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An anthropometric study for determination of femoral neck shaft angles on pelvic radiographs in Indian population from hilly area.

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ABSTRACT & KEYWORDS:
BACKGROUND/INTRODUCTION: *The femur is the longest and heaviest bone in the body, the proximal femur is "bent" (L-shaped) so that the long axis of the head and neck projects superomedially at an angle to that of the obliquely oriented shaft.[1] Neck Shaft Angle is an important anatomic measurement for the evaluation of biomechanics of hip.[2] Most of the implants have different angular options because they are manufactured by the consideration of data and body morphology, biomechanics and anthropology according to western world. So present study aim was to measure as the skeletal dimensions and morphology of the Indian subcontinent in the same time with in Indian subcontinent there is fewer study in hilly terrain and their no studies in district Chamba, H.P.*
AIM: *To evaluate the variability and range of the neck-shaft angle (NSA) in our patient population using plain radiographs of bilateral, unaffected hips.*
METHODS: *Pelvic radiographs of eligible individuals of age between 20-70 years, who present themselves for hip pain/fracture at tertiary care Institute, Pt. Jawahar Lal Nehru Govt. Medical college & hospital, Chamba, H.P. Data like age, sex, height, weight were recorded and their neck-shaft angle of both right and left sides was measured on the digital screen by using IMAGE WORKS,DICOM WORKSTATION(Samsung) software. . The obtained results statistically analysed.*
RESULT: *In present study neck shaft angle of femur in male population on right side 125.10° and left side 124.34°, in female population 127.32° & 124.49° on right and left side respectively. According to statistical analysis on left side in both male and female NSA have similarity but in female population on right side in comparison to male population had higher value that is 127.32°.*
CONCLUSION: *These finding is valuable when selecting an appropriately angled implant, considering variations in hospital inventory and surgeon preference.*
KEYWORDS: *Digital Pelvic radiographs, Neck-shaft angle, Proximal femur.*

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I. INTRODUCTION:

The heaviest and longest bone in the body is femur, length of femur is around a quarter of the person's height. The proximal end of femur is "bent" (L-shaped). The long axis of the head and neck projects as obtuse angle on superomedially to that of obliquely oriented shaft. This angle of inclination, at birth is greatest (most nearly straight) and gradually diminishes (becomes more acute) in adult, angle is approx. (115-140°, averaging 126°). (1).

The angle between femoral neck and shaft, known by many names like as caput-collum diaphyseal angle and collum diaphyseal angle. (3) The slope of the femoral neck is in line with the forward and upward propulsive thrust of normal progression. (4) The measurement of angle formed is between oblique oriented neck with proximal vertical shaft. It is important anatomic measurement for evaluation of biomechanics of hip. The NSA of femur is important in the control mainly lateral balance at the time of mobility. (5) The angle of the Neck shaft in femur varies and in female it is noticed to be smaller. (6) (it may be due to wider pelvis which leading to

greater inclination of bone shaft on the neck). The femoral NSA is generally set at 125°, but it can vary from 120° in females to 140° in males. [3,5,7] Variations in NSA could be due to, age, sex, side (left or right), BMI, climate (leading to regional differences in body shape), activity (e.g. mobile and sedentary lifestyles). [8,9,10]

In Coxa valga there is increased chances of femoral fracture at proximal end and this condition also associated with medial compartment knee arthritis whereas greater trochanteric pain syndrome, osteomyelitis, osteogenesis imperfecta, Paget's disease, osteoporosis may be associated with less femur angle of neck shaft that is coxa vara. [11,12,13]

Femur is widely researched bone in fields of anthropology, orthopaedics, forensic and human kinematics. In orthopaedics research morphometric analysis of femur involved for joint studies to design intramedullary fixators and also helpful to predict the axes for orthopaedic surgery. In particular, neck–shaft angle is frequently used for diagnostics, preoperative planning, and therapy. The neck shaft angle value 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. Accurate assessment of the patient's native neck-shaft angle (NSA), also known as the caput-collum-diaphyseal angle, is critical to prevent varus malreduction. In the nonavailability of pre-injury radiographs, the contralateral NSA of femur is commonly used as a reference radiograph. However, NSA measurement methodologies vary significantly across studies. Boese et al. review revealed inconsistencies in measurement descriptions across 26 publications, with inter-rater reliability ranging from an intraclass correlation coefficient (ICC) of 0.58 to 0.89. Reported measurement error ranges from ±2° to 6°, potentially leading to iatrogenic varus malreduction and implant failure. Consequently, this study focuses on the Indian population, specifically the sub-Himalayan region of northwestern India, due to the distinct skeletal morphology of this population compared to Western populations and the limited existing research in this demographic.

II. AIM & OBJECTIVES:

To evaluate the variability and range of the neck-shaft angle (NSA) in our patient population using plain radiographs of bilateral, unaffected hips.

Primary objective: To determine the mean value of femoral neck shaft angles (NSA) in population of north eastern region of Himachal Pradesh, India, using pelvic radiographs of individuals with normal proximal femoral geometry, hip osteoarthritis.

Secondary objective: To correlate femoral neck shaft angle with laterality (Right NSA/ Left NSA) and gender.

III. METHODS

This study was hospital-based retrospective (6 months data) and prospective study (6 months from date of approval) (Study duration 22/09/2020 – 28/02/2022) by collecting digital pelvic radiographs of patients, with the help of department of radiology and department of Orthopaedics, of individuals of age between 20-70 years, who present themselves for hip pain/fracture at tertiary care Institute, Pt. Jawahar Lal Nehru Govt. Medical college & hospital, Chamba, Himachal Pradesh. [EC Ref. No. - SPRC/RC/GMC-CBA/20/08/05 dated 21/09/2020]

To obtained femoral NSA (angle measured between long axis of oblique oriented neck with long axis of proximal vertical shaft), Pelvic radiography (AP view) would done in supine position on X-ray table with both lower limbs parallel to each other with 10-15 degrees of internal rotation to see the complete profile of the neck, and beam centred over the symphysis pubis.[14]

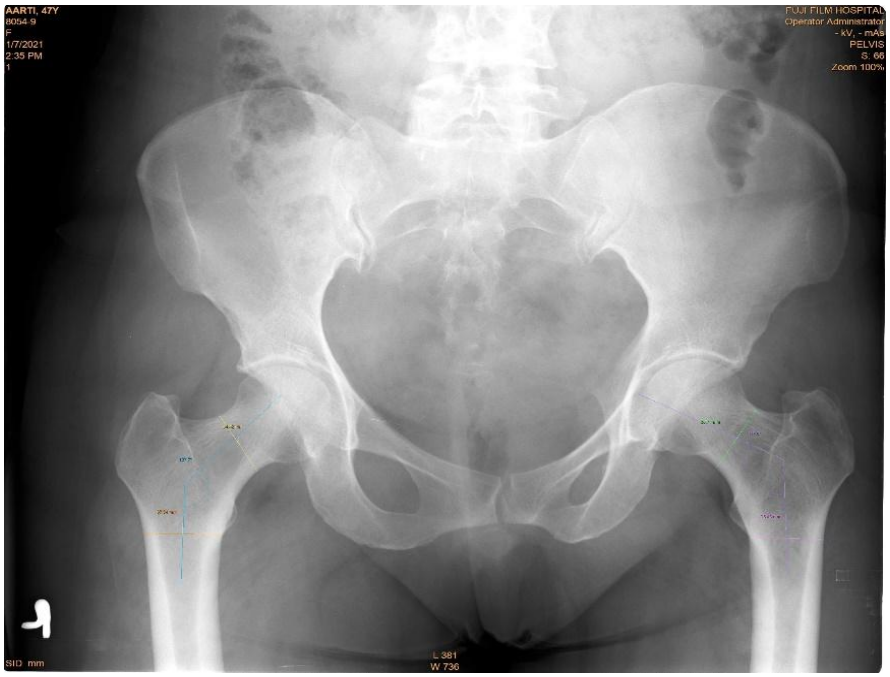

Figure 1 Shows femur neck shaft angle measurement

Data like age, gender was recorded and their neck-shaft angle of both right and left sides femur was measured on the digital screen by using IMAGE WORKS, DICOM WORKSTATION (Samsung) software.

IV. RESULTS

	Number of samples	Mean	Std. Deviation	Std. Error Mean	P value
Right side	261	126.3621	5.93506	.36737	<0.001
Left side	261	124.4149	5.73149	.35477	0.001

Statistical highly significant p value (0.001) less than 0.05.

Table 1- Total (normal and avascular necrosis) samples right and left side.

	Number of samples	Mean	Std. Deviation	Std. Error Mean	P value
Right side	239	126.2582	5.60347	.36246	0.001
Left side	239	124.4226	5.84703	.37821	0.001

Statistical highly significant p value (0.001) less than 0.05.

Table 2- Normal samples right and left side comparison.

	Normal/ Avascular necrosis	Number of samples	Mean	Std. Deviation	Std. Error Mean	P value
Right side	Normal	239	126.2582	5.60347	.36246	.909
	Avascular necrosis	22	127.4909	8.87731	1.89265	(>0.05)
Left side	Normal	239	124.4226	5.84703	.37821	.151
	Avascular necrosis	22	124.3318	4.38682	.93527	(>0.05)

(p value 0.151) Statistical no significant p value.

Table 3 – Normal & Avascular necrosis right & left

	Gender	Number of samples	Mean	Std. Deviation	Std. Error Mean	P value
Right side	Male	130	125.3377	6.26114	.54914	.680
	Female	131	127.3786	5.42759	.47421	(>0.05)

Left side	Male	130	124.3938	5.43997	.47712	.322 (>0.05)
	Female	131	124.4359	6.02772	.52664	

It is Statistical not significant p value (>0.05) more than 0.05.

Table 4- All samples (Normal and Avascular necrosis) collective gender comparison on Right & left side.

Normal samples right and left on gender wise comparison-

In normal samples of male in right and left side neck shaft angle mean is 125.10.(p value .002) and 124.34. (p value .844) respectively. Samples of female on right side neck shaft angle mean value is 127.32.(p value .002) and on left side neck shaft angle mean is 124.49. (p value .844). **For right side in both male and female Statistically significant p value (0.002) less than 0.05. whereas** for left side in both male and female Statistical not significant p value (0.844) more than 0.05.

V. DISCUSSION

Table- 5 shows data of Femur Neck Shaft Angle in other studies and in present study.

Author, year	Method	Population	Age(range)	Male (Mean (SD))		Female (Mean (SD))	
				Right	Left	Right	Left
Alonso et al. 2000	DEXA	Spain	70	126.3 (4.4)		124.6 (4.2)	
Doherty et al. 2008	AP radiograph	England	64	Right 128.3 (7.1) Left 128.3 (7.1)			
Kaptoge et al. 2008	DEXA	US	74			127.2 (6.0)	
HD Atkinson 2010	AP radiograph	British	----	129		128	
Elbuken et al., 2012	DXA	Turkey	20–108	129.6		129.1	
Rawal *et al*., 2012	CT of patient hips	Indian	----	124.42±5.49			
Bagaria et al. 2012	AP radiograph	India	20–80	127.7 (3.9)		126.6 (4.8)	
Gilligan et al. 2013	Femora			126.4 (5.6)			
Mitra et al. 2014	AP radiograph	Iran	24–57	127.5 (5.3)	127.6 (5.6)	125.4 (6.0)	126.6 (6.3)
Boese et al. 2015	CT, coronal	Germany	53, 54	129.6 (5.9)		131.9 (6.8)	
				R 130.8 (6.7) L 130.8 (6.3)			
Dimitriou et al. 2016	3D CT	US	31–58	R 126.7 (4.8) L 126.6 (4.5)			
Thomas Oduntan Adekoya Cole et al 2016	AP radiograph	Nigeria	-------	131.91±6.14	131.15±5.07	130.66±7.16	129.40±5.31
Cornelius S FISCHER et al 2020	MRI coronal plane	Germany	21–90	126.5 (6.8)		127.4 (6.6)	
Present study 2021-2022	AP radiograph	Indian	20- 70	125.10±5.44	124.34±5.52	127.32 ±5.56	124.49 ±6.15

Given the aforementioned data, it may be reasonable to utilize a fixed angle implant that mirrors native anatomy. From pre-operative radiographs contralateral neck shaft angle may ensure selection of an impact with an NSA that matches or is greater than native NSA.

Akbar w. and Kalimullah study, found that mean value of neck shaft angle in females was 137^0, which was significantly higher than male. [(5)] and was consistent with a study by Yoshioka, Tardieu, and Massaki, in which mean neck shaft angle in females was higher than male.

According to the study demonstrated by Aasis Unnanuntana et al, the proximal femoral NSA was different between genders. The average femoral NSA measurement was higher in males than in female.

Research study conducted by Professor F.G. Parsons, on medieval English people's dry bones, the results suggested it to be 126° in males and 125° in females.

Shrestha R, et al conduct a study in year 2018, found that the total mean of right NSA of both male and female in his study were 132.96±6.05° and 134.06±6.58° respectively while the mean of left NSA of both male and female were 131.54±13.67° and 132.98±6.25° respectively. The mean calculated shows no significant differences between right and left NSA. study suggests that there is no significant difference in the right and left femoral NSA in total population. [(9)] In contrast, the study carried out by Chaubber and Singh showed higher values of NSA on left femur than in right one.

According to Radha Pujari at el (2015) study the neck-shaft angles at random were found to be from 113° to 142° and average data of NSA being 127.55°. [(3)]

In present study neck shaft angle of femur in male population on right side 125.10° and left side 124.34°, in female population 127.32° & 124.49° on right and left side respectively. According to statistical analysis on left side in both male and female NSA have similarity but in female population on right side in comparison to male population had higher value that is 127.32°.

VI. CONCLUSION

Current proximal femur fracture fixation techniques may utilize the contralateral femur as a reference. [(15)] Accurately assessing and understanding inter-individual variability in bilateral femoral anatomy is critical for determining the suitability of contralateral femoral neck-shaft angle (NSA) utilization during proximal femur fixation. This study's findings support the use of the contralateral femur as a reliable reference for fracture fixation, demonstrating a strong positive correlation between bilateral femoral NSA in both male and female patients.

Implant selection presents complexities; the surgical objective is not only to restore anatomical neck-shaft angle (NSA) but also to optimize reduction and subsequent healing. [(15,16)] . This finding is valuable when selecting an appropriately angled implant, considering variations in hospital inventory and surgeon preference. These data may also prove beneficial in managing bilateral proximal femur fractures or cases involving significant contralateral femoral deformity, rendering contralateral NSA measurement unreliable.

Limitations- Femoral neck shaft angle (NSA) measurements may have been influenced by pelvic radiograph acquisition, as hip rotation is a known source of measurement variability on plain films [(17, 18, 19)]. To account for femoral rotation and version, biplanar radiographic techniques have been established [(20, 21)]. Our standardized anteroposterior pelvic radiographs were obtained with patients standing, encompassing the iliac crest and femoral shaft for precise angle calculations. Extremities were maintained parallel and neutral, with toes pointing directly forward [(22)]. Our musculoskeletal radiology technicians consistently adhered to this positioning protocol to minimize rotational discrepancies. Although we did not employ biplanar imaging, our methodology has demonstrated adequate performance in prior evaluations [(23)]. However, the use of standing, weight-bearing anteroposterior pelvic radiographs may limit the generalizability of our findings to supine imaging, which is typical for patients with femoral fractures. Furthermore, patients are not weight-bearing intraoperatively during hip fracture repair.

Conflicts of Interest (Financial and/ or non-financial) – NIL

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