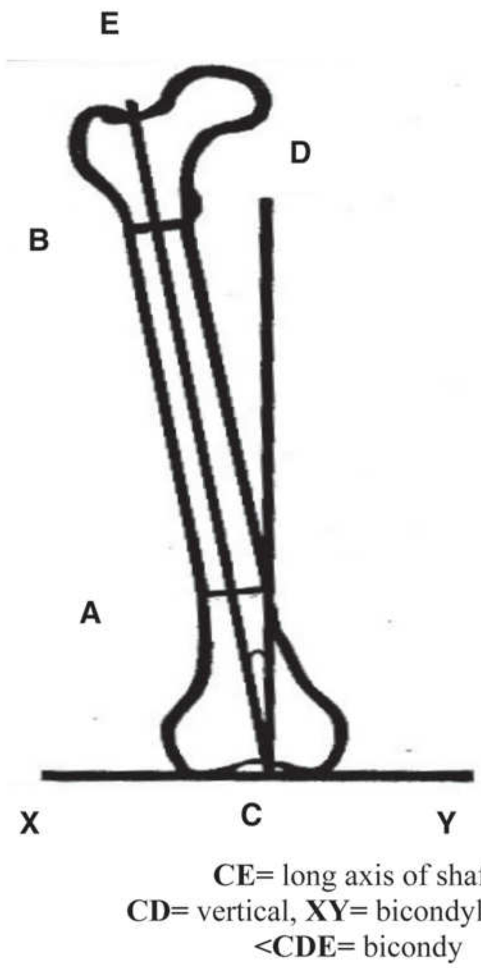

Fig. 2. Method of drawing bicondylar angle

Determination of sex from dry femur could not be made accurately. Since the bones used in the present study were from the pool of bones in different medical colleges of Kolkata and these bones are not age and sex specified. For this particular study, asymmetry, if any, was considered with respect to left-right sidedness, but study of sexual dimorphism were not taken into account for obvious limitations.

Result of the present study when analyzed, mean bicondylar angle of 8.061º ± 2.412º was obtained (Table-3), which was similar with the findings of the other workers in the field. When mean bicondylar angle was compared with respect to their sidedness a higher value was obtained for the left sided femora, support the hypothesis that most people, regardless of handedness, use their left leg for weight-bearing.

Value of bicondylar angle obtained in the present study when statistically compared with values obtained by Kern and Straus[12] in a degree of freedom 186 when student's t-test applied t = 1.16 with P > 0.05 returned. This signified that bicondylar angle obtained in the present study has no statistically significant variation from that of Kern and Straus's study group which comprises of 25 U.S. whites, 15 Eskimos, 2 U.S. Negroes, 7 Kaffirs and 15 Australians. This emphasized that bicondylar angle is one such parameter of femur which shows little variation among the divergent racial groups.

Though some worker predicted a higher value of bicondylar angle in Indians due to short stature,[14] epigenetically developed bicondylar angle as a consequence of bipedal stride in the present study showed no significant difference from researchers in the west.[13] This signifies proportionate reduction in all dimensions in physique that ultimately led to maintenance of comparable bicondylar angle.

A higher value of mean bicondylar angle had been noticed on the left side than that of the right side; attributed to habitual practice of weight bearing on left foot as mentioned by previous workers; however the difference was not statistically significant.

Replacement arthroplasty of knee fast becoming a popular mode of treatment in various disabling knee diseases.[15-17] Many workers are engaged in research work to generate anthropometric data for designing knee prosthesis.[18,19] Knowledge of mean bicondylar angle in eastern Indian population will act as ready-reckoner for biomedical engineers engaged in prosthesis designing for Indian recipient.

REFERENCES

1. Lovejoy CO, Cohn MJ, White TD. Morphological analysis of the mammalian postcranium: A developmental perspective. Proceedings of the National Academy of Sciences of the United States of America 1999; 96: 13247-52.
2. Preuschoft H, Tardieu C. Biomechanical reasons for the divergent morphology of the knee joint and the distal epiphyseal suture in hominoids. *Folia Primatol (Basel)* 1996; 66(1-4) 82 – 92.
3. Standring S, Borley NR, Healy JC *et al*. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 40th Edn. Churchill Livingstone: Elsevier Science Limited 2008: 1360.
4. Palastanga N, Field D, Soames R. Anatomy and Human Movement. 4th Edn. Butterworth Heinemann: Elsevier Science Limited 2002: pp 234, 334-6.
5. Hiss E, Schwerbrock B. Studies on the shapes of condyles of femur. *Z Orthop Ihre Grenzgeb* 1980; 118: 396-404.
6. Igbigbi PS, Sharrif M. The bicondylar angle of adult Malawians. *Amer J Orthoped* 2005; 34: 291-4.
7. Tardieu C, Damsin JP. Evolution of the angle of obliquity of the femoral diaphysis during growth--correlations. *Surg Radioll Anat* 1997; 19: 91-7.
8. Tardieu C. Short adolescence in early hominids: Infantile and adolescent growth of the human femur. *Amer J Physical Anthropol* 1998; 107: 163-78.
9. Shefelbine SJ, Tardieu C, Carter DR. Development of the femoral bicondylar angle in hominid bipedalism. *Bone* 2002; 30: 765-70.
10. Heiple KG, Lovejoy CO. The Distal Femoral Anatomy of Australipithecus. *Amer J Physical Anthropol* 1971; 35: 75-84.
11. Clark LGWE. Observation on the anatomy of the fossil Australopithecinae. *J Anat* 1947; 81: 300-33.
12. Kern HM, Straus WL. The femur of Plesianthropus transvalensis. *Amer J Physical Anthropol* 1949; 7: 53-77.
13. Walnsley T. Vertical axes of the femur and their relations. *J Anat* 1933; 67: 284-300.
14. Singh SP, Singh S. Study of the obliquity of the shaft of the femur (Bicondylar Angle) in Indians. *J Anat Soc India* 1974; 23: 57-60.
15. Cheng FB, Ji XF, Lai Y *et al*. Three dimensional morphometry of the knee to design the total knee arthroplasty for Chinese population. *Knee* 2009; 16: 341-7.
16. Crockarell JR Jr, Hicks JM, Schroeder RJ, Guyton JL, Harkess JW, Lavelle DG. Total knee arthroplasty with asymmetric femoral condyles and tibial tray. *J Arthroplasty* 2010; 25: 108-13.
17. Mensch JS, Amstutz HC. Knee morphology as a guide to knee replacement. *Clin Orthop Relat Res* 1975; 112: 231-41.
18. Kwak DS, Han S, Han CW, Han SH. Resected femoral anthropometry for design of the femoral component of the total knee prosthesis in a Korean population. *Anat Cell Biol* 2010; 43: 252-9.
19. Cheng FB, Ji XF, Zheng WX *et al*. Use of anthropometric data from the medial tibial and femoral condyles to design unicondylar knee prostheses in the Chinese population. *Knee Surg Sports Traumatol Arthrosc* 2010; 18: 352-8.