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ANTHROPOMETRIC MEASUREMENTS OF PROXIMAL FEMUR IN INDIAN POPULATION-A COMPARATIVE STUDY BETWEEN DIGITAL RADIOGRAPHY& DRY BONE MEASUREMENTS

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ABSTRACT　**Introduction** The anatomy of proximal femur varies according to races and geographical distribution of people therefore understanding of the normal range of proximal femoral parameters is important to distinguish femoral deformity from normal anatomical variation.

Methods All eligible subjects underwent detailed measurements of proximal femur by Digital Radiography and Dry Bone Method.

Results Digital radiography group and in dry bone group mean Femoral head Antero-posterior diameter was 45.25+_1.80 and 44.5+_1.80mm, mean Femoral head transverse diameter was 45.22+_2.47 and 44.55+_2.43mm, mean Transverse diameter of femoral neck was 25.59+_3.70 and 25.09+_3.65mm, mean Femoral neck length was 47.88+_3.85and 46.88+_3.77mm, mean Horizontal offset was 47.35+_4.20 and 45.31+_4.67mm and vertical offset was 45.96+_3.13 and 44.97+_2.97mm, mean Femoral canal diameter at 20mm above lesser trochanter was 38.22+_6.15mm and 34.31+_4.03mm, at level of lesser trochanter was 26.08+_4.73 and 24.16+_4.16mm and below 20mm from lesser trochanter was 21.22+_3.39 and 18.54+_4.77mm respectively.

Conclusion The results of this study indicate that marked differences do exist in dimensions between femur of Indian population and that of populations of other regions of the world as well as between male and female femora within Indian population.

KEYWORDS : Proximal femur, lesser trochanter, horizontal offset,implants

Introduction Femur is the weight bearing typical long bone of lower limb which extends from the pelvis to the knee. The anatomical knowledge of different dimensions of femur are very essential in anthropological and medico-legal practice for sex determination and as well as to radiologists, rheumatologists and orthopaedic surgeons for diagnosis and planning of treatment[1].

The anatomy of proximal femur varies according to races and geographical distribution of people. Therefore, the use of implants designed based on other populations posed potential major issues. Dry bones, these parameters can be measured by CT, X-rays and clinically. Because of wide variation in health infrastructure in our country, it may not be possible measure these parameter by uniformly accurate CT method. It is important to know the true value of these anthropometric parameters of proximal femur in our population and its relationship to values obtained by various other methods in different studies. X ray imaging as a modality of investigation is quite commonly available in most of our health institutions. Therefore, this prospective study has been undertaken to ascertain and correlate proximal femoral anthropometry in Indian population presenting to us so that this figure may be applied for various orthopaedic diagnosis and procedures.

Aim & Objectives To compare anthropometric measurements of proximal femur by using digital Radiography of pelvis and hip with that of dry bones by Morphometric measurements. Evaluate any variations of these measurements attributable to Age and Gender.

Materials & Methods This was a prospective hospital-based study conducted in the Department of Anatomy, Orthopaedics and Radiodiagnosis at Dr RPGMC Kangra at Tanda.

Inclusion criteria: All consecutive patients between 18-60 years of age presenting with pain hip, spine or lower limbs were included in the study after informed consent.

Exclusion criteria: Age less than 18 years, patient with fracture proximal shaft of femur, fracture of neck/ head of femur, Old operated cases of above mentioned fractures, Patient with deformity in hip, Osteoarthritis of hip

Group A Digital Radiography Method
Enrolled patients were subjected to detailed history and clinical examination. Intervention in the form of plain X ray both hips and both femora was taken with patient in supine, both lower limbs in 15-30° internal rotation and beam centred over symphysis pubis at a distance of 100 cm.

Medio-lateral diameter of femoral canal above 20 mm of lesser trochanter, at the level of lesser trochanter and below 20 mm of lesser trochanter were measured by digital radiography scale. Femoral Head Diameter was determined by drawing of a perfect circle around the femoral head both in AP and Transverse view by using digital radiography scale.Femoral Neck Length was determined by detecting the Center of femoral head by overlapping Mose circles on femoral head radiograph .Distance from centre of femoral head to tip of lesser trochanter in AP view of digital X-ray by using digital radiography scale. Femoral Neck Diameter was measured by using digital radiography scale at the narrowest part of the neck in AP and Lateral view. Horizontal Offset and vertical offset was determined by measuring the perpendicular distance from the centre of femoral head to the tip of greater trochanter and tip of lesser trochanter respectively by using digital radiography scale.

Group B Dry Bone Method: Dry bone femora in age group18-60 years were included for study in this group. Cross-section area of canal Above 20mm from Lesser trochanter, at level of lesser trochanter and Below 20 mm from Lesser trochanter of shaft of femur was taken and Meadio-lateral canal diameter was measured using varni-calipers. Femoral Head antero-posterior diameter was determined by using Vernier calliper to measure the antero-

posterior (vertical) diameter of the femoral head. It was taken at right angle to the long axis of neck femur which meant the straight distance between the most superior to the most inferior point of the femoral head in a vertical plane. Transverse diameter was determined by using Vernier-calliper to measure the transverse diameter of femoral head. It was taken at right angle to the long axis of the neck of femur which meant the maximum distance of femoral head in horizontal plane. Femoral Neck diameter was determined by measuring the width of the neck by verniercalipers at the narrowest part of neck in AP and transverse plane. Neck length was determined by measuring the length of the neck along the long axis of the neck both anteriorly and posteriorly using verniercalipers. Anteriorly the length was measured between the centre of base of head and the mid-point of the intertrochanteric line. Posteriorly the length was measured between the mi point of base of the head and midpoint of intertrochanteric crest.Vertical offset was measured by using vernier-calipers created by intersection of two lines. A line from centre of femoral head and another line perpendicular from lesser trochanter. Horizontal offset was determined by measuring the perpendicular distance from the centre of femoral head to tip of greater trochanter.

Statistical Analysis: Data were presented as frequency, percentage, and mean ±SD wherever applicable. Difference between continuous and categorical variables was analysed using student t test and chi square test respectively. P value less than 0.05 was considered significant. Statistical analysis was performed using SPSS (Statistical Package for Social Sciences) trial version 23.

Results
The result of present study are tabulated from table 1 to 11 where letter **A** represents Digital radiography (n=66)[a], **B** represents Dry bone (n=77)[b] in males and **C** represents Digital radiography(n=23)[c], **D** represents Dry bone(n=16)[d] in females.

Table1. Age and Sex-based distribution of patients

	Digital Radiography (n=89)	Dry Bone(n=93)	P Value
Age (years)	37.31±10.11	46.64 ± 7.71	0.0001
Sex (M:F)	66:23	77:16	0.2057

Table.2 Mean of Canal diameter 20 mm above lesser trochanter in males and females in digital radiography and dry bone (millimetres).

Age Group	Male		Female		P Value
	A	B	C	D	
≤20	32	-	29	-	
21-30	37.73±2.1	32±1.6	35±2.97	28±2.31	p[ab*]=0.004; p[ac]=0.78; p[cd*]=0.038; p[bd*]=0.001
31-40	39.08±2.1	30.72±1.83	38.66±2.11	34±2.75	p[ab**]=0.000; p[ac]=0.124; p[cd*]=0.026; p[bd*]=0.042
41-50	39.11±1.37	35.37±1.73	38.83±2.41	35±2.11	p[ab*]=0.042; p[ac]=0.78; p[cd*]=0.022; p[bd]=0.821
51-60	42.85±2.74	36.62±2.04	39±2.11	36.6±1.83	p[ab*]=0.001; p[ac*]=0.036; p[cd*]=0.021; p[bd]=0.971

Table.3 Mean of Canal diameter at the level of lesser trochanter in males and females in digital radiography and dry bone.(millimetres)

Age Group	Male		Female		P Value
	A	B	C	D	
≤20	26.5	-	18	-	
21-30	26.75±2.84	16±1.37	26.4±1.94	16±1.12	p[ab*]=0.000; p[ac]=0.287; p[cd*]=0.000; p[bd]=0.977
31-40	26.75±4.42	24.84±3.13	24.22±3.56	22.85±2.1	p[ab]=0.169; p[ac]=0.126; p[cd]=0.322; p[bd]=0.121
41-50	27.88±2.35	23.26±3.12	24.66±2.1	22.83±1.61	p[ab]=0.822; p[ac]=0.172; p[cd]=0.03; p[bd*]=0.028
51-60	32±2.1	24.12±1.9	27.57±2.13	22.8±0.92	p[ab*]=0.004; p[ac*]=0.028; p[cd*]=0.019; p[bd*]=0.010

Table.4 Mean of Canal diameter below 20 mm from lesser trochanter in males and females in digital radiography and dry bone.(millimetres)

Age Group	Male		Female		P Value
	A	B	C	D	
≤20	17.5	-	16	-	
21-30	17.66±4.71	13±1.41	17.25±3.74	13±1.98	p[ab*]=0.001; p[ac]=0.822; p[cd]=0.697; p[bd] 0.177
31-40	23±4.53	14.84±3.18	22.11±2.07	16±1.82	p[ab]=0.594; p[ac*]=0.000; p[cd*]=0.005; p[bd] 0.302
41-50	22.5±5.52	22.83±3.37	22.16±4.20	17.5±0.84	p[ab]=0.891; p[ac]=0.909; p[cd*]=0.008; p[bd*] 0.009
51-60	26±4.64	26.20±9.89	24.4±5.22	18.8±3.56	p[ab]=0.741; p[ac*]=0.024; p[cd]=0.176; p[bd] 0.870

Table.5 Measurements of Antero-Posterior Diameter mean of femoral head in males and females (Digital radiography and dry bone) (millimetres)

Age Group	Male		Female		P Value
	A	B	C	D	
≤20	44	-	42.12	-	-
21-30	45.34±2.11	43.5±1.2	45.09±2.42	43.2±1.7	p[ab]=0.01; p[ac]=0.64 p[cd]=0.04; p[bd]=0.006
31-40	45.17±1.72	44.7±2.66	45.7±1.37	44.25±0.5	p[ab]=0.545 p[cd]=0.742 p[ac]=0.077; p[bd]=0.50
41-50	45.28±0.62	44.55±0.46	45.75±1.06	44.33±0.82	p[ab]=0.411; p[ac]=0.480 p[cd]=0.731; p[bd]=0.068
51-60	46.23±2.98	45.60±0.83	46.15±2.98	45±4.69	p[ab]=0.399; p[ac]=0.121 p[cd]=0.688; p[bd]=0.824

Table.6 Transverse diameter of femoral head means in males and females (Digitalradiography anddry bone) (millimetres)

Age Group	Male		Female		P Value
	A	B	C	D	
≤20	44.6	-	41.01	-	
21-30	45.78±2.85	44.2±2.27	44.72±2.61	43.7±2.435	p[ab]=0.688; p[ac]=0.233

Age Group	Male A	B	Female C	D	P Value
					p^{bd}=0.075; p^{cd}=0.705
31-40	45.90±2.68	44.68±2.89	44.95±2.76	44±2.45	p^{ab}=0.364; p^{ac}=0.924 p^{bd}=0.1; p^{cd}=0.646
41-50	45.93±2.13	44.79±2.83	45.74±2.1	44.5±5.95	p^{ab}=0.377; p^{ac}=0.22 p^{bd}=0.863; p^{cd}=0.938
51-60	46.12±2.9	45.21±2.67	45.96±2.67	44.67±5.50	p^{ab}=0.091; p^{ac}=0.340 p^{bd}=0.882; p^{cd}=0.930

Table.7 Measurements of anterio-posterior mean of neck diameter in male and female digital radiography and dry bone group (millimetres)

Age Group	Male A	B	Female C	D	P Value
≤20	23.41	-	23.14	-	-
21-30	24.94±4.14	24.2±8.14	23.73±7.77	23±8.34	p^{ab}=0.712; p^{ac}=0.127 p^{bd}=0.071; p^{cd}=0.729
31-40	25.22±4.33	24.88±5.66	24.05±5.13	23.5±7.12	p^{ab}=0.412; p^{ac}=0.727 p^{bd}=0.191; p^{cd}=0.439
41-50	25.54±4.14	25.07±5.19	24.77±7.31	23.66±6.66	p^{ab}0.742; p^{ac}=0.621 p^{bd}=0.476; p^{cd}=0.761
51-60	25.74±6.75	25.12±7.12	25.45±7.64	24±6.96	p^{ab}=0.721; p^{ac}=0.524; p^{bd}=0.276; p^{cd}=0.631

Table.8 Mean of transverse diameter of femoral neck in males and females in digital radiography and dry bone. (mms)

Age Group	Male A	B	Female C	D	P Value
≤20	24.99	-	23.01	-	
21-30	26.28±2.22	26±3.13	23.8±4.11	25±4.88	p^{ab}=0.712; p^{ac*}=0.021 p^{cd}=0.312; p^{bd}=0.113
31-40	26.38±3.34	24.2±4.11	25.16±4.09	23.5±5.01	p^{ab}=0.713; p^{ac}=0.818 p^{cd}=0.822; p^{bd}=0.882
41-50	26.5±5.15	24.92±4.80	25.3±4.37	24.66±5.11	p^{ab}=0.882; p^{ac}=0.912 p^{cd}=0.724; p^{bd}=0.773
51-60	27.97±4.12	26.33±4.90	26.52±4.10	26±3.65	p^{ab}=0.881; p^{ac}=0.729 p^{cd}=0.891; p^{bd}=0.897

Table.9 Femoral neck length mean in males and females in digital radiography and dry bone.(millimetres)

Age Group	Male A	B	Female C	D	P Value
≤20	47	-	43	-	
21-30	48±3.18	47.2±2.97	47.5±3.17	47±5.04	p^{ab}=0.07; p^{ac}=0.062 p^{cd}=0.14; p^{bd}=0.074

Age Group	Male A	B	Female C	D	P Value
31-40	48.25±2.1	47.36±3.18	48.15±3.75	47.5±4.18	p^{ab}=0.743; p^{ac}=0.614 p^{cd}=0.13; p^{bd}=0.141
41-50	49.6±2.33	47.41±3.73	48.5±4.14	47.56±5.05	p^{ab}=0.07; p^{ac}=0.61 p^{cd}=0.23; p^{bd}=0.31
51-60	49.74±3.13	47.49±4.44	48.85±5.12	47.88±4.94	p^{ab}=0.11; p^{ac}=0.49 p^{cd}=0.41; p^{bd}=0.12

Table.10 Horizontal offset mean of males and females in digital radiography and dry bone (millimetres)

Age Group	Male A	B	Female C	D	P Value
≤20	46.5	-	43	-	
21-30	46.75±1.85	42±2.12	44.13±3.17	42.1±2.89	p^{ab*}=0.031; p^{ac}=0.67 p^{cd}=0.822; p^{bd}=0.71
31-40	47.16±2.20	42.2±2.16	45.77±3.18	43.75±3.49	p^{ab*}=0.014; p^{ac}=0.62 p^{cd}=0.71; p^{bd}=0.13
41-50	47.83±4.36	45.55±4.57	46.72±5.17	45±5.39	p^{ab}=0.038; p^{ac}=0.912 p^{cd}=0.818; p^{bd}=0.724
51-60	48.28±2.13	45.54±3.28	47.1±3.11	43.6±4.93	p^{ab*}=0.04; p^{ac}=0.13 p^{cd*}=0.004; ;p^{bd*}=0.026

Table 11 Mean of Vertical offset in males and females in digital radiography and dry bone (millimetres)

Age Group	Male A	B	Female C	D	P Value
≤20	48.03	-	45.70	-	
21-30	48.31±1.14	44±2.18	45.78±4.13	43±4.19	p^{ab*}=0.025; p^{ac}=0.081; p^{cd*}=0.004; p^{bd}=0.149
31-40	48.33±2.13	44.12±1.14	46.12±2.74	44.75±0.71	p^{ab}=0.021; p^{ac}=0.912; p^{cd}=0.05; p^{bd}=0.214
41-50	48.47±2.14	45.37±3.12	46.69±3.13	45±3.12	p^{ab}=0.014; p^{ac}=0.712; p^{cd}=0.840; p^{bd}=0.882
51-60	48.74±2.73	45.66±3.11	46.94±3.77	45.6±2.96	p^{ab}=0.012; p^{ac}=0.836; p^{cd}=0.639; p^{bd}=0.904

Discussion Indian femora differ markedly from other ethnic groups as far as their dimensions are concerned. Hence large mismatched implants, different angles and orientations, when applied to Indian population can lead to malreduction, poor compression at fracture site and implant cut out. Reddy et al. highlighted that a mismatch between femoral bone and stem may definitely result in micromotion which can lead to thigh pain, osteolysis and aseptic loosening[2]. If the implant is too large the femur can fracture so the tendency is to undersize for safety but highly undersized implant may fail to bond with bone.[3]

In our study proximal femur measurements increased with the age and measurements were higher in males when compared with females. Further significant difference was noted between the

measured parameters of proximal femur by digital radiography and dry bone method with exception of femoral neck antero-posterior and transverse diameter, femoral neck length. Rubin et al also obtained the measurements using radiographic and direct methods and found that the mean difference obtained using radiography compared to direct measurements was 2.4 ± 1.4 mm (mean ± SD), while the difference obtained using CT scans was 0.8 ± 0.7 mm (mean ± SD)[4]. The magnitude of these errors was much lower than the measured readings. Therefore, the compared values from this study and other studies (involving radiographic measurements) can still convey a fairly accurate idea regarding the anthropometric differences.

TABLE.12 Comparison with Contemporary Literature (values in mm)

	Present Study N= Digital radiography Patients	Present Study N= Dry bone measurements	Rawal et al., 2012[5] N=98 CT of patient Hips	Siwach et al., 2003[6] N=150 Dry bone measurements, Dry bone radiology	Mahaisavariya et al., 2002[7] N=108 CT Measurements	Rubin et al., 1992[4] N=32 Dry bone vsX Ray,CT	Nobel et al., 1988[8] N=80 Radiology of patients	Husmann et al., 1987[9] N=31 CT of patient Hips
Population	Indian	Indian	Indian	Indian	Thai	Swiss	Caucasian	French
Femoral head offset Horizontal Offset	47.35±4.70	45.31±4.67	40.23±4.85	38+-5.52	-	47.0 +-7.2	43.0	40.5±7.5
Vertical Offset	45.96±3.13	44.97±2.97	-	-	-	-	-	-
Femoral head diameter	45.25±1.80	44.58±1.80	45.41+-3.66	43.95+-3.06	43.98+-3.47	43.4 +-2.6	46.1	-
Femoral head position			52.33+-7.19	-	48.94+-4.95	66.1 +-8.2	51.6	57.3+-8.1
Femoral Neck Length	47.88±3.85	46.88±3.77	48.4+-5.56	-	46.22+-5.14	-	-	-
Canal width 2 cm above lesser trochanter	38.22±6.15 [ML]	34.31±4.03 [ML]	26.26+-3.7[AP] 36.78+-5.32[ML]	50.24+-4.81	-	43.1+-5.2[ML]	45.4	38.2+-7.3 [AP] 42.6+-5.5[ML]
Canal width at lesser trochanter	26.08±4.73 [ML]	24.16±4.16 [ML]	-	23.8+-3.20	-	27.9+-3.6	29.4	-
Canal width 2 cm below lesser trochanter	21.22±3.39 [ML]	18.54±4.77 [ML]	-	16.51+-1.99	-	21.0+-2.7	20.9	-

ML Mediolaterl,AP Anteroposterior

Conclusion

The results of this study indicate that marked differences do exist in the dimensions between the femur of the Indian population and that of the populations of other regions of the world as well as between male and female femora within the Indian population, indicating that a range of implants and femoral stem designs are required to reduce the inventory and narrow down the best fit options for a surgeon. This will lead to cost-effective treatment and better clinical outcomes.

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