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Original Research Article

MORPHOMETRY OF FEMORAL NECK SHAFT ANGLE IN DRY FEMORA OF SOUTH INDIA BY COMPUTER ASSISTED IMAGE ANALYSIS METHOD

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ABSTRACT

Background: The neck-shaft angle (NSA) is the angle formed by the neck axis & the long axis of the femur. **Objectives:** The objectives of the study were to estimate the following in dry femora of South Indian origin: 1) NSA. 2) Side differences in NSA. 3) Intra observer & inter observer reliability in measuring NSA.

Material and Methods: About 171 dry adult femora (92 right and 79 left) available in the department of Anatomy were studied. End on digital photographs of the proximal end of the femur & frontal view digital photographs after neutralizing the FA, were utilized to measure the NSA. The axes mentioned above were marked using Microsoft Power Point 2007, after which the images were analyzed. Side differences were determined using the unpaired t-test. Intra observer & inter observer reliability was assessed using Pearson's correlation coefficient.

Results: The mean NSA was 121.2 º ± 6.2 º (range 93 to 136). No significant side differences were noted. There was good intra & inter observer reliability.

Conclusion: In the present study the mean NSA was 121.2°. No significant side differences in NSA were noted. There was a good intra & inter observer reliability in measuring NSA by using computer assisted image analysis method.

KEY WORDS: Femur, femoral neck shaft angle, Shaft axis, Neck axis.

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INTRODUCTION

The femoral neck-shaft angle (NSA) is the angle formed by the neck axis & the long axis of the femur. It is also known as the angle of inclination, cervicodiaphyseal angle or caput collum diaphysis (CCD) angle [1]. The neck axis is the line drawn from the centre of the femoral head to the centre of the femoral neck at the narrowest part of the neck. The long axis of the femur is defined as the line drawn from the middle of the femoral condyles to the middle of the greater trochanter in two planes [1]. The mean NSA in

adults is 135° & ranges from 125° to 132° [2,3]. According to Kate, in Indian femora the NSA is about 128.4º, being greater in South and west of India [4]. The NSA is one of the main diagnostic criterions that clinicians use to detect femoral neck fracture. A large discrepancy from the healthy NSA would indicate a possibility of fracture [5].

Awareness about the proximal femoral geometry is important in the pre-operative planning of osteotomy, arthroplasty or fracture fixation [6]. It also helps in designing suitable implants with more accurate angulations of femur neck [4].

Presently in developing countries like India, injured femur replacements are carried out using standard sized Austin Moore femur implants selected from a range provided by manufacturers. Femur implants are available in standard sizes of diameter of the femoral head & neck shaft angle. However, there is discrepancy as regards the measurement of the parameters [7]. Undersized or overhanging femoral implants could lead to altered soft-tissue tensioning & altered patella femoral stresses [8]. Non availability of proper shaped & sized femur implant or improper selection of femur implant could create serious problems for the patients in long run [6,9]. In addition, the NSA has implications for femoral neck fracture risk [10,11].

Racial variations in anthropometric parameters exist because of genetic & various socio-cultural practices. In India, the data on NSA established from Western population is being used. Indians use more of floor level activities like squatting, therefore they tend to externally rotate their hips & use them in extreme range of motion. This makes the Indian hips to be evolutionally & morphologically different from Western counterparts. Therefore the data from Western population may not be applicable to the Indian population [12,13]. Since, the data on the morphometry of femoral NSA on dry adult femora in South Indians is less, the present study was undertaken. The main objective was to compile a database of normal femoral NSA in healthy adults among South Indian population & to know Intra observer & inter observer reliability in measuring NSA.

MATERIALS AND METHODS

A total of 171 dry femora of unknown age & sex available in the Anatomy department were studied of which 92 belonged to right side & 79 to left side. All adult dry femora without any external abnormality were included in the study. Femora having any gross deformities or damage were excluded from the study. The bones were numbered and the parameters were measured.

Measurement of Femoral NSA: The femur bone was placed on a flat board covered with a graph sheet. Each femur was placed with the posterior surface of its condyles and greater trochanter touching the smooth horizontal surface of the board. The digital camera was fixed at a a distance of about 1feet form the bone to a stand for proper focus and centralized along with the bone on the graph sheet. In order to increase the accuracy of the NSA measurement, the FA was negated by manually rotating the proximal end of femur (Fig-1). The picture thus taken was transferred to the computer and analysed using Microsoft Power Point 2007 software. Relevant lines were drawn to mark the midpoint of head and neck of femur (Fig-2).

Femoral head neck axis: Two horizontal lines (a & b) were drawn, each passing through the superior and inferior most point of the head respectively. Another line (c) was drawn joining the superior and inferior most points of the head of femur. A line (d) was drawn joining the narrowest point of the neck. Mid points of line c represents centre of head and mid point on line d represents centre of neck of femur. The line passing through these 2 points represents head neck axis (Fig- 2).

Femoral shaft axis: Two horizontal lines were drawn, a. One (e) at the proximal end of femur where the inter trochanteric line ends**.** b**.** Second one (d) at the midway between both the ends of the femur. a. A line joining the two horizontal lines on the shaft represents shaft axis. The background image was deleted and printouts were taken (Fig- 3). Femoral NSA is the angle formed between head neck axis and shaft axis of femur. NSA was measured by using a protractor on femur.

The results were tabulated & the mean & stan-

dard deviation was calculated and compared between right & left side for significance. The level of significance was set at $p < 0.05$. The data were computationally tested using SPSS for Windows, version 16.0 (SPSS Inc., Chicago, IL, USA). The measurements were repeated by the principal investigator on 20 randomly selected femora to assess intra-observer reliability. Another observer independently made the above measurements on 20 randomly selected femora to test the reliability of the method.

Fig. 1: Method of Taking Frontal View Photograph of Femur.

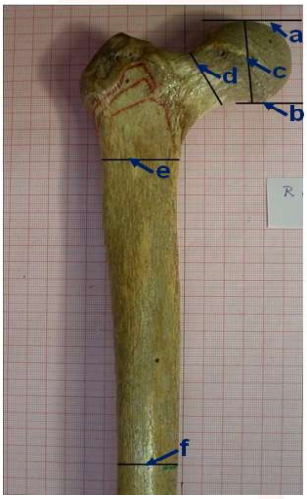


Fig. 2: Analysis of The Frontal View Photograph Using Microsoft Power Point.

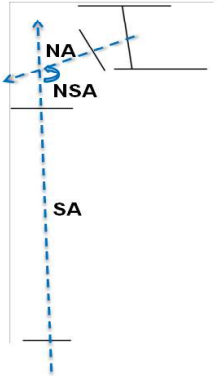
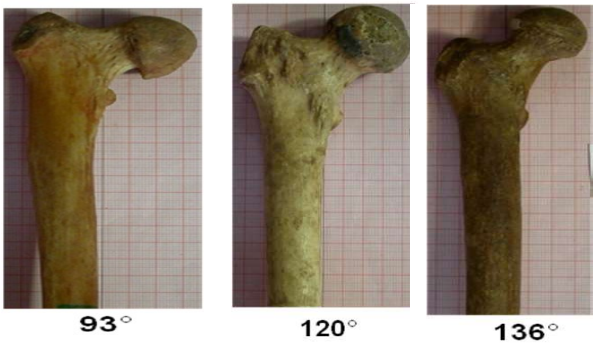


Fig. 3: Relevant Axes and the measurement of Femoral Neck Shaft Angle.
NA- Femoral head neck axis,
SA- Femoral shaft axis,
NSA- femoral neck shaft angle

Fig. 4: Figure showing minimum, average & maximum femoral NSA.



RESULTS

The mean NSA on right side was 120.9°± 6.0° & on left side it was 121.5°± 6.4°. Since there was no statistically significant differences between right & left side (P value 0.59) the average on right & left NSA was calculated & was used for comparison. The mean NSA was 121.2°± 6.2° & range between 93° to 136°. There is a good intra observer correlation in measuring NSA (Pearson's Correlation coefficient was 0.69). There is a good inter observer correlation in measuring NSA. (Pearson's Correlation coefficient was 0.89).

Table 1: Comparison of NSA of present study with other foreign studies.

Sl.no	Authors	Year	Sample size	Population	Method	NSA	SD
1	M Lequesne	2004	446	French	X- ray	132.8°	4.4°
2	PF Umebese	2005	116	Nigerian	X- ray	121.0°	6.0°
3	PA Toogood	2008	375	American	Dry bone- Digital Photo	129.2°	6.2°
4	Liang J	2009	56	Chinese	CT	126.2°	7.1°
5	HD Atkinson	2010	100	British	CT	M- 129° F- 128°	-
6	M Inam	2011	100	Pakistan	X- ray	134°	5.6°
7	Present study	2016	171	Mangaluru India	Dry bone- computer assisted	121.2°	6.2°

Table 2: Comparison of NSA of present study with other Indian studies.

Sl.no	Authors	Year	Sample size	Population	Method	NSA	SD
1	RC Siwach	2003	150	Rohtak	Dry bone-	123.5°	4.3°
2	RC Siwach	2003	150	Rohtak	Dry bone– X- ray	123°	4.3°
3	KC Saikia	2008	92	Guwahati	CT	139.5°	7.5°
4	TR Deshmukh	2010	77	Vidarbha	X- ray	131.5°	-
5	Present study	2010	171	Mangalore	Dry bone- computer assisted	121.2°	6.2°

DISCUSSION

The mean NSA in the present study (121.2°) was similar to that of the study by PF Umebese [14]

on Nigerians (121.0°) which was done on plain x rays. The mean NSA was less as compared to other authors as observed in Table 1. The maximum NSA was observed in the people of Pakistan which was done on plain x rays by M Inam [15]. These variations in NSA may be due to different methods that were used in measuring the NSA by different authors. Toogood PA [16] studied NSA among dry bone using digital method among American population & observed NSA to be 129.2° which is higher than the present study which may be due to racial variations among the two different populations.

On comparing the mean NSA with other studies done on Indian subjects it was observed that the NSA in the present study was lower than most of the Indian studies (Table- 2). The study done by KC Saikia [17] among people of Guwahati using CT scan showed very high NSA of 139.5° as compared to other studies. The NSA of present study was similar to study done by RC Siwach [18] in Rothak which was done on dry bone. There is considerable overlap between the ranges of NSA in other studies done on Indian population. These variations in NSA may be due to different working conditions of people as non mechanized rural people have the lowest angles & the urban people have the maximum NSA, with the agricultural groups being more variable.

The femoral NSA shows considerable variation both within & between human populations. The NSA ranges from 122° to 136°. According to Anderson JY[19] who studied 30 different groups & population there is a consistent pattern of increased mean angles with an increasingly sedentary existence. He observed that a strong pattern of increasing NSA with decreasing mobility & decreasing NSA with more heavy workers. On an average, the non mechanized hunting & gathering people have the lowest angles & the urban samples have the highest ones, with the agricultural groups being more variable. Therefore, lower values, even below 120°, are by no means unusual in medically normal individuals in nonindustrial societies [19].

Since build, physique, habits & genetic makeup vary markedly in different ethnic groups, it is possible that anthropometric dimensions described as normal for proximal end of femur for Westerners might be quite different from those encountered amongst Indians. Similarly the other anthropometric measurements can be seen to vary markedly from the Western values. It can also be seen that the implants designed for western skeletons occupy much more space in the Indian femoral head and neck [18].

There were no significant differences on right & left NSA in the present study which was similar to most of the other studies [7,18-20]. NSA are characteristically very high (150°) in neonatal modern humans & then gradually decrease during development, reaching adult values during adolescence [21,22].

Although there appears to be a minimal decrease in the angle in infants & juveniles who do not assume normal weight-bearing of the lower limb [21,22], the normal process of reduction in the angle to a more varus orientation of the femoral neck during development is dependent on the assumption of normal weight-bearing through the hip region & increasing locomotor activity levels during development [21,22].

This is particularly evident in cases of reduced or absent weight-bearing during development. This is seen in infantile congenital dislocated hip [23], slipped femoral capital epiphysis [25], cerebral palsy & immature idiopathic scoliosis [25].

In these cases of minimal weight-bearing, the femoral neck remains in a coxa valga position. Surgical correction of the condition with consequent normal weight-bearing produces a gradual decrease in NSA of femur over a period of a maximum of 2 years [23].

The higher the activity level, the greater the decrease in NSA from the neonatal value as the individual matures. From an adaptive perspective, the more varus orientation of the femoral neck, or the decrease in its neck-shaft angle, acts to reduce the moment at the hip joint, tending to sublux the femoral head [26] & thereby produces a more stable joint; this is especially relevant during the first decade of life, when the acetabulum is largely cartilaginous. These considerations thus indicate that the NSA is heavily influenced by load levels in the hip region during development.

At the same time, several studies have shown that the NSA is very stable from mid adolescence

through most of adulthood. Some decrease has been observed in cases of hip arthrosis [27]. The femoral NSA was measured previously by various methods which includes mechanical & radiological methods on dry bones, x-rays, dual-energy X-ray absorptiometry (DXA scan) [28] & CT scan [17].

There was good intra & inter observer reliability in measuring NSA using this novel computer assisted image analysis method. Hence this method is reliable. Upadhyay SS [29] & Nagar M [30] studied dry femora using USG & mechanical method. They found good inter & intra observer reliability in their methodology. Many western authors also observed good inter observer correlation in measuring NSA [31,32].

CONCLUSION

In the present study the mean NSA was 121.2°. There was no femur with NSA less than 93° & the maximum NSA observed was 136°. There was no significant difference in the NSA on right & left sides. There was good intra & inter observer reliability in measuring NSA. The findings of the present study will be helpful to the clinicians, therapists & researchers as ready references to NSA among South Indian population. Any deviation from this value should be correlated with clinical findings. It is hoped that these morphometric findings on NSA could be of some use possibly in designing prosthesis for Indian population. However, for the purpose of authentic use further progressive study in the same direction is desirable.

Conflicts of Interests: **None**

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