Original Article

A Morphometric Study of the Acetabulum in the Population of Bihar and Its Clinical Significance

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ABSTRACT

Background: The acetabulum, a component of the pelvic girdle, plays a pivotal role in the biomechanics of the hip joint, serving as the concave surface of the ball-and-socket articulation with the femoral head. Precise knowledge of its morphometric parameters is essential for understanding the variations that can influence normal hip function and the outcomes of surgical interventions such as total hip arthroplasty outcomes. This study aims to provide a comprehensive morphometric analysis of the acetabulum in the population of Bihar.

Materials and Methods: Sixty adult dry hip bones of unknown age and gender were analyzed in this cross-sectional study. Thirty hip bones belong to the right side and thirty to the left. With the use of a digital vernier caliper with a 0.01 mm sensitivity and the lowest count recorded, we were able to measure the acetabulum's diameter, depth, and width. Graph Pad Prism version 9 was used to statistically analyze the results.

Results: We recorded that the diameter of the acetabulum measured 49.68 ± 3.89 mm on the right side and 48.62 ± 5.39 mm on the left. The depth of the acetabulum was 24.75 ± 3.15 mm on the right side and 25.48 ± 2.65 mm on the left side. The acetabular notch measured 22.55 ± 3.20 mm on the right side and 22.72 ± 2.85 mm on the left. The current investigation yielded no statistically significant distinctions between the acetabulum's left and right-side characteristics. In the present study, a positive statistically significant correlation was observed between the diameter and depth of the acetabular cavity [r=0.2436, R squared value =0.0542, p-value =0.04].

Conclusion: Understanding the various dimensions of the acetabulum is crucial for orthopedic surgeons during hip surgeries and in selecting appropriate prostheses. The findings from this study can also be valuable for forensic science professionals, as well as orthopedic surgeons and prosthetists.

Keywords: Morphometry, Hip bones, Prosthesis, Lunate articular surface, Hip arthroplasty.

INTRODUCTION

The hip bone, a part of the pelvic girdle, is a big, asymmetrical bone that is enlarged above and below and contracted centrally. The hip joint is formed by the articulation of the femoral head with the deep, cup-shaped depression known as the acetabulum on the lateral surface of the hip bone. The ischium, pubis, and ilium: the three parts of the hip bone, all contribute to the formation of the acetabulum.[1] The acetabulum, a component of the pelvic girdle, plays a pivotal role in the biomechanics of the hip joint, serving as the concave surface of the ball-and-socket articulation with the femoral head. Precise knowledge of its morphometric parameters is essential for understanding the variations that can influence normal hip function and the outcomes of surgical interventions such as total hip arthroplasty outcomes. For patients with hip diseases such as osteoarthritis, avascular necrosis, and fractures, total hip arthroplasty (THA) is a commonly used surgical procedure. Proper placement of the implant within the acetabulum is critical for the successful outcome of total hip arthroplasty (THA) since incorrect placement can result in postoperative problems like impingement, dislocation, and premature wear of the prosthetic components. The process of morphometric examination of the acetabulum entails the quantitative evaluation of its anatomical characteristics, which has a significant impact on the surgical technique, implant choice, and total hip joint performance following surgery.[2,3] It also acts as a baseline data source for clinical practice acetabulum prosthesis development. While numerous studies have explored the morphometry of the acetabulum across various populations, there is a paucity of data specific to the regional demographics of Bihar, India. Understanding these regional morphometric variations is crucial for several reasons. First, it aids in the design and selection of prosthetic components that better match the anatomical contours of the population, thereby improving the fit and function of hip implants. Second, it informs the surgical techniques tailored to the specific anatomical nuances of the population, potentially reducing the risk of complications and enhancing postoperative outcomes.

Aim and Objectives: This study aims to fill the gap in the existing literature by providing a comprehensive morphometric analysis of the acetabulum in the population of Bihar.

MATERIALS AND METHODS

Sixty adult dry hip bones of unknown age and gender were analyzed in this cross-sectional study in the anatomy department of the Bhagwan Mahaveer Institute of Medical Sciences in Pawapuri, Nalanda, Bihar (India). Among that, thirty hip bones belong to the right side and thirty to the left.

Inclusion criteria: It included the following:

- **Hip bone with the intact acetabulum:** Only bones in good enough condition to allow for precise morphometric measures were collected.
- **Age and Sex:** Adult bones from different age groups were included. Both genders' bones (i.e. male and female) were considered.
- **Specimen Quality:** Bones with pathological diseases affecting the acetabulum or severe abnormalities were removed.

Exclusion criteria: The study excluded bones exhibiting signs of wear and tear, congenital abnormalities, or fractures involving the hip bones.

Using a digital vernier caliper with a sensitivity of 0.01 mm and a minimum count of 0.01 mm, linear measurements were made. The average of the two measurements was used in the analysis. The mean and standard deviation of the collected data are reported. In this study, an analysis was considered significant if the p-value was less than 0.05. Graph Pad Prism version 9 was used to statistically analyze the results.

The following parameters were observed:

A. **Diameter of the acetabulum:** The acetabular diameter was estimated by using a digital vernier caliper to measure the distance between the acetabular ridge closest to the body of ischium and the anterior iliac edge intersecting the acetabular ridge.

B. **Depth of the acetabulum:** The depth was calculated by the maximum vertical distance from the acetabulum's brim to the acetabular cavity's deepest point. After inserting a metallic strip across the acetabular edge, the depth of the acetabulum was measured in millimeters from the deepest point to the metallic scale using a digital vernier caliper.

C. **Width of the acetabular notch:** The width of the lunate-shaped articular portion of the acetabulum was assessed by measuring the distance between its two ends.

RESULTS

We recorded that the diameter of the acetabulum measured 49.68 ± 3.89 mm on the right side and 48.62 ± 5.39 mm on the left. The depth of the acetabulum was 24.75 ± 3.15 mm on the right side and 25.48 ± 2.65 mm on the left side. The acetabular notch measured 22.55 ± 3.20 mm on the right side and 22.72 ± 2.85 mm on the left. The current investigation yielded no statistically significant distinctions between the acetabulum's left and right side characteristics (Table 1).

Table 1: Showing different parameters of the acetabulum.

Parameters	Right Side (Mean ± SD)	Left Side (Mean ± SD)	P value	t value
Diameter of the acetabulum	49.68 ± 3.89	48.62 ± 5.39	0.384	0.878
Depth of the acetabulum	24.75 ± 3.15	25.48 ± 2.65	0.340	0.963
Width of the acetabular notch	22.55 ± 3.20	22.72 ± 2.85	0.384	0.878

All measurements were taken in mm.

In the present study, a positive statistically significant correlation was observed between the diameter and depth of the acetabular cavity [r=0.2436, R squared value =0.0542, p-value =0.04]. There was no statistically significant correlation observed between the diameter of the acetabular cavity and the width of the acetabular notch [r= -0371, R squared value =0.00137, p-value =0.779] and in between the width of the acetabular notch and the depth of the acetabular cavity [r= -2163, R squared value =0.04677, p-value =0.097].

DISCUSSION

In this study, we emphasize the importance of understanding the individual differences in hip joint structure through a morphometric analysis of the acetabulum. Orthopedic surgeons can improve their decision-making during total hip arthroplasty by establishing connections between acetabular dimensions. With these insights, precise preoperative planning can lead to better patient outcomes, fewer complications, and optimal implant positioning. Researchers worldwide have examined different variations in the morphometry of the hip bone's acetabulum in various populations. As shown in Table 02, we compared our findings with those of other scholars worldwide.

Table 2: Demonstrating the comparison of the different measurements of the parameters of the acetabulum.

Authors (Year)	Diameter of the acetabulum (mm)		Depth of the acetabulum (mm)	
	Right Side (Mean ± SD)	Left Side (Mean ± SD)	Right Side (Mean ± SD)	Left Side (Mean ± SD)
Makhopadhaya et al.[4] (1967)	-		27.1	
Salamon et al.[5] (2004)	-		30 ± 3.2	
Aksu F et al.[6] (2006)	54.29 ± 3.8		29.49 ± 4.2	
Saikia et al.[7] (2008)	-		25 ± 8	
Parmar G et al.[8] (2013)	49.23 ± 7.91		26.16 ± 7.69	
Devi TB and Philip CX[9] (2014)	50.99 ± 1.99		28.32 ± 1.32	
Solomon L B et al.[10] (2014)	48.6 ± 4.0		-	
Thoudam and Chandra[11] (2014)	50.99±1.99		28.32±1.32	
Ukoha UU et al.[12] (2014)	54.8 ± 3.5	53.9 ± 3.0	29.7 ± 3.1	30.2 ± 3.1
Yugesh and Kumar[13] (2016)	47.4 ± 0.23	48.0 ± 0.37	29.9 ± 0.21	29.7 ± 0.23
Gangavarapu and Muralidhar[14] (2017)	49.40 ± 3.5	48.06 ± 5.65	24.09 ± 2.69	25.16 ± 2.84
Khobragade L and Vatsalaswamy P[15] (2017)	-		26.24 ± 2.92	26.11 ± 2.77
Sreedevi G and Sangam MR[16] (2017)	49.4 ± 3.52	48.06 ± 5.65	24.09 ± 2.84	25.16 ± 2.97
Indurjeeth K et al.[17] (2019)	54.84 ± 4.18		31.30 ± 3.18	
Bahl I et al.[18] (2020)	48.6 ± 3.5		27.1 ± 3.2	
Singh A et al.[19] (2020)	48.04 ± 3.67	48.23 ± 2.93	26.73 ± 3.06	27.96 ± 2.5
Arunkumar KR et al.[20] (2021)	48.98 ± 2.91		24.12 ± 2.54	
Present study (2024)	49.68 ± 3.89	48.62 ± 5.39	24.75 ± 3.15	25.48 ± 2.65

The mean diameter of the acetabulum in the current study was 49.68 ± 3.89 mm on the right side and 48.62 ± 5.39 mm on the left, which were much closer to the findings of Yugesh and Kumar[13] and Singh A. et al.[19], whereas much larger values than our observations were reported by Aksu F et al.[6], Ukoha UU et al.[12], and Indurjeeth K et al.[17] Parmar G et al.[9] reported the mean value of the diameter of the acetabulum was 42.54±3.6 mm and the depth of the acetabulum was 19.07±2.47 mm in their study**,** which was much less than our observations. Acetabular depth is essential for a wide range of motion and appropriate hip function. It is one of the elements contributing to the dislocation of components.[15] Many experts have considered the acetabular depth a crucial sign of acetabular dysplasia. An acetabulum less than 9 mm deep is referred to as having acetabular dysplasia.[7] The acetabulum depths in the current study were 24.75 ± 3.15 mm on the right side and 25.48 ± 2.65 mm on the left, which were significantly closer to the findings of Saikia et al.[7], Gangavarapu and Muralidhar[14], Sreedevi G, and Sangam MR[16], whereas much larger values than our observations were reported by Aksu F et al.[6], Ukoha UU et al.[12], and Yugesh and Kumar[13]. These discrepancies in the outcomes could result from disparities in geographic and racial distributions. Our measurements of the acetabular notch width were 22.55 ± 3.20 mm on the right side and 22.72 ± 2.85 mm on the left, in contrast to Sreedevi G and Sangam MR [16], who reported that the notch width on the right and left sides was 22.25±2.97 mm and 22.52±2.46 mm, respectively, and Yugesh and Kumar[13], who noted that the notch width was 30.8±0.42 mm and 31.1±0.72 mm in the right and left side, respectively.

Limitations: This study had limitations in that the age and sex of the hip bones were not examined because the information was not readily available.

CONCLUSION

The comprehensive analysis and understanding of the measurements of the acetabulum is crucial for biomedical engineers as it allows them to design and create prostheses that are not only functional but also custom-tailored to the specific needs of patients. This study, focusing on preoperative planning for total hip replacement, has identified and detailed several specific acetabulum measures that can be leveraged to thoroughly evaluate the condition of the acetabulum, thereby informing the surgical approach and prosthetic design.

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