

## Morphometric Study of Femur for Determination of Sex of a Person: Cadaveric Cross Sectional Study in North Karnataka

Dnyaneshwar\*, Sudhakara Babu Chelli\*\*, Suresh P. Desai\*\*\*, Vijaynath Itagi\*\*\*\*

### Abstract

*Background and Objectives:* Most of the studies described anatomical parameters on X-ray. Here the measurements were carried out on adult human cadavers. This study will essentially help orthopedicians to make suitable hip joint prosthesis, also help forensic expert in disputed sex and help to understand biomechanics of hip joint. These parameters help us to understand etiopathogenesis of disease like osteoarthritis of hip joint. *Methodology:* A total 60 hip joints were studied in 20 male and 10 female cadavers. Measurements taken with soft tissue in situ of vertical diameter of head of femur. These measurements were taken using vernier caliper and a steel scale. Mean values of parameters were recorded and compared between males and females. The mean values also compared with right and left side for males and females. *Results:* The mean vertical diameter of head of femur was found to be 43.75 mm in males and 40.30 mm in females. *Conclusion:* The parameters of hip joint are immense importance to orthopaedicians, radiologists, and prosthetists. These values are useful to identify the fragment of bone for sex determination sent to forensic expert.

**Keywords:** Femoral Head; Diameter; Vernier Caliper; Adult Cadaver.

### Introduction

Determination of individual sex from the available skeleton is of great importance in the identification of a person. In medico-legal cases, determination of stature, sex and age from skeletal remains of deceased person is often referred to anatomists and anthropologists. Therefore most of the long bones either individually or in combination have been subjected to statistical and morphological analysis. Knowledge of the bony component of hip joint will not only help the radiologists but will also be of immense importance to orthopaedicians and prosthetists [1].

Assessment of these parameters to detect the sex by radiograph, CT scan, MRI would include magnification errors and may not be cost effective for the developing countries like India. Awareness of average dimensions of hip joint in both sexes helps in determination of sex by forensic experts. As this is a cadaveric study, various parameters are almost near normal situations, as those encountered on operation table.

### Review of Literature

Ruma Purkait and Heeresh Chandra (2002) studied 280 dry adult femora from 200 males and 80 females from resident of Central India. In their study the mean vertical diameter of head of femur was found to be 44.28 mm in males and 38.39 mm in females. They concluded that sexual dimorphism was maximum at the ends of femur. The ends of a bone are the areas where a number of muscles make their insertion and subjected to more pull than at the point of origin. If sex of a person has to be detected, then vertical diameter of head of femur is the single best determinant with an accuracy of 91.1 % and epicondylar width with 89.6% accuracy [2].

---

**Author's Affiliation:** \*Assistant Professor, \*\*Lecturer, Department of Anatomy, \*\*\*\* Professor, Department of Physiology, Koppal Institute of Medical Sciences, Koppal, Karnataka-583231. \*\*\*Professor, Department of Anatomy, Jawaharlal Nehru Medical College, Belgaum, Karnataka-590010

**Corresponding Author:** Dnyaneshwar, Assistant Professor, Department of Anatomy, Koppal Institute of Medical Sciences, Koppal - 583 231 Karnataka.  
E-mail: [drdnyan83@gmail.com](mailto:drdnyan83@gmail.com)

Michael Sean Patton et al. (2006) studied relationship between proximal femoral geometry and fracture of hip joint in England. For this he studied radiographs of 50 patients with intracapsular and 50 patients with extracapsular fractures of hip. The parameters studied on this radiograph are neck width, vertical head diameter, trochanter diameter, neck length. He found the vertical diameter of head of femur in males 60.20 mm and 53.93 mm in females. This shows that vertical diameter of head of femur is more in males than in females. They also concluded that increase in femoral neck length is the cause of increased proximal femoral fractures in elderly people. It has been suggested that variations in proximal femoral geometry also play important role in hip fracture [3].

Masood Umer et al. (2010) in Pakistan studied pelvic radiographs of 116 male and 20 female healthy volunteers. The purpose of the study is to measure the morphology of the proximal femur in Pakistan. They studied 12 parameters of proximal femur, among them one parameter was vertical diameter of head of femur. The mean vertical diameter of head of femur in Pakistani population was 50.10 mm. They also concluded that morphology of proximal femur in studied population differed significantly from those of western population indicating the regional variation. So these parameters can be utilized to construct population specific prosthesis in Pakistan [4].

Thomas K Black (1978) studied 114 skeletons from Ohio USA, which included 63 males and 51 female skeletons. He measured femoral head circumference and femoral length for the determination of sex from fragment of femur. They recorded that individuals with femur circumference greater than 81mm were classified as males, those with circumference less than 81mm classified as females.

Of the 107 individuals who were assigned sex by femoral head circumference, 85% were correctly classified. From this they concluded that femoral head circumference can be a useful tool in determination of sex, especially where skeletal remains are fragmentary or poorly preserved. For skeletal collections in good condition, femoral head circumference can serve as rapid and reliable method of sexual assessment [5].

Javadekar BS (1961) studied 108 femora from 86 adult male and 22 adult female cadavers in India. Measurements were taken from femora with articular cartilage in situ. In his study the average vertical diameter of head of femur in males was 45.26 mm and in females 40.37 mm. He studied that femur showing a diameter of less than 40 mm can be identified

as female and one having diameter more than 45 mm should be considered as male. He also found that the maximum difference between right and left femoral diameter is 2 mm in a same individual [6].

## Material and Method

A total 60 hip joints were studied in 20 male and 10 female cadavers. The measurements were taken with soft tissue in situ, which includes vertical diameter of head of femur. These measurements were taken using vernier caliper and a steel scale. mean values were compared with right and left side for males and females.

The followings steps were carried out to dissect hip joint on both sides as given in the Cunningham's Manual:

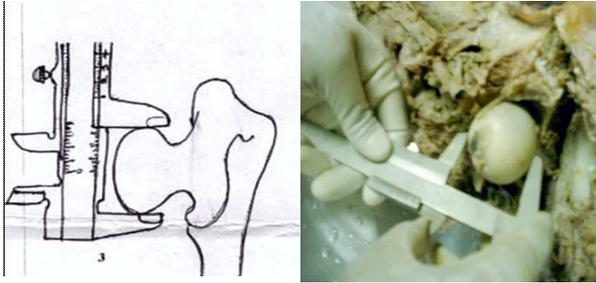
1. Femoral vessels and nerve were cut immediately inferior to inguinal ligament.
2. Sartorius and rectus femoris muscles were cut about 5 cm from their origins and turned downwards. Iliopsoas muscle was cut near its insertion and the two parts were turned upwards and downwards exposing the psoas bursa and capsule of hip joint. The bursa was removed and margins of thick iliofemoral ligament were identified.
3. Articular capsule was incised along the borders of iliofemoral ligament and all parts of capsule were removed.
4. Open the hip joint to disconnect the round ligament of femur or cutting the round ligament with scalpel [7].

With soft tissue in situ, using vernier caliper and metallic scale, diameter of head of femur have been calculated as follows :-

### *Vertical Diameter of Head of Femur*

Vernier caliper was used to measure vertical diameter of femoral head. It was taken at right angle to long axis of neck of femur, which meant the straight distance between the most superior to most inferior points of the femoral head. The transverse diameter was not taken because there was not any significant difference between vertical and transverse diameter of head of femur.

Intraobserver variation was avoided by measuring parameter three times by each of the three investigators and mean of the three readings were taken as final value and recorded.



**Fig 1:** Method used for measuring vertical diameter of head of femur

**Results**

In this study parameter of sixty hip joints were measured using vernier caliper. In 30 human cadavers of age group 18-85 years belonging to 20 male cadavers and 10 female cadavers with soft tissue in situ. All measurements were taken three times by three separate investigators. The mean of the three readings were considered as the final reading and recorded. The data thus collected was analyzed and tabulated.

**Table 1:** Mean vertical diameter of head of femur for 20 right and 20 left hip joints in males

Serial No	Cadaver no	Vertical diameter of head of femur	
		Right	Left
11	17	44	44
12	19	38	37
13	20	45	47
14	21	44	44
15	22	44	44
16	23	47	45
17	25	37	36
18	26	46	44
19	28	45	45
20	29	47	46

**Table 2:** Measurements taken in female cadavers (in mm)

Serial No	Cadaver no	Vertical diameter of head of femur	
		Right	Left
1	2	41	42
2	5	40	40
3	8	37	36
4	11	40	36
5	13	44	43
6	15	43	42
7	18	40	39
8	24	42	41
9	27	39	38
10	30	42	41

**Table 3:** Mean vertical diameter of head of femur (in mm)

	Male(n=20)		Female(n=20)	
	Right (20)	Left (20)	Right (10)	Left (10)
Minimum value	37	36	37	36
Maximum value	47	47	44	43
Mean	44.00	43.50	40.80	39.80
Standard deviation	2.57	2.81	2.04	2.48

**Table 4:** Comparison of parameters (in mm) between males and females

Parameters	Side	n	Male		n	Female		P Value
			Mean	S.D.		Mean	S.D.	
Vertical diameter of head of femur	Right	20	44.00	2.57	10	40.80	2.04	0.002 S
	Left	20	43.50	2.81	10	39.80	2.98	0.0015 S

**Observation****Males**

- a. The mean vertical diameter of head of femur on right side was 44.00 mm and left side was 43.50 mm with range of 37 mm to 47 mm on right and 36 mm to 47 mm on left side (Table 3).
- b. The mean vertical diameter of head of femur was 40.80 mm and 39.80 mm on right and left side respectively. The minimum value is 37 mm and 36 mm on right and left side respectively. . The maximum value for right side is 44 mm and for left side it is 43 mm (Table 3).
- c. From above data comparison was made for male and female hip head of the femur. It was noted that the parameters are more in males than females. The difference of values between males and females are statistically significant. The difference was significant for all the parameters of vertical diameter of head of femur.

**Discussion**

Hip joint is one of the major joint of the body. It is a multiaxial, synovial ball and socket (spherical, cotyloid) type of joint. Menschik (1997) described it as rotational conchoids.

Knowledge of anatomical parameters of the bony components of hip joint is very essential because it will help in early detection of disputed sex of a person. We can also identify the race of a person by these parameters. Awareness of the normal parameter of hip joint can also help in diagnosis of acetabular dysplasia. In turn it opens a new horizon into understandings of etio-pathogenesis of diseases like primary osteoarthritis. An abnormal joint is more prone to develop osteoarthritis rather than joint with normal parameters.

The normal values for vertical diameter of head of femur in males and females are given in Table 5 for different set of populations

**Table 5:** Comparative study of vertical diameter of head of femur

Serial No	Authors	Male	Female
1	Gita malla et al. ( 2006) in Germany <sup>7</sup>	49.00 mm	44.00 mm
2	Aasis Unnanuntana(2002) in USA <sup>8</sup>	55.46 mm	48.73 mm
3	P S Igbigbi et al. (2000) in Malawi <sup>9</sup>	48.30 mm	44.56 mm
4	Asala SA et al. (1998) in Nigeria	54.16 mm	47.00 mm
5	Singh et al. (1986) in Nigeria	52.02 mm	46.80 mm
6	Clarke et al. (1987) in England <sup>10</sup>	51.30 mm	45.10 mm
7	Akhtari Afroze et al. (2005) Bangladesh <sup>11</sup>	51.55 mm	45.65 mm
8	Ruma Purkait et al. (2005) in India	44.28 mm	38.39 mm
9	Thomas Dwight (1905) in USA	49.68 mm	43.84 mm
10	Khan (1959) in India <sup>12</sup>	48.00 mm	41.00 mm
11	Javadekar BS (1961) in India	45.26 mm	40.37 mm
12	V.Davivongs(1963) in Australia	43.05 mm	38.16 mm
13	B.R.Kate (1964) in India <sup>13</sup>	41.50 mm	39.00 mm
14	Yasar Iscan M et al. (1995) in China	46.16 mm	41.13 mm
15	Rajendra Prasad et al. (1996) in India	43.00 mm	39.10 mm
16	Gonazalo et al. (1997) in Spain	47.15 mm	41.13 mm
17	Chauhan R et al.(2002) in India	45.64 mm	44.27 mm
18	Present Study in North Karnataka	43.75 mm	40.30 mm

From above said values the vertical diameter of head of femur for both males and females in Africa and Western world was greater than the present study. But the values of present study are very near to the study done by V.Davivong on femora of Australian Aborigine population.

From above studies it was also concluded that the vertical diameter of head of femur was more in males than in females. This sex difference in vertical diameter of head of femur was based on the fact that the males skeleton was longer and more robust than skeleton of an average females.

**Conclusion**

Present study provides valuable parameters which will help the forensic expert in early detection of disputed sex, race, and stature of a person. In this study it was found that the parameters vary from males to females and parameters also vary from right and left side.

The values are more in the males than in the females. It was due to longer and robust bones in males than in the females. This above said fact was also proved by the present study. In the sixty hip joints we have

studied it was found that the values are more for male cadavers than the female cadavers. It was also observed in this study that values are little more on the right side than on the left side for all hip joint parameters. This finding was statically insignificant.

It was observed in the study that average vertical diameter of head of femur was 42.02mm, in males it was 43.75 mm and in females it was 40.30 mm. From these observations it can be concluded that if vertical diameter of head of femur was more than 44 mm, then the given bone belongs to the male. If vertical diameter of head of femur was less than 40 mm, it can be said that the given bone belongs to the female in North Karnataka population.

### References

1. Chauhan R, Paul S, Dhaon BK. Anatomical parameters of North Indian hip joints-Cadaveric study. *J. Anat. Soc. of India.* 2002; 51(1): 39-42.
2. Ruma Purkait, Heeresh Chandra. Sexual dimorphism in femora- An Indian study. *Forensic science communication.* 2002; (4)3: 45-48.
3. Michael Sean Patton, Robert Andrew, Alsidair George. Proximal femoral geometry and hip fractures. *Acta. Orthop. Belg.* 2006; 72: 51-54.
4. Masood umer, Yasir jamal sepah, Afrasyab khan, Ali wazir, Mahmood ahmed, Muhammad umar jawad. Morphology of the proximal femur in a Pakistani population. *Journal of Orthopedic surgery.* 2010; 18(3): 279-81.
5. Thomos K. A new method for assessing the sex of fragmentary skeletal remains, femoral shaft circumference. *Am.J.Phys Anthrop.* 1978; 48: 227-32.
6. Javaderkar BS. A study of measurements of femur with special reference to sex. *J.anat.soc.India.* 1961; 10: 25-27.
7. Gita malla et al. Determination of sex from femora. *Forensic science international.* 2000; 113(1-3): 315-21.
8. Aasis unnanuntana, Paul Toogood, Daniel Hart, Daniel Cooperman, Rechar E.Grant. The evaluation of two references for restoring proximal femoral anatomy during total hip arthroplasty. *J.Clinical Anatomy.* 2010; 23: 312-18.
9. P.S. Igbigbi, B.C.Msamat. Sex determination from femoral head diameter in black Malawians. *East African medical journal.* 2000; 77: 147-51.
10. Clark JM, Freeman MAR, Witham D. The relation of neck orientation to shape of femur. *J arthroplasty.* 1987; 2: 99-109.
11. Akhtari afroze, M Durrul Huda. Femoral head diameters and sex differences in northern zone (Rajshahi) of Bangladesh. *The journal of teachers association.* 2005; 18(2): 84-88.
12. Khan MA. Modi's text book of medical jurisprudence and toxicology. 13<sup>th</sup> ed. Bombay, Tirupathi pvt ltd.1959; 78-79.
13. Kate BR. A study of regional variation of the Indian femur- the diameter of the head. *J. anat .soc. India* 1964; 10: 25-27.