

## Profound Morphometric Analysis of Acetabulum in South Indian Population (Acetabular Dimensions)

Hannah Sugirthabai Rajila Rajendran<sup>1</sup>, R. Abitha<sup>2\*</sup>,  
S. Logithkumar<sup>2</sup> and Vaithianathan Gnanasundaram<sup>1</sup>

<sup>1</sup>Department of Anatomy, Chettinad Hospital and Research Institute,  
Chettinad Academy of Research and Education, Chennai, Tamil Nadu, India.

<sup>2</sup>Chettinad Hospital and research Institute, Chettinad Academy of Research and Education,  
Chennai, Tamil Nadu, India.

\*Corresponding Author E-mail: abitharaja2022@gmail.com

<https://dx.doi.org/10.13005/bpj/2846>

(Received: 15 April 2022; accepted: 23 October 2023)

Acetabular dimensions plays a challenging role in various arthroplasties and reconstructions. Morphometric study of acetabulum of dry hip bones is a necessity to make proper prosthesis and to ensure good quality of life. **Materials & methods** - In this 71 dry human hip bones of 35 right and 36 left collected in department of anatomy of Chettinad Hospital and Research Institute, to analyze & measure the diameter, acetabular notch, acetabular circumference, depth and volume of acetabulum. **Results** - The transverse diameter on right-  $49.33 \pm 7.36$  mm, left  $48.57 \pm 6.79$  mm, depth-right  $23.28 \pm 3.27$  mm, left  $22.50 \pm 3.18$  mm, vertical diameter- right  $48.05 \pm 4.40$  mm, left  $47.66 \pm 4.95$  mm, acetabular notch- right  $22.00 \pm 3.28$  mm, left  $20.56 \pm 2.61$  mm, outer rim circumference -right  $11.90 \pm 0.99$  cm, left  $12.43 \pm 0.87$  cm, inner rim circumference- right  $7.66 \pm 0.84$  cm, left  $8.06 \pm 0.72$  cm, acetabular circumference- right  $15.26 \pm 1.38$  cm, left  $14.60 \pm 1.35$  cm, capacity- right  $27.22 \pm 5.43$  ml, left- $27.22 \pm 5.77$  ml. **Conclusion** - All the parameters were statistically analysed and the results suggest that the acetabular dimensions are mostly smaller in South Indian population and hip prosthesis should be made patient specific to increase the success rate of arthroplasties.

**Keywords:** Acetabulum; Arthroplasty; Biometry; Hip prosthesis.

The Acetabulum is known as the vinegar cup. Its deep concavity faces laterally and anteroinferiorly. The cup shape socket forms the hip joint on articulation with the head of a femur which provides stability to the joint. Development of cavity embryologically begins at 4th to 6th week and completion of cavity happens at 8th week of intrauterine life. Triradiate cartilage (immature ischium, ilium and pubis) fuses to form acetabulum. The morphology of acetabulum shows 2 surfaces, a smooth articulating lunate

surface, which has its anterior and posterior end and a rough non articulating part called acetabular fossa covered with a pad of fat.<sup>1,2,3</sup> The peripheral moon-shaped articular surface of acetabulum covered by hyaline cartilage and deficient at the inferior margin forms acetabular notch. This gap is bridged by transverse acetabular ligament to form acetabular foramen. Knowledge of morphometry & anatomical framework is necessary to understand the mechanics and enhances the acumen to perform hip arthroplasties.<sup>4,5</sup> A joint incongruity may also

lead to more dislocation & fractures. So a small change in any parameter of acetabulum leads to anatomical variations.

#### Aim

The morphometry of acetabular fossa enhances major baseline data for prosthesis construction of acetabulum .<sup>6,7</sup> In various hip dysplasia, damage to size and shape of acetabulum parameters are evaluated by applying measurements of acetabular parameters by an orthopedic surgeon. The present study aims to obtain morphometric data of various acetabular parameters which provide data to improve hip arthroplasty.

### MATERIALS AND METHODS

A total 71 hip bones of unknown sex were studied from Department of Anatomy of Chettinad Hospital and Research Institute. Out of 71 hip bones, 35 were of right side and 36 were of left side irrespective of age and sex, as these parameters can be included when the bones are derived from a single individual, which gives a precise idea. But, when the collection of bones are from different sources, the authenticity of the determination of sex and age becomes controversial. All the hip bones were fully ossified with intact normal anatomical features.

Specimens with any pathological evidences or damages were not included in the study. Measurements of the parameters were done with the help of digital vernier caliper, twine with measuring scale, plasticine, and urinometer. The parameters taken were vertical diameter, transverse diameter, acetabular notch width, acetabular rim, outer margin, inner margin, depth and capacity.

**Vertical diameter:** Maximum distance measured from the anterior superior iliac spine to prominent point on ischial tuberosity,

**Transverse diameter:** Maximum distance measured on acetabular rim in horizontal axis,

**Depth:** Distance measured from the brim of acetabulum to the deepest point in acetabular fossa with a thin metallic strip of vernier caliper.

**Acetabular notch:** Distance measured from the two end points of lunate with vernier caliper.

**Acetabular Circumference:** Circumference of the acetabular cavity measured over the lip of the acetabulum.

**Outer rim circumference:** Circumference

measured around the outer margin of anterior horn of lunate surface to outer margin of posterior horn of lunate surface.

**Inner rim circumference:** Circumference measured around the inner margin of anterior horn of lunate surface to inner margin of posterior horn of lunate surface excluding acetabular notch.

**Capacity:** A solid mass of plasticine was moulded to fill the entire acetabular cup till the circumference of acetabulum including acetabular notch. The excess plasticine after the filling was removed in order to provide proper morphometric evidence of volume of acetabulum.

Then the filled plasticine was taken and submerged in the measuring cylinder which was partially filled with water. So the volume of displaced fluid = volume of immersed object according to Archimedes principle. According to Force of buoyancy submerged volume=volume of object. All these values were analyzed statistically using SPSS software.

### RESULTS

The morphometry of acetabulum were measured and tabulated as below with side difference in respective units. Table 1 show the various results obtained during the study period. The value of acetabulum circumference in this study on right side was  $15.26 \pm 1.38$  cm and left side was  $14.60 \pm 1.35$  cm. Outer rim circumference

Table 1. Results

Acetabulum	Side	Mean $\pm$ SD
Transversediameter	Right	$49.33 \pm 7.36$ mm
	Left	$48.57 \pm 6.79$ mm
Depth	Right	$23.28 \pm 3.27$ mm
	Left	$22.50 \pm 3.18$ mm
Verticaldiameter	Right	$48.05 \pm 4.40$ mm
	Left	$47.66 \pm 4.95$ mm
Acetabularnotch	Right	$22.00 \pm 3.28$ mm
	Left	$20.56 \pm 2.61$ mm
Outer Rimcircumference	Right	$11.90 \pm 0.99$ cm
	Left	$12.43 \pm 0.87$ cm
Inner Rimcircumference	Right	$7.66 \pm 0.84$ cm
	Left	$8.06 \pm 0.72$ cm
Acetabularcircumference	Right	$15.26 \pm 1.38$ cm
	Left	$14.60 \pm 1.35$ cm
Capacity	Right	$27.22 \pm 5.43$ ml
	Left	$27.22 \pm 5.77$ ml

**Table 2.** Comparison table

Parameters	Our study	Gursharan <sup>14</sup>	Archana <sup>15</sup>	Ilankathir <sup>16</sup>	Yugesh <sup>17</sup>
Transversediameter[mm]	49.33 ± 7.36	51.3±2.6 P=0.073	47.43±3.43 P=0.031		
	48.57±6.79	50.3±3.5 P=0.103	48.13±3.33 P=0.591		
Depth[mm]	23.28±3.27	26.7±2.7 P<0.0001	26.73±3.06 P<0.0001	24.34 ±2.53 P=0.01499	29.9±0.21 P<0.0001
	22.50 ±3.18	26.4±3.0 P<0.0001	28.04±2.88 P<0.0001	24.35±2.54 P<0.0001	29.7±0.23 P<0.0001
Verticaldiameter[mm]	48.05±4.40		48.00±3.56 P= 0.938	50.43±3.88 P= 0.0002	47.4±0.27 P= 0.256
	47.66±4.95		48.38±3.12 P= 0.264	50.28±3.85 P<0.0001	48.0±0.37 P= 0.597
Acetabularnotch[mm]	22.00±3.28		23.11±2.70 P= 0.021	24.48±1.89 P<0.0001	30.8±0.42 P<0.0001
	20.56±2.61		23.98±2.79 P<0.0001	24.29±1.86 P<0.0001	31.1±0.72 P<0.0001
Capacity[ml]	27.22±5.43	36.68±6.23 P<0.0001			
	27.22±5.77	33.56±5.63 P<0.0001			

on right side was 11.90±0.99 cm & left side was 12.43±0.87cm and inner rim circumference on right side was 7.66±0.84cm & left side was 8.06±0.72cm.

**DISCUSSION**

Our study would give an elaborate idea of possible parameters in anthropometry of acetabulum of dry hip bone in South Indian population, which provides a strong anatomical knowledge to orthopedic surgeons for enhancing the success rate of hip arthroplasties.<sup>8,9,10,11</sup> Anthropometry of acetabular fossa is a major baseline data for making hip prosthesis.<sup>12,13</sup>

Our study accounts for precise morphometric values of the possible parameters measurable in the acetabular cavity. The transverse diameters of acetabulum of right and left side were 49.33 ± 7.36 mm, and 48.57±6.79mm respectively. The transverse diameter reported by Gursharan,<sup>14</sup> was found to be greater than the same in the present study and quite nearer to value was reported by Archana,<sup>15</sup> 47.43±3.43mm and 48.13±3.33mm on right and left sides. The diameter of acetabular cavity on vertical axis was 48.05±4.40mm and

47.66±4.95mm on right and left side respectively. The same diameter as compared with Sridharan, was smaller and statistically significant with p value less than 0.05 on both sides (Table 2).<sup>16</sup>

On the statistical analysis of the transverse and vertical diameters of acetabulum in our study, there was no significant difference between the parameters of the right and left side.

The depth of acetabulum in present study was 23.28±3.27mm on right side and 22.50 ±3.18mm on left side. Our values were smaller and statistically significant on comparison with the study of Sridharan.<sup>16</sup> The comparison of the same with Archana of North Indian population is also statistically significant.<sup>15</sup> The cavity depth in the South Indian population ranges from 23mm to 29mm with reference of other similar studies by Gursharan and Yugesh.<sup>14,17</sup> The width of acetabular notch of present study was measured as 22.00±3.28mm and 20.56±2.61mm on right and left side. It was found that the findings were again smaller and statistically significant with Sridharan, Archana, and Yugesh as mentioned in [Table 2].<sup>15,16,17</sup>

The morphometric knowledge of acetabular rim is very important for labral reconstruction, which is necessary to repair labral tears. In this study the value of acetabular rim measured was  $15.26 \pm 1.38$  mm and  $14.60 \pm 1.35$  mm on right and left side respectively. Outer rim of acetabulum on right and left side were  $11.90 \pm 0.99$  mm and  $12.43 \pm 0.87$  mm and the inner rim measured were  $7.66 \pm 0.84$  mm and  $8.06 \pm 0.72$  mm. This understanding of acetabular rim plays a main role in hip stability, but this parameter was infrequently noted in hip anthropology studies, that have been done till date.

The volumes of acetabulum in this present study were  $27.22 \pm 5.43$  mm and  $27.22 \pm 5.77$  mm on right and left side respectively. The study by Gursharan, done by the same method showed a huge difference in volume with a comparatively greater range and significant statistically as well.<sup>14</sup> Thereby the measured values enhanced by manual method are more accurate than the radiological method as these provide a better understanding for biomedical engineers for modeling the prosthesis as readings are near the real value.<sup>18,19,20,21,22,23</sup>

### CONCLUSION

This study emphasizes mainly on the detailed knowledge of anatomical parameters of acetabulum which are more important & essential to orthopedic surgeons for various hip surgeries. The depth of acetabular cavity plays an important role in acetabular dysplasia. Acetabular rim parameters were studied in great detail and plays important role in labral reconstructions. The values obtained here are pertaining to a part of South Indian population. These values were very smaller when compared to other races and even other Indian states.

The study has proved the importance of making prosthesis at an individualized level, rather than on a general level. This knowledge of acetabular parameters is essential for anatomist, forensics experts and orthopaedicians to deliver their performances to the maximum in their specialties.

### ACKNOWLEDGEMENT

None.

### Conflict of Interest

There is no conflict of interest.

### Funding Sources

None.

### REFERENCES

1. Standring S. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 41st Edition. Elsevier Churchill Livingstone; 2005.
2. Last RJ. Lower limb. In: McMinn RM, editor. Last's Anatomy Regional and Applied. 9th ed. New York: Churchill Livingstone; 1996.
3. Govsa F, Ozer MA, Ozgur Z. Morphologic features of the acetabulum. *Arch Orthop Trauma Surg.* 2005; 125: 453-461.
4. Chauhan NS, Thakur L, Singh S, Awasthi B, Raina SK. Morphometric evaluation of acetabular dimensions: A computed tomography based study from a tertiary care center in rural North-West India. *J Med Soc.* 2018 ;32: 195-198.
5. Murtha PE, Hafez MA, Jaramaz B, DiGioia AM III. Variations in acetabular anatomy with reference to total hip replacement. *J Bone Joint Surg [Br].* 2008;90-B: 308-13.
6. Eng JT, Baker A, Tang P, Thompson S, Gomez JM. 2012. Morphometric analysis of acetabular rim shape among ancient Mongolian pastoralists. Poster presented at the 19th Annual Meeting of the Midwest Bioarchaeology and Forensic Anthropology Association, Carbondale, IL, October 2012.
7. Safir O, Lin C, Kosashvili Y, Mayne IP, Gross AE, Backstein D. Limitations of conventional radiographs in the assessment of acetabular defects following total hip arthroplasty. *Can J Surg.* 2012; 55: 401-407.
8. Hettich G, Schierjott RA, Ramm H, Graichen H, Jansson V, Rudert M, Traina F, Grupp TM. Method for quantitative assessment of acetabular bone defects. *J Orthop Res.* 2019; 37(1): 181-189.
9. Gaurang P, Reliab SR, Patel SV, Patel SM, Jethvaa N. Morphology and morphometry of acetabulum. *Indian J Biol Med Res.* 2013; 4: 2924 - 6.
10. Jadhav S, Rokade S, Nomulwar S, Ahire P, Bahetee B. Morphometric study of acetabulum. *Appl Physiol Anat Dig.* 2017; 2: 26 - 34.
11. Saikia KC, Bhuyan SK, Rongphar R. Anthropometric study of the hip joint in northeastern region population with computed tomography scan. *Indian J Orthop.* 2008 ; 42(3): 260-6.
12. Johanson NA, Driftmier KR, Cerynik DL,

- Stehman CC. Grading acetabular defects: the need for a universal and valid system. *J Arthroplasty*. 2010 ; 25(3): 425-31.
13. Sreedevi G, Sangam MR. The study of morphology and morphometry of acetabulum on dry bones. *Int J Anat Res*. 2017; 5(4.2): 4558-4562.
  14. Dhindsa GS. Acetabulum : A morphometric study. *J EvolMedDentSci* 2013; 2(7): 657-665.
  15. Singh A, Gupta R, Singh A. Morphological and morphometric study of the acetabulum of dry human hip bone and its clinical implication in hip arthroplasty. *J AnatSoc India* 2020; 69: 220- 225.
  16. Sridharan I ,Muthusamy S, Thangarasu R, Krishnamoorthy S, Ganesan S. Morphometric Study of Acetabulum in Adult Dry Human Pelvic Bone. *Indian J Anat*. 2019; 8(4): 289–292.
  17. Yugesh K, Kumar SS. Morphometric analysis of acetabulum and its clinical correlation in south Indian population. *Int J Appl Res*. 2016; 2(6): 1011-1014.
  18. Benazzi S, Maestri C, Parisini S, Vecchi F, Gruppioni G. Sex assessment from the acetabular rim by means of image analysis. *Forensic Sci Int*. 2008; 180: 58.e1–58.e3.
  19. Pratibha K, Hema L, Devishankar. Acetabulum of the hip bone: A morphometric study in the south coastal region. *Int J Rec Trends Sci Technol*. 2015; 17(2): 136–39.
  20. R Chauhan, S Paul, Dhaon BK. Anatomical parameters of North Indian Hip joints- Cadaveric Study. *J Anat Soc*. 2002; 51(1): 39-42.
  21. San-Millán M, Rissech C, Turbón D. Shape variability of the adult human acetabulum and acetabular fossa related to sex and age by geometric morphometrics. Implications for adult age estimation. *Forensic Sci Int*. 2017;272:50-63.
  22. Parmara G, Rupareliab S, Patelc SV, Patelb SM, Jethvaa N. Morphology and Morphometry of Acetabulum. *Int J Biol Med Res*. 2013; 4(1): 2924-2926.
  23. Krishan K, Chatterjee PM, Kanchan T, Kaur S, Baryah N, Singh RK. A review of sex estimation techniques during examination of skeletal remains in forensic anthropology casework. *Forensic Sci Int*. 2016;261:165.e1-165.e1658.