Morphological and Morphometrical Study of the Human Acetabulum and its Clinical Implications

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ABSTRACT

Background: The acetabulum is a cup-shaped depression on the hip bone. All three innominate elements, the ilium, ischium and pubis contribute to its formation unequally. The acetabular fossa articulates with the head of femur to form the hip joint.

Objectives: To document the relationship between the depth and diameter of the acetabulum and to describe the anterior acetabular ridge morphology.

Material and Methods: The study was conducted on 73 adult unpaired dry hipbones of unknown age and sex were assessed for two morphometric and one morphological character. The data of the acetabular depth and diameter was determined using Vernier calipers. The morphology of anterior acetabular ridge was evaluated and classified as curved, angular, straight and irregular.

Results: The mean diameter of acetabular cavity on right side was found to be 48.3 ± 3.4mm and on the left side 48.9 ± 3.5mm. The mean depth on right side was measured to be 27.1 ± 3.4mm and on left side 27 ± 3mm. We observed positive co-relation between the mean and standard deviation of total diameter and depth of acetabular cavity. The Curved shape anterior acetabular ridge was the most predominant type (41.1%) and the least type was straight shaped (5.5%).

Conclusion: The morphometric assessment of the acetabulum has a myriad of utilities for Anatomists, anthropologists, experts in forensic medicine and orthopaedic surgeons for better alignment of acetabular cup placement during total hip arthroplasty. Further, the anterior ridge morphology may be vital in diagnosing congenital acetabular dysplasia and during treatment of hip joint fractures.

Key Words: Acetabulum, Acetabular ridge, Morphology, Morphometric, Prosthesis, Dysplasia

INTRODUCTION

Age, stature, gender and ethnicity form the corner stone’s of an individual’s biological identity. The distinct morphology of the human hip bone not only helps attribute these parameters to establish a person’s identity but is also fundamental from the orthopedic, anthropologic and forensic point of view¹.

The shape of the acetabulum can be altered prenatally due to disruption in its development or during the postnatal period due to damage to the cartilage of lunate articular surface. Acetabular dysplasia is the most common developmental disorder of the hip bone, due to underdeveloped acetabulum, wherein acetabular roof remains shallow, superficial and vertically oriented. This results in smaller surface area for weight bearing and hence receives much larger force per unit area while walking and may lead to early degeneration which is the indication for hip arthroplasty².

The anthropometric study of the acetabulum aids radiologists in diagnosing congenital hip dysplasia, and orthopedicians for planning for an acetabular surgery, during hip arthroplasty and in the treatment of hip fractures.
This study would also be beneficial in understanding the pathophysiology of the hip pathologies such as femoroacetabular impingement and preparing prosthesis of desirable sizes.

The present study becomes all the more vital as acetabular dimensions show regional variations and the study is crucial to provide valuable parameters in the Indian population which would exterminate the catastrophic consequences of prosthetic loosening or dislocation.

The aim and objectives of the present study would be

– To document the acetabular depth and diameter
– To demonstrate the relationship between the two parameters
– To describe the morphology of the anterior acetabular ridge

**MATERIAL AND METHODS**

The study was conducted on 73 dry adult hip bones of unknown gender and age collected from Department of Anatomy bone bank, Ramaiah Medical College, Bangalore. Bones with gross damage or anomalies were excluded from the study. Vernier calliper was employed for the accurate measurements.

Morphometric and Morphological features documented (Figure 1-4).

- The transverse diameter of the acetabulum- The maximum distance between the anterior and posterior ends of the acetabular cavity.
- The vertical diameter of the acetabulum - The greatest dimension between the Upper and Lower Margins of the Acetabular Cavity.
- The total acetabular diameter - the average of the transverse and vertical diameter.
- The depth of the acetabulum - the maximum vertical distance from the deepest point in the acetabular cavity to the horizontal plane touching the margins of the acetabular cavity. A plastic ruler was kept across the margins of the acetabular cavity and the depth of the acetabulum was measured on the Vernier calliper from the deepest point in the acetabulum to the ruler.
- The shape of the anterior acetabular ridge was classified as curved, angular, straight and irregular. (Fig 5)
- The relationship between the acetabular depth and diameter was also evaluated.

**RESULTS**

A comparison of 73 dry unpaired hip bones comprising 34 bones of left side and 39 bones of right side yielded the following results. Regarding the anterior acetabular ridge morphology, the commonest type was curved shape 31(41.10%), the least common was straight shape 4 (5.48%). (Table 1).

The mean values for acetabular diameter on right side was found to be 48.3 ± 3.4mm and on the left side 48.9 ± 3.5mm.
The mean values for acetabular depth on right side was measured to be 27.1 ± 3.4 mm and on left side 27 ± 3 mm. (Table 2, 3). The mean and standard deviation of total diameter and depth of acetabular cavity are shown and a significant positive co-relation was found between them.

### Table 1: Comparison of shape of the anterior acetabular ridge on the right and left side

| Shapes   | Total No | Right side | Left side |
|----------|----------|------------|-----------|
| Curved   | 30 (41.1%) | 15 (38.5%) | 15 (44.1%) |
| Angular  | 19 (26.2%) | 11 (28.2%) | 8 (23.5%)  |
| Straight | 4 (5.5%)   | 2 (5.1%)   | 2 (5.9%)   |
| Irregular| 20 (27.4%) | 11 (28.1%) | 9 (26.4%)  |

### Table 2: Mean diameter and depth of the acetabular cavity

| n=73 | Transverse Diameter | Vertical Diameter | Total Diameter | Depth |
|------|---------------------|-------------------|----------------|-------|
| Mean (mm) | 47.2 | 49.9 | 48.6 | 27.1 |
| Standard Deviation | 3.3 | 3.7 | 3.5 | 3.2 |
| Maximum | 53.1 | 60.6 | 55.9 | 35.4 |
| Minimum | 40.3 | 40.6 | 40.7 | 20.1 |

p=0.0001 (Positive correlation between Total Diameter and Depth)

### Table 3: Comparison of Total diameter and Depth of Acetabular cavity according to side

| Variables | Total diameter | Depth |
|-----------|----------------|-------|
| RIGHT(mm) | LEFT(mm)       | RIGHT(mm) | LEFT(mm) |
| Mean      | 48.3           | 48.9   | 27.1     | 27.0   |
| Standard Deviation | 3.4 | 3.5 | 3.4 | 3.0 |
| Maximum   | 54.6           | 55.9   | 35.4     | 32.4   |
| Minimum   | 40.7           | 42.2   | 21.5     | 20.0   |

### DISCUSSION

The acetabular morphology is very important for successful hip arthroplasty and for selecting a suitable prosthesis. The curved shaped acetabular ridges were found more frequently in our study. The comparison with other authors also showed same result. The percentage of irregular shape bones is significantly higher in the present study as compared to the study by Maruyama et al. The percentage of bones with straight shape of anterior acetabular ridge is significantly lower as compared to the studies by Vyasa et al, Prathiba et al and AKSU et al (Table 4).

The findings of measurements of Total Acetabular diameter and Depth of acetabular cavity in the present study are consistent with other studies (Table 5).

The knowledge of acetabular dimensions will help us in understanding the acetabular pathology and also in identifying disputed person through forensic expertise.

The differences observed between the values of present study and that of other studies could be attributed to ethnic and racial variations.

### Table 4: Comparison of shape of anterior acetabular ridge morphology with other studies

| Authors | Shape   | Maruyama et al\(^7\) | Vyasa et al\(^8\) | Prathiba et al\(^9\) | AKSU et al\(^10\) | Govsa et al\(^11\) | Present study |
|---------|---------|----------------------|------------------|---------------------|------------------|-----------------|--------------|
| Curved  | 60.5%   | 37.5%                | 38.2%            | 46.1%               | 43.3             | 41.1%           |
| Angular | 25.5%   | 12.5%                | 11.5%            | 16.8%               | 28.3%            | 26.0%           |
| Irregular | 4.5%   | 18.4%                | 28%              | 13.6%               | 16.3%            | 27.4%           |
| Straight | 4.5%    | 31.6%                | 38%              | 23.3%               | 11.9%            | 5.5%            |
However, it should be kept in mind, that the present study employed smaller number of hip bones, so it is worthwhile to perform similar studies on more number of hip bones for its theoretical and practical value in the coming years.

**CONCLUSION**

The findings of our study are vital for the accurate design of side specific prosthetic cups that replicate the curvaceous acetabular profile which would prevent prosthetic overlap, mechanical loosening and reduce the incidence of ilio-psoas impingement. The precise knowledge about the variations in morphology and morphometry of acetabular cavity would help clinicians, orthopedic surgeons, prosthetic surgeons and radiologists for better understanding about the pathologies of hip region which aids in accurate diagnosis and in planning a suitable treatment.

**ACKNOWLEDGEMENTS**

Authors acknowledge the immense help received from Mrs Radhika our statistician for the statistical analysis. Authors acknowledge the immense help received from the scholars whose articles are cited and included in references of this manuscript. The authors are also grateful to authors/editors/publishers of all those articles, journals and books from where the literature for this article has been reviewed and discussed.

**Source of Funding:** N/A

**Conflict of Interest:** Nil

| Authors                   | Diameter of acetabulum (cm) | Depth of acetabulum (cm) |
|---------------------------|-----------------------------|-------------------------|
|                           | Right | Left | Right | Left |
| Dhindsa et al            | 5.1   | 5.0  | 2.6   | 2.6  |
| Vyas et al               | 4.8   | 4.8  | 2.7   | 2.6  |
| Pratibha Kareddy et al   | 4.8   | 4.7  | 3.0   | 3.0  |
| Chauhan et al            | 4.7   | 4.7  | 2.7   | 2.8  |
| Present study            | 4.9   | 4.8  | 2.7   | 2.7  |

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