



## Proximal femoral geometry in cadaveric femora and its clinical relevance

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### Abstract:

**Introduction:** Morphology and statistical analysis of femoral anthropometry among different populations reveals a great amount of variation. The morphology of proximal femur is an essential parameter in the design and development of implant. The aim of present study is to remove the lacunae of information about proximal femoral geometry in Indians and evaluate its impact on implant design.

**Material and Method:** 200 adult dry human cadaveric femora of known sex were collected. The Neck Shaft angle, Neck width and Neck length were determined.

**Result:** The mean neck-shaft angle in cadaveric femora in the present study irrespective of gender and side was 132.60°. The mean neck shaft angle in male femora was 132.21° and in female femora was 133.3°. The mean neck length was 37.61 mm in male femora and 34.75 mm in female femora. The mean neck width was 31.54 mm in male femora and 27.20 mm in female femora. The mean neck shaft angle was 133.9° in right femora and 131° in left femora. The mean neck length was 35.80 mm in right femora and 37.53 mm in left femora. The mean neck width was 30.13 mm in right femora and 29.85 in left femora. The mean Neck length in both male and female femora on both right and left sides showed significant positive correlation with the Neck width.

**Conclusion:** This study will help the orthopedic surgeons and biomechanical engineers to design implants and restore normal anatomy of femur in Indian Population.

**Keywords:** neck length, neck shaft angle, neck width, proximal femoral geometry, femur

### Introduction:

Morphology and statistical analysis of femoral anthropometry among different populations reveals a great amount of variation.<sup>1</sup> The femoral heads support the entire weight of the body, suggesting that the morphometry of the proximal femur may contribute to femoral neck strength. Proximal femur acts as a brace, its biomechanical properties depend on the width and length of femoral neck.<sup>2</sup> The neck of femur in humans is important functional

modification after man attained erect bipedal posture. The angulation was found to be different in different races and at different ages.<sup>3</sup>

The clinical importance of neck shaft angle of femur lies in the diagnosis, treatment and follow up of fractures of neck of femur, trochanteric fractures, developmental dysplasia of hip and neuromuscular disorders of lower extremity.<sup>4</sup> Operations on the proximal femur are one of the commonest in orthopedic surgical practice. The aim of these

operations is to restore femoral anatomy to the normal as far as possible.<sup>5</sup> The morphology of proximal femur is an essential parameter in the design and development of implant. The use of implants designed based on other populations posed at least two potential major issues. First and foremost is the difference of the anthropometry of the proximal femur between ethnics due to differences in lifestyle, physique, applied force and their distribution. Another issue is implant-morphology mismatch that might cause difficulties during implant placement and could lead to accelerated deterioration of the implant life thus affecting short-term and long-term outcome of the surgery.<sup>6</sup> Most of Indian orthopedic surgeons have felt the need for modification of the dimensions of these implants to suit Indian standards.<sup>4</sup>

So to minimize intraoperative and postoperative complications, the implants should be designed by taking in to account anthropometry and biomechanics data. The study conducted with aim to remove lacunae of information about proximal femoral geometry in Indian population and evaluate its impact on implant design.

### Materials & Methods:

The present study was carried out in Dept of Anatomy at Dr. Shankarrao Chavan Government Medical College, Nanded, Maharashtra. 200 adult dry human cadaveric femora of known sex were studied. Of the 200 femora 129 were male in which 70 of right side and 59 of left side; 71 female femora of which 38 of right side and 33 of left side.

**Inclusion and Exclusion criteria:** Femora which showed osseous pathology, previous fracture, burnt and abnormal bones and bones of children were excluded from the study. Femora of adult human having all the component parts were included in the present study.

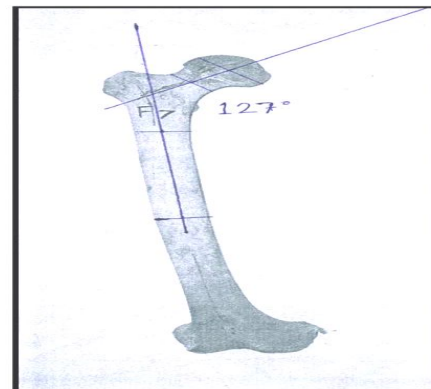
Following measurement was recorded:

**Neck Shaft angle (NSA):** The neck shaft angle was determined according to the guidelines given by Singh and Bhasin<sup>6</sup> (1968). Each femur was placed on flat surface with posterior surface of its condyles

and greater trochanter touching the surface. The digital camera was fixed to a stand and centralized with proper focus. The picture was captured and printout taken. For determining neck axis 2 lines were drawn, one at the narrowest point of neck and other the vertical diameter of head. Midpoints of both the lines were marked. Line passing through these 2 points represents the neck axis. Similarly, for determining shaft axis 2 horizontal lines were drawn on shaft, one below intertrochanteric line and other at mid shaft. Midpoints of both the lines were marked. Line passing through these 2 points represents the shaft axis.

The angle between the neck axis and shaft axis was measured using protractor. This angle represents the neck shaft angle. (Figure 1)

**Figure 1: Measurement of Neck shaft angle**



**Neck length (NL):** The length of neck was measured along the long axis of neck posteriorly between the base of the head and midpoint of intertrochanteric crest using digital vernier caliper. (Figure 2)

**Figure 2: Measurement of Neck length**



**Neck width (NW):** The width of the neck was measured using digital vernier calipers at the narrowest part of the neck. (Figure 3)

**Figure 3: Measurement of Neck Width**



By calculating Neck shaft angle, Neck length and Neck width, the observations were analyzed by statistical method with the help of Mean, Standard Deviation, unpaired 't'- test and p- value.

### Results:

The mean neck-shaft angle in cadaveric femora in the present study irrespective of gender and side was  $132.60^\circ$ . The mean neck shaft angle in male femora was  $132.21^\circ$  and in female femora was  $133.3^\circ$  which is statistically not significant. The mean neck length was 37.61 mm in male femora and 34.75 mm in female femora and it is statistically significant. The mean neck width was 31.54 mm in male femora and 27.20 mm in female femora which is statistically significant.

**Table 1: Mean NSA, NL, NW in male and female cadaveric femora**

Parameters	Male	Female	p – value
Mean Neck Shaft Angle	$132.21^\circ \pm 6.64^\circ$	$133.3^\circ \pm 8.10^\circ$	0.0895
Mean Neck Length	$37.61 \pm 4.69$	$34.75 \pm 4.57$	0.0001
Mean Neck Width	$31.54 \pm 3.36$	$27.20 \pm 3.17$	0.0001

The mean neck shaft angle was  $133.9^\circ$  in right femora and  $131^\circ$  in left femora and it is statistically significant. The mean neck length was 35.80 mm in

right femora and 37.53 mm in left femora which is statistically significant. The mean neck width was 30.13 mm in right femora and 29.85 in left femora and it is statistically not significant.

**Table 2: Mean NSA, NL, NW in Right and Left cadaveric femora**

Parameters	Right Femora	Left Femora	p- value
Mean Neck Shaft Angle	$133.9^\circ \pm 7.02^\circ$	$131^\circ \pm 7.11^\circ$	0.0040
Mean Neck Length	$35.80 \pm 4.54$	$37.53 \pm 5.03$	0.0118
Mean Neck Width	$30.13 \pm 3.88$	$29.85 \pm 3.92$	0.6116

The mean neck shaft angle in both male and female femora, on both right and left side did not show significant correlation with mean Neck length and mean Neck width. The mean Neck length in both male and female femora on both right and left sides showed significant positive correlation with the Neck width.

**Table 3: Correlation between NSA, NL, NW in cadaveric femora**

Correlation Between	Male Cadaveric Femora				Female Cadaveric Femora			
	Right		Left		Right		Left	
	R value	p value	R value	p value	R value	p value	R value	P value
Neck shaft angle & Neck length	-0.03	0.788	-0.08	0.505	-0.20	0.225	-0.16	0.362
Neck shaft angle & Neck width	0.089	0.462	-0.02	0.858	0.22	0.176	-0.11	0.512
Neck length & Neck width	0.259	<b>0.030</b>	0.388	<b>0.002</b>	0.397	<b>0.013</b>	0.563	<b>0.001</b>

### Discussion:

The mean neck-shaft angle in cadaveric femora in the present study was  $132.60^\circ$ , and is correlating with previous Indian studies of Singh et al<sup>7</sup> and Ian Gilligan<sup>11</sup> with mean neck shaft angle  $131.10^\circ$  and  $129.90^\circ$  respectively. Whereas it is higher than earlier Indian studies of Kate<sup>4</sup>, Issac<sup>9</sup>, Siwach<sup>5</sup>, Ravichandran<sup>4</sup> and Bulagouda<sup>12</sup> with mean neck

shaft angle of 126.70°, 123.50°, 126.55° and 124.49° respectively and less than earlier study of Gujar<sup>4</sup> and Shakil<sup>13</sup> with mean neck shaft angle 136.30° and 137.10° respectively. (Table 4)

Mean neck-shaft angle of other regions of the world are less than present study and this may be due to ethnic and racial difference.

**Table 4: Comparison of mean Neck Shaft angle in cadaveric femora**

Sr. No.	Author	Year	Region	Mean NSA
1	Davivongs et al. <sup>7</sup>	1963	Australia	127.60°
2	Kate et al. <sup>4</sup>	1967	India	128.40°
3	Olav Reikeras et al. <sup>8</sup>	1982	Norwegia	127.70°
4	Bada and Endo et al. <sup>7</sup>	1982	China	125.60°
5	Singh et al. <sup>7</sup>	1986	India	131.10°
6	Macho et al. <sup>7</sup>	1992	Africa	121.90°
7	Isaac B. et al. <sup>9</sup>	1997	India	126.70°
8	R. C. Siwach et al. <sup>5</sup>	2003	India	123.50°
9	P. A. Toogood et al. <sup>10</sup>	2009	USA	129.23°
10	Ian Gilligan <sup>11</sup>	2010	India	129.90°
11	D. Ravichandran et al. <sup>4</sup>	2011	India	126.55°
12	Subhash Gujar et al. <sup>4</sup>	2013	India	136.30°
13	Bulagouda R S et al. <sup>12</sup>	2014	India	124.49°
14	Shakil M K et al. <sup>13</sup>	2014	India	137.10°
15	<b>Present study</b>	<b>2017</b>	<b>India</b>	<b>132.60°</b>

Sexual difference, with respect to the neck-shaft angle in cadaveric femora was observed in the present study. Mean neck-shaft angle in males was 132.21°, which was comparatively lower than in females with mean neck-shaft angle 133.30°. Similar lower values for males in comparison with females were observed by Bulagouda<sup>12</sup> in south Indian population and by Parson<sup>14</sup> in London population. However, mean neck-shaft angle in males was slightly higher or equal to females in studies by Sanchita Roy<sup>15</sup> in Indians and Reikeras<sup>8</sup> in Norwegians. (Table 5)

**Table 5: Comparison of Sexual Difference in Mean Neck Shaft Angle in cadaveric femora**

Sr. No.	Author	Year	Region	NSA (degrees)	
				Male	Female
1	Olav Reikeras et al. <sup>8</sup>	1982	Norwegia	128.30°	127°
2	F. G. Parson <sup>14</sup>	1995	London	122°	124°
3	Bulagouda R S et al. <sup>12</sup>	2014	India	123.32°	128.18°
4	Sanchita Roy et al. <sup>15</sup>	2014	India	131°	130.37°
5	<b>Present study</b>	<b>2017</b>	<b>India</b>	<b>132.21°</b>	<b>133.30°</b>

Side difference with respect to the neck shaft angle was also noted in the present study. Right side femora have mean neck-shaft angle of 133.90° which is comparatively more than the left side 131°. Such findings of Right side mean neck shaft angle more than left side were observed in earlier study by DE Sausa<sup>18</sup> and Caetano<sup>17</sup> in Brazilian population. However, in another studies by DA Silva<sup>16</sup> in Brazilians and Khaleel<sup>19</sup> in Indians the mean neck-shaft angle on the right side was less than left side. (Table 6)

**Table 6: Comparison of Mean Neck Shaft Angle in cadaveric femora with respect to Side**

Sr. No.	Author	Year	Region	NSA (degrees)	
				Right	Left
1	DA Silva et al. <sup>16</sup>	2003	Brazil	122.55°	125.61°
2	E.B. Caetano et al. <sup>17</sup>	2007	Brazil	128.23°	128.04°
3	DE Sousa et al. <sup>18</sup>	2010	Brazil	132.10°	131.80°
4	Khaleel N. et al. <sup>19</sup>	2014	India	124.44°	126.30°
5	<b>Present study</b>	<b>2017</b>	<b>India</b>	<b>133.90°</b>	<b>131°</b>

In the present study, the mean neck length in cadaveric femora taken together irrespective of side and sex was 36.59mm whereas of right femora was 35.80mm and of the left femora was 37.53mm. When seen sex wise NL in males it was 37.61mm and females it was 34.74mm. This mean neck

length correlated with the observations of Siwach<sup>5</sup>, Gujar<sup>3</sup> and Ravichandran<sup>4</sup>. However the mean values were considerably higher when compared to Brazilian study of DA silva<sup>16</sup>, Caetano<sup>17</sup> and DE sousa<sup>18</sup>. Whereas the mean value were on much lower side when compared with study of Parsons.<sup>14</sup> (Table 7)

**Table 7: Comparison of Mean Neck length in cadaveric femora**

Sr. No.	Author	Year	Region	Mean Neck length (mm)
1	F. G. Parson <sup>14</sup>	1995	London	M=Rt.67, Lt.66 F=Rt.58, Lt.57
2	Siwach et al. <sup>5</sup>	2003	India	37.2
3	DA Silva et al. <sup>16</sup>	2003	Brazil	Rt.22.3, Lt.23.5
4	E.B. Caetano et al. <sup>17</sup>	2007	Brazil	Rt.28.69, Lt.28.81
5	DE Sousa et al. <sup>18</sup>	2010	Brazil	Rt.30.1, Lt.30.4
6	Ravichandran et al. <sup>4</sup>	2011	India	33.68
7	Subhash Gujar et al. <sup>3</sup>	2013	India	34.4 Rt.34.5, Lt.34.2
8	<b>Present study</b>	<b>2017</b>	<b>India</b>	<b>36.59</b> <b>Rt.35.8,</b> <b>Lt.37.53</b> <b>M-37.61,</b> <b>F-34.74</b>

The mean neck width taken together irrespective of sex and side is 30mm which is comparatively correlating with the studies of Ravichandran<sup>4</sup>, Siwach<sup>5</sup>, and DE sousa<sup>18</sup>. (Table 8)

**Table 8: Comparison of Mean Neck Width in cadaveric femora**

Sr. No.	Author	Year	Region	Mean Neck width (mm)
1	Ravichandran et al. <sup>4</sup>	2011	India	30.99
2	Siwach et al. <sup>5</sup>	2003	India	31.87
3	DE Sousa et al. <sup>18</sup>	2010	Brazil	30.96
4	<b>Present study</b>	<b>2017</b>	<b>India</b>	<b>30</b>

## Conclusion:

This study will help the orthopedic surgeons and biomechanical engineers to design implants and restore normal anatomy of femur in Indian population.

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