BICONDYLAR ANGLE OF FEMUR IN SOUTH INDIAN POPULATION – AN ANALYTICAL STUDY

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ABSTRACT

The bicondylar angle of femur is an angle between the axis of shaft of the femur and a line perpendicular to the infracondylar plane. This angle is unique to humans due to their erect posture. Measuring of this angle helps in identifying sex of the bone and has a role in reconstructive orthopedic surgeries, primatology and paleoanthropology. This angle is zero at birth and starts developing only when the child walks. This angle is more in females due to their wider pelvis and short stature. Racial and regional variations are noted in this angle. Number of studies have been done on the bicondylar angle of the femur in human anatomy, primatology and paleoanthropology. But there is no previous study on South Indian adult femora, hence this study is undertaken to measure the bicondylar angle of femur and to compare with different regions of the country. This angle was measured in 204 South Indian adult femora. The mean bicondylar angle of male and female was 8.53° and 10.16° respectively. The bicondylar angle exhibited sexual dimorphism with stastically significant higher value for female femora. This angle was higher when compared to North Indian population and almost similar to North West Indian population.

Key words: Bicondylar angle, Sexual Dimorphism, Obliquity of femoral shaft, Femur.

INTRODUCTION

The bicondylar angle of femur is defined as "Angle between an axis through the femoral shaft and a line perpendicular to the infracondylar plane." Bicondylar angle is unique to humans. This angle helps to keep the man erect by placing the knee and foot under the body's center of gravity during single support phase of gait. The bicondylar angle is greater in females due to their wider pelvis. This angle is not present in other primates as they lack single support phase of gait. The bicondylar angle is 0° at birth because the axis of the shaft is perpendicular to the metaphyseal growth. Bicondylar angle develops when the child walks as the medial side of the distal metaphysis grows faster than the lateral side[1]. This angle reaches adult value when the child is about four to eight years of age depending on their walking activity[1,2]. In bedridden children since birth, children with neuromuscular disorders, and paraplegic children who do not ambulate in childhood, the bicondylar angle does not develop[2]. This clearly explains the formation of the bicondylar angle as an epigenetic phenomenon, in which growth of the distal femur is influenced by the mechanical loading environment[6]. Although there is a clear link between the bipedal gait and bicondylar angle, very little research work has been done to demonstrate the mechanism by which bipedal gait results in the bicondylar angle. Many studies have revealed the sexual dimorphism, racial and regional variations of the bicondylar angle due to obliquity of the femoral shaft[1, 2,3,4,5,6,7,8,9]. The australopithecines were identified as the earliest known bipedal human ancestors from about 4.2 million years ago[10, 11]. The bicondylar angle of the femur of australopithecines is an indicator of the human lineage. In present humans, this angle ranges from 8°–11°[1] but in australopithecines, bicondylar angle is slightly larger between 12° and 15° and could be related to their broad pelvis, the short stature and long femoral neck of early hominids[14]. The bicondylar angle in quadrupedal apes is less compared to human approximately 1° in chimpanzees, 5° in orangutans and 2° in gorillas[15]. The bicondylar angle in some primate femora, especially orangutans seems to be the result of a different growth process than that occurring in humans. In orangutans the medial condyle grows longer superioinferiorly than the lateral condyle.

Bicondylar angle – a hallmark of hominid bipedality has not been documented in South Indian population. Hence this analytical study was undertaken.

Aim:

This study was aimed at measuring the bicondylar angle of femur in South Indian population and to find out the sexual dimorphism by comparing the bicondylar angle of male and female femora.

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Materials and Methods:

Materials for this study consisted of 204 human adult femora from the South Indian skeletal collection from the Anatomy departments of the following medical colleges namely Vinayaka Mission's Kirupananda Variyar Medical College, Vinayaka Mission's Homeopathy Medical College and Annapoorna Medical College, Salem, Tamil Nadu, India. Femora with fractures, pathological changes and femora purchased from outside South India were excluded. All the femora were initially divided into male and female keeping distinct anatomical dimorphic sex variation. Using anatomical features of the femora they were further separated as right and left side of the respective sex. An osteometric board, white papers, scale, pencil, vernier caliper and goniometer were used to measure the bicondylar angle (Fig- 1) . A white paper sheet was fixed on the osteometric board and the femur was placed on the board in such a way that the posterior aspect of the condyles and the greater trochanter touched the base of the osteometric board. Inferior surface of both the condyles were placed against the vertical plate of the osteometric board (Fig- 2). Plane of vertical plate was marked on the sheet and considered as infra condylar plane (XY in Figure 5). Using vernier caliper two points were marked on the sheet at the level just below the lesser trochanter of the femur (AB in Fig- 3) and another set of points were marked at the distal 1/4th of the femur (CD in Fig- 4). A line was drawn joining the midpoint of "AB" and "CD" and this line is considered as a long axis of the shaft (Fig- 5). This axis line was extended to meet the infracondylar plane (Z in Fig- 5). A line was drawn from the point "Z" perpendicular to the line XY (Fig- 5). The angle between the axis of shaft and the perpendicular line was measured using goniometer and was considered as bicondylar angle (Fig- 6).

Figure-1 Materials used to measure bicondylar angle of Femur

Figure-2 Femur on osteometric board - infracondylar surface touching the vertical plate

Figure-3 Marking two points (A-B) just below the lesser trochanter

Figure-4 Marking two points (C-D) at distal 1/4th of the femur

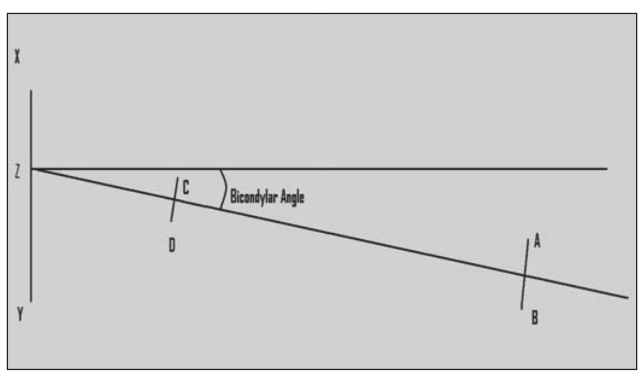

Figure-5 Infracondylar plane (XY), Long axis of femur, Z point and perpendicular plane from Z point

Figure 6 Measuring the bicondylar angle by using goniometer

Statistical Analysis

We summarized descriptive data as mean, standard deviation, range and percentage. The Independent-Samples't' test procedure is used to compare mean angle for two groups. The procedure assumes that the variances of the two groups are equal and it was tested with Levene's test statistics. We used univariate analysis to compare demographic and anatomical variations. A p value <0.5 was considered statistically significant. All analysis were done using SPSS 13.0 Version.

Observations:

The bicondylar angle between the genders of the femora is shown in Table –1. The table displays the descriptive statistics of the sample size, mean and standard deviation. The table also shows that the 't' statistics, calculated as the ratio of the difference between sample means divided by the standard error of the difference. The column p value shows the probability value from the 't' distribution. Since the p value is less than 0.01 we reject the hypothesis. Hence there is **highly significant difference in the mean bicondylar angle between the two groups male and female.** Gender wise distribution of mean and standard deviation of angle of the femora shows that the highest mean angle is 10.16 $\pm$ 2.73, which is obtained for female femora whereas, the lowest mean angle is 8.53 $\pm$ 2.34 which is obtained for male femora. Further over all mean angle is 9.18 $\pm$ 2.62, revealing that the femora had higher angle among female. Hence it is concluded that the mean bicondylar angle of female is greater than male.

The bicondylar angle was higher in females on both the sides and this difference is highly significant (p – 0.002) (Table – 2). The difference in the obliquity of femoral shaft between right and left was not statistically significant in both the sexes. (p > 0.05) (Table-3).

Table. 1 Test for mean bicondylar angle between the genders of the femora

Gender	N	%	Range		Mean	Std. Deviation	t	P value	Remark
			Min	Max					
Male	123	60.29	4	14	8.53	2.34	4.55	0.00	Highly Significant
Female	81	39.71	5	18	10.16	2.73			
Over all	204	100	4	18	9.18	2.62			

Table .2 Test for mean bicondylar angle between the genders in right and left sides of the femora

Side	Gender	N	%	Range		Mean	Std. Deviation	t	P value	Remark
				Min	Max					
Right	Male	68	61.82	4	14	8.26	2.47	3.17	0.002	Highly Significant
	Female	42	38.18	6	14	9.74	2.21			
	Over all	110	100	4	14	8.83	2.47			
Left	Male	55	58.51	6	14	8.85	2.16	3.20	0.002	Highly Significant
	Female	39	41.49	5	18	10.62	3.17			
	Over all	94	100	5	18	9.59	2.75			

Discussion:

In the present study the bicondylar angle is higher in female population; this can be linked with the broader pelvis and short stature of the female population as mentioned by the text books of anatomy[13, 14]. Similar to our study the bicondylar angle of female femora was found to be widened in North West Indian population and Malawian population[7,9].

The present study is compared with two other studies done on bicondylar angle of North Indian and North West Indian population. Table 4 shows the comparative analysis of the obliquity of the femora. In the present study the bicondylar angle is higher than the North Indian population and almost similar with North West Indian population. This could be attributable to the following factors such as genetic variation, growth factor, nutrition and diverse physical activity. However looking more deep into these studies, the study on North Indian population was conducted during the period of 1974 and other two studies were conducted in 2008 and 2010, and there was about three and a half decade delay in the last

Table. 3 Test for mean bicondylar angle between the right and left sides of both the sexes

Sex	Gender	N	%	Range		Mean	Std. Deviation	t	P value	Remark
				Min	Max					
Male	Right	68	55.28	4	14	8.26	2.47	1.39	0.166	Not Significant
	Left	55	44.72	6	14	8.85	2.16			
	Over all	123	100	4	14	8.53	2.34			
Female	Right	42	51.85	6	14	9.74	2.21	1.45	0.15	Not Significant
	Left	39	48.15	5	18	10.62	3.17			
	Over all	81	100	5	18	10.16	2.73			

Table . 4 Comparison of bicondylar angle variation of our Present study with other Indian Studies

Study	Parameters	Right		Left	
		Male	Female	Male	Female
S.S.Singh & S.S.Singh (1974- North India)	Mean	8.16°	8.82°	7.79°	8.67°
	S.D	2.21	2.17	2.20	2.21
	Range	2° – 13°	5° – 16°	3° – 13°	3° – 14°
Pandya A.M (2008 - North West India)	Mean	8.88°	10.50°	8.76^{0}	10.83°
	S.D	2.05	2.42	2.24	1.94
	Range	3° – 13°	5° – 13°	4° – 13°	6° – 13°
Present study (2010- South India)	Mean	8.26°	9.74°	8.85^{0}	10.62°
	S.D	2.47	2.21	2.16	3.17
	Range	4° – 14°	6° – 14°	6° – 14°	5° – 18°

two studies. This could explain the possibility of the bicondylar angle variation in these two studies may be due to the life style changes and significant difference in the physical activities in the past and present. The study done by Tardieu. C, Tardieu C & Trinkaus revealed that the bicondylar angle is 0° at birth and it increases as the child starts walking, as well there was no bicondylar angle in those who had never ambulated or minimally ambulated[2,3]. This explains the high degree of potential for the plasticity in the development of this angle. Thus it is very clear that bipedal locomotion has got significant impact on the development of the bicondylar angle. During the bipedal walking, the body weight is loaded on the distal end of femur in such a way to promote the growth and ossification more on the medial condyle to form bicondylar angle. Because of the obliquity of the shaft, this angle is very important for the reconstruction of the total length of the femur reconstruction of stature from the femur, identifying sex of the bone and has a role in primatology and paleoanthropology. Knowledge about bicondylar angle of femur is essential for orthopedicians while performing open reduction and internal fixation of fractures of femur.

Chart .1 Comparison of mean bicondylar angle variation of our study and two other Indian studies

Conclusion:

The bicondylar angle of female femora is higher than the male femora in the present study which shows sexual dimorphism in South Indian population. The bicondylar angle of the present study is comparable with North West Indian population and differs from North Indian population.

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