

## Original Research Article

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# Morphometric study of depth of acetabulum

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## ABSTRACT

**Background:** Anatomy of the hip must be taken into account to study the anatomy of various surgical approaches. Reconstruction of the acetabulum in patients with significant acetabular bone deficiency remains a major challenge in revision total hip arthroplasty. Appropriate anatomic concepts for surgery to treat femoroacetabular impingement require a precise appreciation of the native acetabular anatomy. Since the acetabulum is not always of same shape, width or depth, joint congruences are frequent with minor anatomical variations in the shape of the acetabulum. Hence the present study was undertaken as controversies still exist on the importance of these variations and to prevent problems following surgical procedures such as acetabular reconstruction and femoroacetabular impingement.

**Methods:** Material of the study consisted of 110 human hip bones (60 males and 50 females). Depth of Acetabulum (DA) was measured on these hip bones on both the sides. Statistical analysis was done using SPSS (Statistical Package for the Social Sciences) version 11 and Microsoft Excel 2007.

**Results:** The mean depth of acetabulum in male was 26.89 mm and female was 25.31 mm. The mean depth of acetabulum on right side was 26.24 mm and left side was 26.11 mm. Depth of the acetabulum was greater in males as compared to females and the differences were statistically significant. Depth was greater on the right side as compared to the left side but the difference was statistically non-significant.

**Conclusions:** Depth of the acetabulum was greater in males as compared to females.

**Keywords:** Acetabulum, Depth, Hip arthroplasty, Reconstruction

## INTRODUCTION

The acetabulum functions as the socket that accepts the rounded head of the femur. Together the acetabulum and the femoral head form the hip (coxal) joint. In male acetabulum is large and faces laterally and in female it is small and faces anteriorly.<sup>1</sup> The hip joint socket, the acetabulum ('vinegar cup'), is a concave hemisphere whose axis is not strictly horizontal but is directed also downwards and slightly backwards along the axis of the femoral neck. Its inferior margin is lacking, so the vinegar would run out of the cup. The margins of this acetabular notch, curved in outline, are lined with hyaline

cartilage, which continues as a wide band inside the concave surface of the acetabulum. It is widest above, opposite the notch. This wide upper part of the articular surface is the weight bearing area, lying like a cap over the femoral head.<sup>2</sup>

The acetabular articular surface is deficient inferiorly opposite the acetabular notch and covered by articular cartilage, which is thickest where the surface is broadest. The acetabular fossa within it is devoid of cartilage but contains fibroelastic fat largely covered by synovial membrane. Acetabular depth is increased by the acetabular labrum, a fibrocartilaginous rim attached to the

acetabular margin. This deepens the cup and bridges the acetabular notch as the transverse acetabular ligament.<sup>3</sup> A deeper acetabulum would confer greater stability, but would limit the range of movement. Even with the fibrocartilaginous labrum the socket is not deep enough to accommodate the whole of the femoral head, whose articular surface extends considerably beyond a hemisphere. The opening of the acetabulum faces downwards and forward (about 30 degrees in each direction).<sup>4</sup>

The depth of the acetabulum was defined as the distance between the deepest part of the acetabulum relative to the rim plane. The acetabular depth is the length measured along a perpendicular line after joining the superior and inferior lips of the acetabulum from the midpoint of the lips to the deepest point of the acetabulum. This depth is of interest because of its influence on the range of movement of the femoral component and acetabular cover.<sup>5,6</sup>

Acetabular dysplasia was assessed by morphometric measurement of the centre-edge (CE) angle and acetabular depth.<sup>7</sup> Acetabular dysplasia is associated with labral tears and early osteoarthritis (OA), a condition known as lateral rim syndrome. Even a mildly abnormal shallow acetabulum predisposes to the development of premature degenerative chondral changes and labral tears.<sup>8</sup> Dysplasia of the acetabulum or minor anatomical variation in the fitting of the components of the joint have been suggested as contributory factors in the causation of osteoarthritis.<sup>9</sup> In Indians congenital dislocation is also rare and primary osteoarthritis of the hip is uncommon.<sup>10,11</sup> Radiologically, it may appear that primary osteoarthritis of hip joint is rare in Indians but gross examination of the joint reveals that the disease is not as rare as it was earlier thought to be. Erosion of the cartilage was the commonest pathology observed. Anterosuperior quadrant of the acetabulum and femoral head cartilage was the most frequent site of involvement.<sup>12</sup>

Keeping in view the more generally accepted views and the discrepant claims of many workers an attempt has been made in the present study to observe and verify the depth of the acetabulum and assess sexual dimorphism if any.

## METHODS

A The present study was conducted in the Department of Anatomy, Dr. D.Y. Patil Medical College, Hospital and Research Centre, Pimpri, Pune. Material of the study consisted of 110 human hip bones (60 males and 50 females). All the bones were fully ossified (adult) and free from any pathological or congenital defect. The hip bones studied were collected from the various departments of Dr. D.Y. Patil Medical College, Pimpri, Pune, Dr. D.Y. Patil College of Ayurved and Research Centre, Pimpri, Pune and MIMER'S Medical college,

Talegaon, Pune. Depth of acetabulum was measured on these hip bones on both the sides. Classification of the bones regarding gender was carried out. The diameter of the acetabulum and the distance between its anterior rim and symphysis pubis, width of greater sciatic notch, preauricular sulcus, obturator foramen, ischiopubic ramus and features of ilium and pubis were considered for the classification of the hip bones regarding gender.

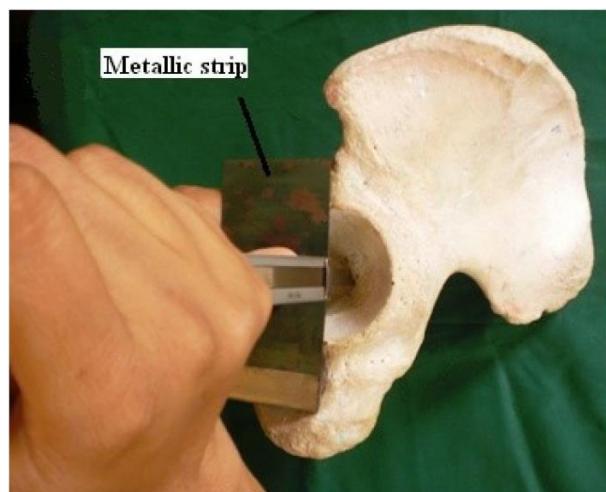
### **Method of measurement used for depth of acetabulum (DA)**

#### *Centre of acetabulum*

Line drawn from the anterior superior iliac spine to the most prominent part of the ischial tuberosity crosses the centre of the acetabulum. i.e. midpoint of anteroposterior diameter.

#### *Depth of acetabulum (DA)*

A thin metallic strip was placed across the anteroposterior diameter of the acetabulum. Depth of the acetabulum was measured in millimeters using dial caliper from the center of the acetabulum to the metallic strip. Measurements could be made as accurate as 1/10 of a millimeter by this scale.



**Figure 1: Measurement of depth of acetabulum by dial calliper using thin metallic strip.**

The data obtained for depth was analysed in the following manner:

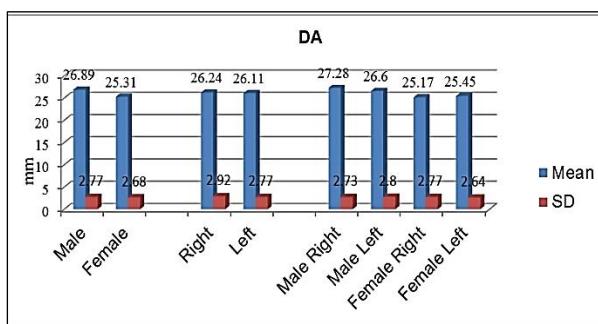
- Measurements of males were compared with measurements of females
- Measurements of right side were compared with measurements of left side
- In males, right side measurements were compared with left side measurements
- In females, right side measurements were compared with left side measurements

- Measurements of right side in males were compared with measurements of right side in females
- Measurements of left side in males were compared with measurements of left side in females.

The data obtained for depth was tabulated and analysed statistically to find Mean, Standard deviation (SD) and Range in both the sexes and both the sides. The results were analysed statistically, by unpaired Student's 't' test. P value of  $< 0.05$  was considered for Statistical significance.<sup>13</sup> Statistical analysis was done using SPSS (Statistical Package for the Social Sciences) version 11 and Microsoft Excel 2007.

## RESULTS

This study observed mean depth of acetabulum was 26.17 mm. Out of total 110 acetabulum studied 60 were male and 50 were female. The mean depth of acetabulum in male and female was 26.89 and 25.31 mm respectively. Depth of acetabulum was greater in male as compared to female and the difference was statistically significant ( $P < 0.01$ ) shown in Table 1 and Figure 2.



**Figure 2: Comparison of depth of acetabulum (DA) with respect to sex and side in total and subtotal sample.**

Depth of acetabulum was measured on right and left side. The mean depth of acetabulum on right and left side was 26.24 mm and 26.11 mm. Depth of acetabulum was greater on right side as compared to left side and the difference was statistically non-significant ( $P > 0.05$ ) shown in Table 2 and Figure 2.

Depth of acetabulum was also measured for right and left side in the same sex. In case of male acetabulum, the

mean depth was greater on right side as compared to left side while in case of female acetabulum, the mean depth was greater on left side as compared to the right side. The difference was statistically non-significant in both ( $P > 0.05$ ) shown in Table 3 and Figure 2.

Depth of acetabulum was also measured for right and left side in the different sexes. The mean depth of acetabulum in male right side was greater than female right side. The difference was statistically significant ( $P < 0.01$ ). Similarly, the mean depth of acetabulum in male left side was greater than female left side but the difference was statistically non-significant ( $P > 0.05$ ) shown in Table 3 and Figure 2.

Following tables summarize the observations and results of the present study.

**Table 1: Depth of acetabulum (DA) in male and female.**

Sex	n	Depth (mm)			P value
		Mean	SD	Range	
Male	60	26.89	2.77	20.26-32.32	<0.01
Female	50	25.31	2.68	20.58-30.83	

The mean DA in Male > Female. The difference is statistically significant ( $P < 0.01$ ).

**Table 2: Depth of acetabulum (DA) on right and left sides.**

Side	n	Depth (mm)			P value
		Mean	SD	Range	
Right	51	26.24	2.92	21.08-31.32	>0.05
Left	59	26.11	2.77	20.26-32.32	

The mean DA on Right > Left. The difference is statistically non-significant ( $P > 0.05$ ).

In case of male, the mean DA on Right > Left. The difference is statistically non-significant ( $P > 0.05$ ). In case of female, the mean DA on Left > Right. The difference is statistically non-significant ( $P > 0.05$ ). The mean DA in Male Right > Female Right. The difference is statistically significant ( $P < 0.01$ ). The mean DA in Male Left > Female Left. The difference is statistically non-significant ( $P > 0.05$ ).

**Table 3: Comparison of depth of acetabulum (DA) in male and female with respect to side.**

Depth of acetabulum (DA) in mm			
	Male (Right) (n=26)	Female(Right) (n=25)	Male(Left) (n=34)
Mean±SD	27.28±2.73	25.17±2.77	26.6±2.80
Range	22.02-31.32	21.08-30.83	20.26-32.32
			Female(Left) (n=25)

**Table 4: Comparison of depth of acetabulum with other studies.**

Author	Sample size	Depth			P value
		Mean	SD	Range	
Mukhopadhyay B et al <sup>9</sup>	100	27.1	-	-	
Salamon A et al <sup>14</sup>	30	30	3.2	21-38	
Saikia KC et al <sup>15</sup>	92	25.0	8.0	14-56	
Present study	110	26.17	2.83	20.26-32.32	

**Table 5: Comparison of depth of acetabulum in male and female with other studies.**

Author	Sex				P value
	Male		Female		
	n	Mean	SD	Range	
Lang C <sup>16</sup>	21	29.00	3.80	-	18 26.64 2.93 - <0.05
Kim YH <sup>17</sup>	488	20.3	-	15-29	512 18.1 - 14-25 -
Arsuaga JL et al <sup>18</sup>	187	25.1	2.6	-	171 22.8 2.2 - -
Murtha PE et al <sup>5</sup>	20	22.7	-	17.5-28.0	22 19.5 - 15.7-24.2 -
Saikia KC et al <sup>15</sup>	56	25.0	8.0	-	36 25.0 6.0 - -
Present study	60	26.89	2.77	20.26-32.32	50 25.31 2.68 20.58-30.83 <0.01

## DISCUSSION

Acetabular depth is important in restoring normal hip mechanics and establishing a good range of movement. It is considered a contributing factor in component dislocation. As a result, to get a better insight, the present study was compared with that of other workers.

Mukhopadhyay B et al carried out a study on 100 hip joints of 50 adults obtained from medicolegal post-mortem cases. Three measurements i.e. the depth of acetabulum and the radii of acetabulum and the femoral head were made on each hip. They found that the mean depth of acetabulum was 2.71 cm.<sup>9</sup> Salamon A et al measured 30 macerated anatomical specimens of pelvic bones. Mean acetabular depth was 30±3.2 mm (21-38 mm).<sup>14</sup> Saikia KC et al recorded the mean depth of acetabulum was 2.5 cm.<sup>15</sup>

In the present study, the mean depth of acetabulum is 26.17±2.83 (20.26-32.32). The mean depth of the present study coincides with the study done by Mukhopadhyay B et al and Saikia KC et al (Table 4).<sup>9,15</sup>

Lang C et al studied a series of mostly unorthodox measurements on a sample of 45 (19 females and 26 males) dry hip bones from the Grant Collection, curated in the Medical Sciences Building at the University of Toronto. They found that the mean acetabular depth in males and females was 29.00 mm (SD-3.80) and 26.64 mm (SD- 2.93) respectively. Mean values for the male group were higher in all cases. These higher values indicate that males have larger measurements dealing with the inner structures of the pelvis.<sup>16</sup>

Kim YH measured the equatorial and meridian diameter of acetabulum in 655 Korean adult cadavers and 172 Korean fetuses with a caliper by taking the greatest width of the cavity (a1), and the depth was measured using two wires. The mean depth of acetabulum in male and female was 20.3 mm and 18.1 mm respectively.<sup>17</sup>

Arsuaga JL et al studied 34 linear variables and 10 non-metrical (morphological) characters in a series of 418 adult hip bones of known sex (227 males and 191 females) born in the Beira Litoral region of Portugal between 1820 and 1920. The mean acetabular depth in males and females was 25.1 mm (SD = 2.6) and 22.8 mm (SD = 2.2) respectively. They found that acetabulum were deeper in men than in women in both hips and this was significant ( $P < 0.01$  right hip,  $P < 0.02$  left hip).<sup>18</sup>

Chauhan R et al carried out the dissections of fifty-four cadaveric hip joints belonging to the age group of 50-70 years of both sexes. Average depth of acetabulum (in mm) on the right side and left side of male was 27.49±2.70 (23.0-34.0) and 28.18±2.58 (24.3-34.0) respectively. Similarly, average depth of acetabulum (in mm) on the right side and left side of female was 24.68±1.20 (23.0-26.0) and 25.70±2.11 (23.0-28.0) respectively. It was observed that the depth of the acetabulum was greater in males than females both on right and left side. On the right side the difference being statistically significant (right  $p = 0.02$ , left  $P = 0.06$ ).<sup>19</sup>

According to Murtha PE et al the mean depth of acetabulum in male and female was 22.7 mm and 19.5 mm respectively.<sup>5</sup> Msamati BC et al found the mean acetabular depth in 52 males on right side was 31.7 mm (12.0- 32.0; SD- 1.55) and on left side was 31.8mm (15.0- 33.0; SD- 1.86). Mean acetabular depth in 38

females on right side was 29.5 (23.0-38.0; SD- 2.06) and on left side was 29.8 (24.0-39.0; SD- 2.12). Acetabulum were deeper in men than in women in both hips and this was significant ( $P < 0.01$  right hip,  $P < 0.02$  left hip).<sup>6</sup> Saikia KC et al found the mean values of acetabular depth was identical between males: 2.5 cm (1.6-5.6 cm) and females: 2.5 cm (1.4-5.2 cm).<sup>15</sup> Papaloucas C et al carried out the measurements of 200 hip bones within the Greek population. It was found that in males, in comparison to the females acetabular depth was larger.<sup>20</sup>

The mean depth of male and female acetabulum of the present study almost coincides with the mean depth found by the Saikia KC et al and Arsuaga JL et al.<sup>15,18</sup>

In the present study, the mean DA in male > female. Similar finding was observed in all other studies except the study of Saikia KC et al where they found identical values of mean acetabular depth between males and females (Table 5).<sup>15</sup> In the present study a statistically significant difference ( $P < 0.01$ ) was found when the mean depth of acetabulum was compared between male and female. Mukhopadhyaya B et al found that the mean depth of acetabulum on right and left side was 2.465 cm (2.13-3.03) and 2.451 cm (2.13-3.65) respectively.<sup>9</sup> Saikia KC et al found the mean values of acetabular depth was identical when comparison was made between right side: 2.5 cm (1.4-5.6 cm) and left side: 2.5 cm (1.4-5.6 cm).<sup>15</sup>

In the present study, the mean DA on Right > Left. The difference was statistically non-significant. The finding in the present study coincides with the study done by Mukhopadhyaya B et al where the mean depth of acetabulum was greater on right side.<sup>9</sup> However, Saikia KC et al found identical values of mean acetabular depth between right and left sides.<sup>15</sup>

Arsuaga JL et al found that there was no significant difference between the left and right hip within the same sex.<sup>18</sup> Chauhan R et al noticed that the depth of the left acetabulum was greater than that of the right side in both sexes but the difference was statistically insignificant (male  $p = 0.34$ , female  $p = 0.20$ ).<sup>19</sup> Msamati BC et al also noted that the depth of left acetabulum was greater than that of the right side in both male and female but there was no significant difference between the left and right hip within the same sex.<sup>6</sup> Chibber et al suggest that left limb is dominant. Therefore, the dimensions of the bones forming the hip joint of left side should be more so as to bear greater loading force on femur.<sup>21</sup>

In the present study, in case of male the mean DA on Right > Left. In case of female the mean DA on Left > Right. The difference was statistically non-significant.

## CONCLUSION

Scientific improvement urges researchers and practitioners in any field of medicine to deepen knowledge, resulting

in emergence of specialties. Hip surgery being one of them requires more detailed knowledge, about the complex acetabular measurements. The depth studied on acetabulum in the present study showed statistically significant differences between males and females. Studies based on depth of acetabulum are relatively few in the literature, hence the findings of the present study can provide a guideline for further studies on acetabulum. Considering that total hip replacement is a common surgery performed now a day, awareness of the dimensions of the acetabulum is of immense importance to the orthopaedic surgeons. It will assist prosthodontists to construct suitable prostheses. It will also help in detection of disputed sex by forensic experts.

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