Radiographic Anatomy of the Neck-Shaft Angle of Femur in Nepalese People: Correlation with its Clinical Implication

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ABSTRACT

Background

Neck-shaft angle (NSA) is one of the prominent features in the proximal femur which is an important determinant of fracture of femoral neck. Present study evaluating the value of neck-shaft angle has relied heavily on radiographs. As knowledge of neck-shaft angle is important to orthopaedic surgeons, there is need to elucidate whether there is significant variation of this angle among the two different genders and various age groups of both right and left femora of Nepalese population.

Objective

To ascertain the value of neck-shaft angle in the Nepalese population by means of a radiographic study and to correlate the values with regard to right neck-shaft angle/ left neck-shaft angle side (RNSA/LNSA), gender and three different age group.

Method

Normal pelvic radiographs of 148 patients seen at department of orthopedic and radiology, College of Medical Sciences- Teaching Hospital (COMS-TH), Bharatpur, Chitwan from the month of February 2017 to June 2017 were divided into two different gender and three different age groups (21-40 years, 41-60 years and Above 60 years) and their neck-shaft angle of both right and left sides were recorded.

Result

The average of RNSA and LNSA were found to be 132.96±6.05° and 131.54±13.66° respectively for male and 134±6.57° and 132.98±6.23° respectively for female. In total the average RNSA and LNSA were 133.51±6.32° and 132.26±10.61° respectively. Similarly, the average RNSA and LNSA for three different age groups (21-40 years, 41-60 years and Above 60 years) were found to be 133.76±6.44°, 133.69±6.36° and 132.50±6.06° and the 133.35±6.29°, 132.47±5.85° and 128.84±21.98° respectively.

Conclusion

The average neck-shaft angle recorded here shows no significant difference in both RNSA and LNSA in males except for a small and significant difference in LNSA in female of three different age groups.

KEY WORDS

Left neck-shaft angle, Neck-shaft angle, Pelvic radiographs, Proximal femur, Right neck-shaft angle

INTRODUCTION

Proximal femoral geometry bears one of the most conspicuous anatomical landmarks as Neck-shaft angle (NSA), which is the angulation between the long axis of femoral shaft with the axis of femoral neck. It is also known as femoral carrying angle, angle of inclination, cervico-diaphyseal angle and collo-diaphyseal angle.[1] The value of NSA is an important assessment of the biomechanics of the hip and clinical orthopedics for the planning of operations.[2] The value of NSA ranges from 115°-140° (mean of 126°).3 The angle decreases gradually from around 150° in newborns to around 133° at 15 years of age.[4,5] However apart from age, this angle also varies with stature, width of pelvis, in person with short limbs and in women.[6]

The femoral NSA is the result of the evolution of erect posture and the bipedal locomotion in man. This angulation results in structural weakness at this junction and a special consideration should be given during proximal femoral surgery and total hip anthroplasty. The large disparity in NSA is one of the main diagnostic features for the clinicians to detect femoral neck fracture.[7] Thus identifying the normal ranges of NSA and their influencing factors may help clinician for the better preoperative plannings.[8] Most of the study relied on radiographs or Computed Tomography Scan. Thus, it becomes obligatory to obtain highly standardized antero-posterior radiograph of pelvis to correctly assess the NSA.[9]

Majority of the implants which are used to treat proximal femur fractures are designed considering the anthropological data and body morphology to the western world. The normal value of femoral NSA has only been standardized for western population and the study conducted of Nepalese population may or may not correspond to that of the western world. Foremost, normal range of NSA in Nepalese population is lacking which might be quite different from those encountered.[10] It is crucial to match the dimension of the implant with those of femur. Inappropriate and incorrectly placed prosthesis might cause aseptic loosening and improper load distribution causing huge discomfort to the patient and ultimately affecting long term success of the operation.[8,11]

METHODS

An observational cross-sectional study was initiated after approval of Ethical Review Committee, in College of Medical Sciences - Teaching Hospital in the department of Radiology and Orthopedics. The study was conducted from February 2017 to June 2017 on the pelvic radiographs of 148 patients with equal number of both male and female, from 21 to above 60 years of age. Antero-posterior view of Pelvic radiographs of patients who presented to accident and emergency care or the outpatient department were used for evaluation. History of each patient was obtained by interviewing patients used in the study. None of the radiographs was produced for occupational reasons. Digital radiographs of patients with osteoarthritis, metabolic diseases, renal failure, hip fractures and pathological (metastatic) hip fracture were excluded.

All patients 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° of internal rotation to see the complete profile of the neck, supine position and beam centered over the symphysis pubis. The radiograph was taken at routine object film distance of 5 cm and focal film distance of 92 cm in the antero-posterior view while the big toes touching on their medial aspects (femur in internal rotation of 10° – 15°). The value of NSA were measured bilaterally on the digital screen using the software digimizer as given in Figure 1 and Figure 2 .

Image Analysis in Digimizer Software:

1. Center of the femoral head: It was obtained using concentric circles with the center of the circles best fitted for the femoral head.

2. Center of neck: It was obtained by joining the mid points of the lines passing through diameter of femoral neck

3. The head-neck axis: A line was drawn from the center of femoral head and passing through the midpoint of diameter of femoral neck.

4. Femoral Shaft axis: It is represented by joining following two centre points on the anterior surface of the shaft.

a. First at the proximal end of femur where the inter-trochanteric line ends.

b. Second at the midway between both the ends of the femur.

5. NSA: The angle between the head-neck axis and the femoral shaft axis

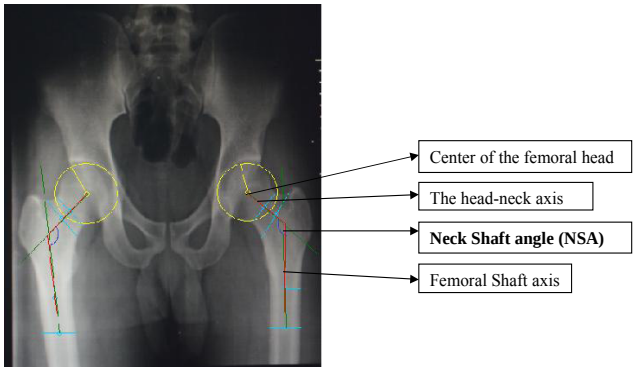

Figure 1. Anteroposterior radiograph of male pelvis, showing the measurement of NSA

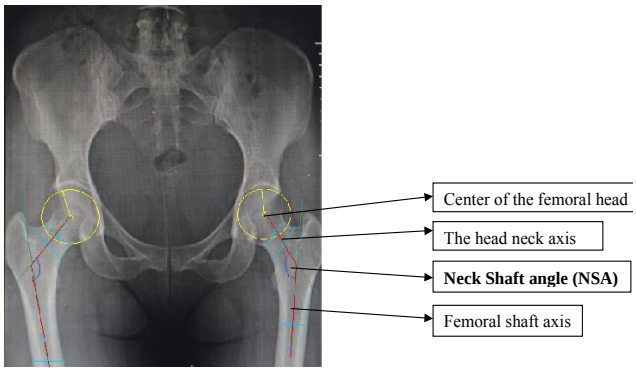

Figure 1. **Anteroposterior radiograph of male pelvis, showing the measurement of NSA**

After the measurement in digimizer software, the data was entered into Epi Data version 3.1. After the double checking on the completeness of the data, it was analyzed by using SPSS version 20.0. In descriptive statistics, frequency, percentages were found, for normally distributed data, mean and Standard deviation was calculated. Inferential statistics independent and pair sample t-test were used. In our study, sample size was 148. So, Kolmogorov Smirnov test was used to check the normality of data. Here all (age, LNSA, RNSA) data was normally distributed (p-value>0.05)

RESULTS

In this study we examined pelvic radiographs of 148 patients, 74 males and 74 females. The mean age of male patients was 45.70±18.33 years (95% CI: 41.45-49.95 years) and female patients was 41.60±14.60 years (95% CI: 38.22-44.99 years) while the mean age of total patient was 43.56±16.64 years (95% CI: 40.95-46.35 years) as shown in Table 1.

Table 1. **Mean age of male, female and the total patients.**

Gender	Number	Mean age	95% CI for mean	
			Lower bound	Upper bound
Male	74	45.70±18.33	41.45	49.95
Female	74	41.60±14.6	38.22	44.99
Total	148	43.56±16.64	40.95	46.35

All the patients were categorized into three different age groups ranging from 21-40, 41-60 and above 60. The highest number of patients, including both male and female were in age group 21-40 followed by age group 41-60. The least number of patients, including both male and female were in age group above 60.

The total mean of RNSA of both male and female were 132.96±6.05° and 134.06±6.58° respectively while the mean of LNSA of both male and female were 131.54±13.67° and 132.98±6.25° respectively as shown in Table 3. The mean calculated shows no significant differences between RNSA and LNSA. Similarly, the total mean of RNSA of all three age groups(21-40 years, 41-60 years and Above 61) were 133.76±6.44°, 133.69±6.36° and 132.50±6.06° degree respectively while the mean of LNSA of all three age groups (21-40 years, 41-60 years and Above 61) were 133.35±5.29°, 132.47±5.85° and 128.50±21.98° respectively as shown in Table 3. It also revealed that the mean NSA of both right and left sides shows no significant differences all three age groups.

Table 2. **Total number of male and female patients of three different age groups.**

Age groups (years)	Gender		Total
	Male	Female	
21-40	34	42	76
41-60	22	23	45
Above 60	18	9	27
Total	74	74	148

Table 3. **Comparison of mean RNSA and LNSA in two genders**

Gender	Mean(RNSA)	Mean(LNSA)	t-value	p-value
Male	132.96±6.05°	131.54±13.66°	0.99	0.32
Female	134.05±6.57°	132.98±6.24°	2.19	0.03
Total	133.51±6.32°	132.26±10.61°	1.66	0.09

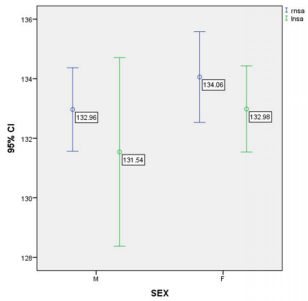

Figure 3. **Confidence Interval of mean RNSA and LNSA in both the genders.**

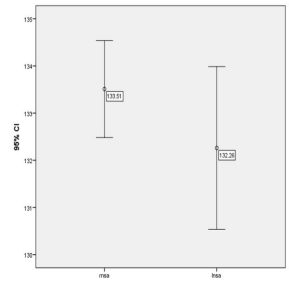

Figure 4. **Confidence Interval of mean RNSA and LNSA in all the population.**

Table 4. **Comparison of mean NSA in two genders and three different age groups**

NSA	Gender	Mean (degree)	Test Statistic	Significance (p-value)
RNSA	Male	132.96±6.05°	t=1.05[a]	0.29
	Female	134.06±6.58°		
LNSA	Male	131.54±13.67°	t=0.83[a]	0.41
	Female	132.98±6.25°		
NSA	Age groups	Mean	Test Statistic	Significance
RNSA	21-40	133.76±6.44°	f=0.41[b]	0.66
	41-60	133.69±6.36°		
	Above 60	132.50±6.06°		
LNSA	21-40	133.35±5.29°	f=1.84[b]	0.16
	41-60	132.47±5.85°		
	Above 60	128.84±21.98°		

[a]Independent t-test
[b]oneway ANOVA test

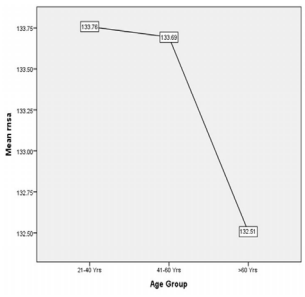

Figure 5. Confidence Interval of mean RNSA in all three age groups.

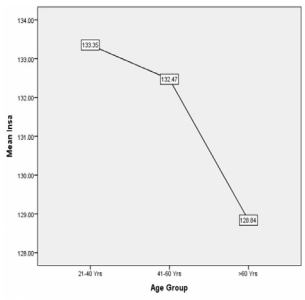

Figure 6. Confidence Interval of mean LNSA in all three age groups.

DISCUSSION

The biomechanical goals of total hip anthroplasty and any of the hip surgeries are to create a stable anatomical articulation with an optimum range of movement, to restore normal biomechanics for muscular efficiency and to equalize the limb length.[12] One can achieve this goal with proper knowledge of anatomy of proximal femur. Femoral NSA is one of the important landmarks during hip surgeries and for designing as well as placing the femoral implant during total hip anthroplasty.[13] This study contributes to this knowledge by using radiograph of antero-posterior view of pelvis taken in standard position. Most of the standard prostheses available in the market are designed on the data available from the Western population. This study mainly focus on the knowing the normal range of NSA in Nepalese population and design the prostheses on these outcomes.

Several studies on femoral NSA had been examined by several authors on the basis of radiographs, CT scan or even the cadaveric bones. Some authors found considerable variation in this angle in different countries, regions and ethnicity. The classic text books of anatomy quotes the NSA as 120° which may vary from 110° to 140°.[14] In present study, it was found that the total mean of RNSA and LNSA of all subjects were 133.51±6.32° and 132.26±10.61° respectively. According to Standring et al., the average NSA in adults is 128°.[15] According to Ferrario et al., asymmetry between the right and left femoral NSA is a common finding in human beings and that there is a weight, length and shape asymmetry of long bones in humans when analysed from mathematical stand point.[16] Our study suggests that there is no significant difference in the right and left femoral NSA in total population (p=0.09) and in male (p=0.32) but in female it was found to be with significant difference (p=0.03) and the mean NSA of the femur in right side is more than that of left side whether the person is right handed or left handed. It suggests that more people used right lower limb for weight bearing. In contrast, the study carried out by Chaubber and Singh showed higher values of NSA on left femur than in right one.[17]

According to the study demonstrated by Aasis Unnanuntana et al, the proximal femoral NSA was different between genders. The average femoral NSA was higher in males than in female.[18] In the study conducted by Professor F.G. Parsons on dry bones of medieval English people, the results suggested it to be 126° in males and 125° in females.[19] However, our study concluded that there is no significant difference in both male and female (p=0.29 and p=0.41 respectively). Nelson and Magyesi studied sex and ethnic differences in bone architecture and therefore established the need of gender specific implants.[20] But our study confirms that no separate gender implants must be designed for the opposite gender. Unlike other studies, our study also compares the femoral NSA of both sides in different age groups ranging from (21-40 years, 41-60 years and Above 60 years). The angle is greatest at birth and decreases gradually, from around 150° in newborns to around 133° at 15 years of age.[16,21] Results from our finding revealed that NSA does not differ much in age after the age of 21. Although it is mentioned that it increases with age,16 our study concluded that there is no significant changes in both RNSA and LNSA (p=0.66 and p=0.16 respectively) with age. Thus, it showed that there is no significant correlation with age.

The limitation of the study comprises small sample size and the patients below 21 years of age were not included in the study because there were very limited numbers of patient below that age. Further there were no equal numbers of patients in all three different age groups as we were focused more on equal distribution of gender than the equal distribution of different age groups.

CONCLUSION

Although various methods exist for the study of NSA of femur, we propose a reliable and cheap method on radiograph of pelvis. The present study establishes the relation among NSA between genders, age groups and left and right sides. The study concluded that there is no significant difference in NSA between left and right in male although there exists small but significant difference in female of Nepalese population. Similarly there is no significant difference in both right and left NSA across different age groups of Nepalese population. Data obtained from this study may be used as a normal value of NSA in Nepalese population for the manufacture of implants that are used to treat proximal femur factures and for long term success of the operation.

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