

Original Research Article

Evaluation of femoral neck shaft angle on plain radiographs and its clinical implications

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ABSTRACT

Background: The femoral neck-shaft angle is the measurement of the angle formed between the oblique oriented neck with the vertical shaft and is an important anatomic measurement for the evaluation of biomechanics of hip. The neck shaft angle is important in surgeries that involve the neck of femur, Intertrochanteric fractures, slipped capital femoral epiphysis, and developmental dysplasia of hip. Different variation of neck shaft angle has been seen in different literature and all the orthopedic implants are designed according to the values of the western literature which is different from the Indian subcontinent.

Methods: Pelvic radiographs of patients who presented to Accident and emergency care or the outpatient department were used in the study 110 patients radiographs were assessed in the study. There were 55 males and 55 females in our study. The mean age for males was 46.5 years and that for females was 43.2 years. The pelvis radiographs were studied for neck shaft angle. The measurements were performed bilaterally on the digital screen using the PACS (picture archiving and communication system) with handheld 360 degree goniometer.

Results: The mean neck shaft angle in our study was 129.26 degree for males and 126.62 degree for females. The overall mean neck shaft angle in 110 radiographs was 128.60 degree.

Conclusions: We conclude that consideration of neck shaft angles in orthopedics surgery and designing of implant can give more angle options for the surgeons which can improve the overall prognosis of the patient.

Keywords: Proximal femur, Neck shaft angle, Femoral neck, Geometry, Implants

INTRODUCTION

The hip joint is a ball and socket joint formed by the head of the femur and acetabulum. The femoral neck-shaft angle, also known as caputcollum-diaphyseal (CCD) angle or inclination angle or the Mikulicz angle is the measurement of the angle formed between the oblique oriented neck with the vertical shaft and is an important anatomic measurement for the evaluation of biomechanics of hip.¹ Involvement of the proximal femur

in various pathological conditions such as developmental dysplasia of hip, fibrous dysplasia, congenital coxa vara, osteoarthritis of hip changes the neck shaft angle and thereby alters the biomechanics and the gait.^{2,3} The neck shaft angle has an important role in gait as it clears femoral shaft off the pelvis during the swing phase.⁴ The proximal femur acts as a brace, and its biomechanical properties depends on the width and length of the femoral neck. The neck shaft angle is important in surgeries that involve the neck of femur, intertrochanteric fractures,

various osteotomies used in perthe's disease, slipped capital femoral epiphysis, during all types of osteotomies used in developmental dysplasia of hip, neuromuscular disorders of lower limb and during total Hip arthroplasty.⁵ The rotations and version of the femoral neck to the femoral condyles and its projection on the anterior posterior radiograph influences the implant choice during total hip arthroplasty and hence the rotational influences has to be considered using the biplanar radiographs.^{6,7} The implants which are used to treat the proximal femur fractures include the Sliding Hip screws, The proximal femoral nail, cannulated cancellous screws, angle blade plates and even hemi replacement with bipolar or unipolar prosthesis etc. Majority of these implants come with different angular options and are manufactured considering the biomechanics and anthropological data and body morphology according to the western world. The study was conducted as the skeletal dimensions and morphology of the Indian subcontinent is different than that of the western world.

METHODS

This is a retrospective study done at a tertiary care center. Pelvic radiographs of patients who presented to accident and emergency care or the outpatient department were used in the study. All patients between 20-70 years of age who had undergone pelvic radiograph in supine position with radiological normal radiograph as reported by the radiologist were included in the study. Demographic data like age and sex were also noted. All the radiographs of the pelvis were taken using standard protocols for AP pelvic radiographs. 10-15 degrees of internal rotation to see the complete profile of the neck, supine position and beam centered over the symphysis pubis.

The measurements were performed bilaterally on the digital screen using the PACS (picture archiving and communication system) with digital goniometer and hand held goniometers as given in Figure 1 and Figure 2 and reconfirmed using the AP films of the radiograph on the view box and measuring it with standard 360 degree manual goniometer.



Figure 1: Neck shaft angle.



Figure 2: Measurement of neck shaft angle in 48 year old male using PACS and 360° hand held goniometer.

The radiographs were measured by three different orthopedics trainees to increase the validity of the test. They were blinded to each other's findings. The neck shaft angle was measured by the intersection of the longitudinal axis of the shaft with that of femoral neck. Longitudinal angle of the shaft was obtained by joining two midpoints of the diameter of the proximal shaft and then at the lowest point of the shaft on the film. Longitudinal axis of the neck was obtained by joining two midpoints of the diameter of the neck and head of the femur. The center of the head of the femur was obtained using concentric circles. The angle formed by the intersection of the two longitudinal axis was determined as the NSA with the manual goniometer. The data was written in a proforma which included columns for age, sex and left and right neck shaft angle. The mean of neck shaft angle for males and females were calculated separately.

RESULTS

In this study we examined pelvic radiographs of 110 patients with equal distribution of males and females. The mean age of male population was 46.5 years and that of females was 43.2 years. The mean age of overall study population was 44.8 years (20 to 68 years) as presented in Table 1.

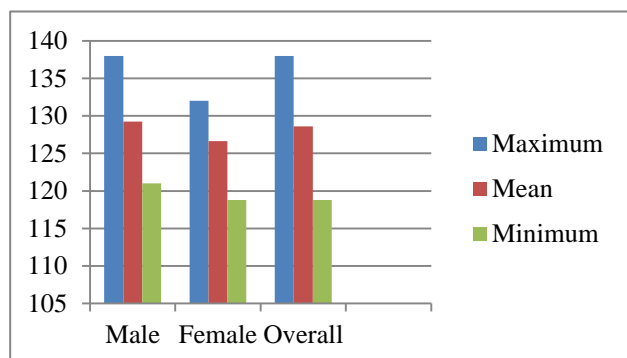
Table 1: Mean distribution of age.

Gender	Number	Mean age
Male	55	46.5 years
Female	55	43.2 years
Total	110	44.8 years

The mean neck shaft angle of males was 129.26 degree±4.22 (range 121 to 138 degree). The mean right side neck shaft angle was 129.6±4.61 and mean left side was 129.1±4.8. The mean neck shaft angle of females was 126.62 degree±2.52 (range 118.8 to 132 degree). The mean right side neck shaft angle was 126.86±3.68 and mean left side was 126.2±3.82. The mean neck shaft angle for total population was 128.60 as shown in Table 2 and Figure 3.

Table 2: Mean neck shaft angle distribution.

Gender	Mean NSA	Maximum	Minimum	Mean NSA (Left)	Mean NSA (Right)
Male	129.26	138	121	129.18	129.6
Female	126.62	132	118.8	126.24	126.8
Total	128.60	138	118.8	128.40	128.48

**Figure 3: Mean neck shaft angle.**

DISCUSSION

The studies on neck shaft angles have been done in different authors in different parts of the world. Variations in neck shaft angle has been found and this can be attributed to varying level of activity, genetics, race, diet and lifestyle.^{8,9} Despite lot of research in the anatomic and biomechanical factors which influence the modality of treatment of orthopedics conditions, consideration of neck shaft angle has gained less importance in assessment of hip biomechanics and preoperative planning and templating of hip surgeries.

In our study the mean neck shaft angle for males was 129.26 degree and that for females was 126.62 degree, and for the total population the mean neck shaft angle on the right side was 128.48 degree and that on the left side was 128.40 degree. This result is comparable to studies published in the literature. As due to wide variation in these angles there is a wide standard deviation. Ravichandran et al in their study of 578 dry femur found the mean neck shaft angle to be 126.55 degree in Indians.¹⁰ Hoaglund and Low stated that the average neck shaft angle in Caucasian and Hong Kong Chinese people is 135 degree.¹¹ Togwood et al published their work on 375 normal femurs and found the mean NSA as 129 degrees.¹² Highest variation for the neck shaft angle was seen between western literature and Mongoloids. Saikia et al in their study of 104 individuals concluded the neck shaft angle in the north east population to be around 139.5 degree.¹³ The overall mean value in our study was 128.6 degree (range 118 to 138) is comparable to studies by Togwood et al and Gilligan et al.^{12,14} The mean Neck shaft angle in study by Gilligan et al was 126.4±5.57 involving multiple parts of world. The value documented for Nigeria was 129.5 degrees. Gilligan et al also

documented neck shaft angle values for other countries around Nigeria and these include NSA value of 132.3° for Chad, 130.8° for Mali, 132.5° for Senegal and 130.5° for Sudan. In regard to bilateral symmetry our study showed no significant difference in the means of neck shaft angle of right and left side in either sex. Chhiber et al in his articles on dominance of limb suggested that left limb is more dominant and even if person is right handed he uses left lower limb for weight bearing.¹⁵ Whereas De Sousa et al showed that a person has a natural tendency for bilateralism and he did not find any difference between sides.¹⁶ In retrospective study of 100 patients by Chiuck et al he concluded that the mean neck shaft angle of females (135.9) were higher than that of males (135.9).¹⁷ In this study we did not find statistically significant difference between the neck shaft angle between right and left side. In this study we found neck shaft angle to be on higher side for males than for females but this difference was statistically insignificant ($p > 0.005$). This finding is similar to other published studies.^{18,19} In this study we conclude that there is variability in the neck shaft angle between the published literatures and this could be due to various factors like ethnicity, race, lifestyle and diet. The importance of neck shaft angle lies in the diagnosis, treatment of various orthopedics conditions like developmental dysplasia of hip, osteoarthritis of hip, slipped capital femoral epiphysis and various valgus or varus osteotomies. We did not group the neck shaft angle according to age group and hence to conclude the NSA in specific age group or the change in neck shaft angle in old age cannot be commented upon, this may be the limitation of the study.

Consideration of neck shaft angle in designing and bioengineering orthopedic implants and hip prosthesis might change longevity of implants and less difficulty in fixing the fractures of proximal femur.

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