

Clinical Correlation of Anatomical Parameters of Hip Joint: A Cadaveric Cross Sectional Study

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Abstract

Background: As Ontogeny follows Phylogeny, the environment plays leading role in the growth and development of every organ in every species. The main objective of the present study was to find out the anatomical parameters of the hip joint of the Karnataka and compare the findings with the other study.

Method: In the present time, measurements on the adult human cadaveric hip joints have been carried out. This study was conducted on 80 hip joints (24 male and 16 female cadavers). All the anatomical parameters like vertical diameter of head of femur, diameter of acetabulum and depth of acetabulum were recorded on soft tissue *in situ* by using digital Vernier calipers and metallic scale. In addition, the pathological changes occurring on the articular cartilages were also noted.

Result: The average vertical diameter of head of femur was 46.05 mm in males and 40.9 mm in females, diameter of acetabulum was 46.4 mm in males and 41 mm in females and average depth of acetabulum both sides was 27.55 mm in males and 25.55 mm in females on both side. All the parameters of the hip joint were greater in males when compared to those of females which is statistically significant ($p = 0.03$). There was no comparative difference between the values of right and left side for all parameters in both sexes ($p = 0.63$).

Conclusion: The anatomical parameter of hip-joint had significant regional influenced. The knowledge of variations in the parameters of hip joint will help the orthopedicians and prosthetists to construct the suitable prosthesis for hip joint.

Keywords: Hip Joint; Parameter; Variation; Clinical Correlation; Femoral Head; Acetabulum; Diameter; Cadaver

Introduction

Hip joint is one of the major joints in the human body, originally referred to as ball and socket variety of synovial joint. Theoretically it is rotational conchoids [1]. In hip joint, head of femur articulates with the cup-shaped cavity called acetabulum. Knowledge of anatomy of proximal femur is a pre-requisite to understand mechanics of hip joint. Various bony compartment and knowledge of hip joint will not

only help radiologist, but it will also be of immense importance to the prosthetists and orthopedicians. The anthropometric parameters of bone are strongly influenced by features like race, climate, heredity, geographical area, sex and stature. In this study, we have undertaken the measurement of average diameter and depth of acetabulum and average vertical diameter of head of femur in North Karnataka cadavers. There are many studies on acetabulum and head of femur by several investigators in different places but all studies have been done on dry specimens. In this study, we are measuring parameters in cadaver with soft tissue *in situ*.

The anatomical parameters of the bony compartments of hip joint are very essential. The average dimension of the different parameters of the hip joint in both sexes will help in detection of sex by forensic experts. The knowledge of dimensions of different parameters of hip joint will help to assist prosthetics to construct suitable prostheses, because total hip replacement surgery is very common nowadays. Such a study of cadaveric hip joint with soft tissue *in situ* in different region will help to determine the regional variation of hip joint which will help to construct the suitable prostheses for the given population. Hence these parameters of North Karnataka hip joints will help to reduce errors during hip replacement surgery.

Materials and Methods

Setting

This cross-sectional study was conducted in the department of Anatomy, KLE University's Jawaharlal Nehru Medical College, Belagavi, Karnataka, India. Study was done on 80 hip joints of 40 cadavers (24 male and 16 female) belonging to age group of 50 - 70 years.

Gross observation of normal as well as pathological joints

The hip joints were dissected finely showing the both articular surface (head of femur and acetabulum of hip bone) and articular cartilages. The dissected hip joints were grossly inspected for the presence of any pathological changes like irregularity, and erosion in the cartilage as well as in the bone. The hip joints were considered normal with the following gross features:

1. The surface of hemispherical acetabulum was smooth without bony erosion.
2. The horse-shoe shaped articular cartilage lining of acetabulum was smooth, and regular.
3. The articular cartilage of femoral head was having uniform appearance
4. There was not having any evidence of marginal ossification.

Hip joints with presence of irregularity in shape, size, and texture of the articular cartilage as well as articular surface of the bones and presence of any marginal ossification, and presence of osteophytes were considered as pathological hip joints. Then all the hip joints of normal gross features were considered as normal group (Group-A) and with abnormal or gross pathological features were considered as pathological group (Group-B).

Measurement of anatomical parameters

All the anatomical parameters were measured immediately after the dissection of hip joint. Each parameter was measured thrice and the mean of the three values was recorded as final value. The values of the different parameters were recorded by using digital Vernier Caliper in millimeter (mm) to ensure the exact measurement. All the measurements were taken on soft tissues *in situ* by using digital Vernier caliper. Various parameters of the head of femur and acetabulum were measured as following.

Vertical diameter of head of femur

It was taken at right angle along the long axis of femoral neck. The maximum vertical diameter observed in femoral head was recorded by using digital Vernier caliper.



Figure 1: Method of measuring vertical diameter of head of femur.

Diameter of acetabulum

The diameter of acetabulum was recorded at the margin of acetabulum by using digital Vernier caliper.



Figure 2: Method of measuring diameter of acetabulum.

Depth of acetabulum

To measure the depth of acetabulum, a thin metallic scale was placed over the centre of acetabulum diagonally as shown in photograph 3 and then the maximum depth of acetabulum was recorded by using digital Vernier Caliper through the center of metallic scale. The thickness of metallic scale was subtracted from the depth obtained in the digital Vernier caliper during recording data.



Figure 3: Method of measuring depth of acetabulum.

Results

In the present study, we took 100 hip joints from the 50 cadavers. Out of 50 cadavers, 30 (60%) of the cadavers were male and 20 (40%) of the cadavers were female. Among them, 80 hip joints from 40 cadavers were found to be normal. The anatomical parameters; vertical diameter of head of femur, diameter of acetabulum and depth of acetabulum between male and female hip joints of the normal hip joints were presented in the table 1-3. It was concluded that all the 3 parameters were larger in males than in females ($p = 0.001$). The vertical diameter of head of femur and diameter of acetabulum are found to be statistically on both side were statistically significant with p value < 0.001 in both sexes. However, the depth of acetabulum in male and female was statistically insignificant ($p = 0.086$ on right side and $P = 0.092$ on left side).

Vertical diameter of head of femur: The average vertical diameter of head of femur on both sides was 46.05 mm in males and 40.9 mm in females. The mean vertical diameter of head of femur on right side was 46.1 mm and 40.8 mm in male and female respectively with p value 0.001. The mean vertical diameter of head of femur on left side was 46 mm and 41 mm in male and female respectively with p value < 0.001 (Table 1). The mean diameter of acetabulum on right side was 46.4 mm and 41.1 mm in male and female respectively with p value 0.001. The mean diameter of acetabulum on left side was 46.4 mm and 40.9 mm in male and female respectively with p value.

| Vertical diameter of head of femur (in mm) | Male Cadaver (n = 24) | | Female Cadaver (n = 16) | |
|--|-----------------------|----------------|-------------------------|----------------|
| | Right side (24) | Left side (24) | Right side (16) | Left side (16) |
| Maximum obtained value | 50.89 | 50.37 | 43.82 | 44.84 |
| Minimum obtained value | 40.51 | 41.40 | 37.45 | 37.31 |
| Mean | 46.10 | 46.00 | 40.80 | 41.00 |
| Standard deviation | 03.07 | 02.51 | 02.30 | 02.52 |

Table 1: Results showing the vertical diameter of head of femur.

Diameter of acetabulum: The average diameter of acetabulum on both sides was 46.4 ± 2.9 mm in males and 41 ± 2.3 mm in females which is statistically significant ($p = 0.001$). The mean and SD of diameter of acetabulum on right and left side of male and female cadavers is presented in shown in table 2.

| Diameter of acetabulum (in mm) | Male (n = 24) | | Female (n = 16) | |
|--------------------------------|-----------------|----------------|-----------------|----------------|
| | Right side (24) | Left side (24) | Right side (24) | Left side (24) |
| Maximum obtained value | 51.91 | 51.37 | 44.26 | 44.88 |
| Minimum obtained value | 40.63 | 42.04 | 38.18 | 37.87 |
| Mean diameter of acetabulum | 46.40 | 46.40 | 41.10 | 40.90 |
| Standard deviation | 02.91 | 02.90 | 02.30 | 02.29 |

Table 2: Results showing the diameter of acetabulum in mm.

Depth of acetabulum: The average depth of acetabulum on both sides was 27.55 ± 2.2 mm in males and 25.55 ± 2.4 mm in females which was statistically insignificant ($p = 0.092$ for right side and $p = 0.086$ for left side). The mean and SD for the depth of the acetabulum is presented in the table 3.

Out of 100 hip joints of 50 cadavers, 20 hip joints from 10 cadavers were found to have grossly abnormal or pathological hip joints which were presented in the table 4. Among them male hip joints were found to have more pathological changes than that of hip joints of female which was statistically significant ($p = 0.001$).

| Depth of acetabulum (in mm) | Male (n = 24) | | Female (n = 16) | |
|-----------------------------|-----------------|----------------|-----------------|----------------|
| | Right side (24) | Left side (24) | Right side (24) | Left side (24) |
| Maximum obtained value | 31.41 | 30.59 | 29.35 | 31.47 |
| Minimum obtained value | 25.03 | 25.01 | 22.20 | 23.08 |
| Mean depth of acetabulum | 27.40 | 27.70 | 25.40 | 25.70 |
| Standard deviation | 02.22 | 02.18 | 02.43 | 02.36 |

Table 3: Results showing the depth of acetabulum in mm.

| Gross pathological Changes in articular cartilage of hip joint | Male Cadaver (n = 7) | | Female Cadaver (n = 3) | |
|--|----------------------|---------------|------------------------|---------------|
| | Right side (7) | Left side (7) | Right side (3) | Left side (3) |
| Mild damage to articular cartilage | 2 | 2 | 1 | 1 |
| Moderate damage articular cartilage (No bone erosion) | 3 | 3 | 2 | 2 |
| Severe damage to articular cartilage (With bone erosion) | 2 | 2 | - | - |
| Total | 7 | 7 | 3 | 3 |

Table 4: Gross pathological feature found in the hip joints.

Discussion

The hip joint, ball and socket variety of synovial joint is a unique and major joint of the body. The detail knowledge of the anatomical parameters of the bony and cartilaginous components of hip joint is very essential as it will open new horizons into better understanding of etiopathogenesis of various diseases affecting the hip joint. The osteoarthritis, a degenerative joint disease is most commonly affected to weight bearing joint in old age. The osteoarthritic changes are more common in an incongruous joint than in a joint having normal anatomy [2]. The knowledge of average anatomical dimensions of the hip joint in both sexes will also help in the detection of disputed sex by forensic scientists. Replacement of total hip is a common surgical procedure most commonly performed nowadays and knowledge of the dimensions of acetabulum and femoral head will assist prosthetists to construct suitable prostheses. This gives the average values of various parameters to near normal situations as would be encountered in the patients on the operation table. Present study showed that the mean vertical diameter of the femoral head was found to be 46.1 and 46.0 mm in right and left sides of males, and 40.8 and 41.1 mm in right and left sides of males respectively. Finding of our study was similar to a similar study conducted by various authors in south Indian population [4,6]. However, similar study conducted by Asala, *et al.* on the femora of Nigerians cadavers revealed that the mean vertical diameter of the head of femur on the right and left sides in males was 54.23 mm and 54.08 mm, and in females it was 47.14 mm and 46.83 mm respectively [3,5,12]. This showed that there were significant regional variation in the anatomical parameters of the hip joints.

Our cross-sectional cadaveric study of hip joints revealed that the mean diameter of acetabulum on right side was 46.4 mm and 41.1 mm and on left side was 46.4 mm and 40.9 mm in male and female respectively. This finding was similar with the finding of Javadekar, *et al.* [5] and Chauhan, *et al.* [6,12]. According to Isaac *et al.* short statured had smaller diameter of femoral head which can be easily appreciated [7]. Vertical average diameter of femoral head was nearly the same according to Mukhopadhaya and Barooah B [8].

In the present study, we found that the mean depth of acetabulum on right side was 27.4 mm and 25.4 mm whereas on left side was 27.7 mm and 25.7 mm in male and female respectively which was nearly the same as reported by Chauhan, *et al.* [6], Mukhopadhaya, *et al.* [8] and Jayashree, *et al.* [12]. Sex can be determined particularly by visual examination of the bone as reported by Krogman WM [9].

Our study revealed that the anatomical parameters of the hip joints were slightly higher than the left hand which was in consistent with the findings of various authors [8-11]. The slightly larger dimension of various parameters of hip joints on right side may be due to over-using of right hand as well as right legs in the right-handed person. It is because, most of the right handed person are also used right leg more frequently and due to over use of right leg, the parameters of right hip joints may become slightly larger [10].

| S.N. | Authors/ place | Year | Place of study | Males (in mm) | Females (in mm) |
|------|--------------------------------|------|-------------------|---------------|-----------------|
| 1. | Asala SA, <i>et al.</i> | 1978 | Nigeria | 54.16 | 47.00 |
| 2. | Kurrat, <i>et al.</i> | 1978 | Germany | 51.0 | 41.5 |
| 3. | Thomas Dwight | 1905 | America | 49.68 | 43.84 |
| 4. | Parson FG | 1914 | England | 49.0 | 34.4 |
| 5. | Chauhan R, <i>et al.</i> | 2002 | North India | 45.64 | 44.27 |
| 6. | Prasad R., <i>et al.</i> | 1996 | South India | 43.00 | 39.10 |
| 7. | Javadekar BS., <i>et al.</i> | 1961 | India | 45.26 | 40.37 |
| 8. | Akhtari Afroze., <i>et al.</i> | 2005 | Bangladesh | 51.55 | 46.55 |
| 9. | Ruma Purkait., <i>et al.</i> | 2002 | India | 44.28 | 38.39 |
| 10. | KC Saikia, <i>et al.</i> | 2008 | India (Assam) | 43.05 | 40.75 |
| 11. | C Lavanya., <i>et al.</i> | 2010 | India (Bangalore) | 44.53 | 39.58 |
| 12. | Jayshree., <i>et al.</i> | 2013 | India (Surat) | 44.26 | 41.09 |
| 13. | In present study | 2014 | South India | 46.05 | 40.9 |

Table 5: Comparative study of mean vertical diameter of head of femur in different regions of population in males and females,

It was observed that all the parameters of the hip joint were greater in the study conducted in the population of western world than the Indian population (present study done in North Karnataka, India). This is because the western people are taller and heavier than the average Indians which show the regional variations.

Vertical diameter of head of femur in between males and females

Various study showed that the vertical diameter of head of femur was significantly more in males than in females. However, there was not significant differences in right and left sides. From the studies done by Kurrat (1978) in Germany, Asala (1998) in Nigeria, Thomas (1905) in America and Akhtari (2005) in Bangladesh, the vertical diameter of head of femur for both males and females in Bangladesh and western world were greater than the present study done in North Karnataka which showed that western person are taller than the average Indian population and so their femoral head are bigger than that of the Indian femoral head. In the present study the average diameter of acetabulum was 43.7 mm. It was also observed that mean diameter of acetabulum was 46.4 mm in males and 41 mm in case of females. It was also reported that in the present study the mean diameter of acetabulum was slightly greater than the mean vertical diameter of head of femur in both sexes. This study also shows that diameter of acetabulum was greater in males than in females. It was also observed that diameter of acetabulum in western world was much greater than the diameter observed in the North and South India. It was observed that diameter of acetabulum in females was greater in North India was compared to South India and in the present study. From the present study it was reported that diameter of acetabulum more than 46 mm belonged to males and less than 41 mm belonged to females. This can be used as a point for identification of sex in this region.

Verma and Nalini in 2010 found that the mean vertical diameter of head of femur was 44.53 mm and 39.58 mm in males and females respectively in South Karnataka. In case of diameter of acetabulum, they observed that the mean diameter of acetabulum was 45.30 mm and 40.43 mm in males and females respectively. They also reported that the mean depth of acetabulum was 28.25 mm and 26.91 mm in males and females respectively. However, in the present study, we found that the mean vertical diameter of head of femur were 46.05

mm and 40.9 mm in males and females respectively in North Karnataka. In case of diameter of acetabulum, it was observed that, the mean diameter of acetabulum was 46.4 mm and 41.00 mm in males and females respectively. It was also reported that the mean depth of acetabulum was 27.55 mm and 25.55 mm in males and females respectively. From the above data it was concluded that the mean vertical diameter of head of femur and mean diameter of acetabulum were greater in North Karnataka (present study) than the values observed in South Karnataka. In case of depth of acetabulum, the values observed were greater in South Karnataka than in North Karnataka.

| S.N. | Authors | Year of study | Place of study | Average Diameter of Acetabulum | |
|------|---------------------------|---------------|-------------------|--------------------------------|-----------------|
| | | | | Males (in mm) | Females (in mm) |
| 1. | Werner., <i>et al.</i> | 2009 | Switzerland | 54.0 | 47.50 |
| 2. | Namachi., <i>et al.</i> | 2002 | Thailand | 52.38 | 49.54 |
| 3. | MP Moon | 1998 | France | 51.92 | 47.17 |
| 4. | John Emmet | 1967 | New York | 50.80 | 47.62 |
| 5. | Kurrat., <i>et al.</i> | 1978 | Germany | 49-53 | 43-45 |
| 6. | Chauhan R., <i>et al.</i> | 2002 | North India | 47.29 | 45.19 |
| 7. | Jayshree., <i>et al.</i> | 2013 | India (Surat) | 45.24 | 43.37 |
| 8. | C Lavanya., <i>et al.</i> | 2010 | India (Bangalore) | 45.30 | 40.43 |
| 9. | In present study | 2014 | India (Karnataka) | 46.4 | 41.0 |

Table 6: Comparative study of mean diameter of acetabulum in males and females in different regions of population.

| S.N. | Authors/ place | Year of study | Place of Study | Average diameter of acetabulum (in mm) |
|------|--------------------------------|---------------|-------------------|--|
| 1. | Funda Tastekin., <i>et al.</i> | 2006 | Turkey | 54.29 |
| 2. | Namachi., <i>et al.</i> | 2002 | Thailand | 51.82 |
| 3. | Antum Salamon | 2004 | Croatia | 51.60 |
| 4. | In present study | 2014 | India (Karnataka) | 43.70 |

Table 7: Comparative study of average diameter of acetabulum in different regions.

Conclusion

The anatomical parameter of hip-joint had significant regional influenced. The knowledge of variations in the parameters of hip joint will help the orthopedicians and prosthetists to construct the suitable prosthesis for hip joint. Thus, finding of this study helps forensic scientist to determine the ambiguous sex, and orthopaedicians and prosthetists to build the suitable prostheses for the people of North Karnataka. Hence this gives the average values of various parameters to near normal situations in hip replacement and which will help to reduce clinical errors and also helps to increase the patient compliance after the surgical procedure.

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