

## Morphologic and Morphometric Evaluation of the Acetabulum

### Acetabulum'un Morfolojik ve Morfometrik Olarak Değerlendirilmesi

<sup>1</sup>Mehmet ÜLKİR, <sup>1</sup>Hasan Barış ILGAZ

<sup>1</sup>Department of Anatomy, Faculty of Medicine, Hacettepe University, Sıhhiye, Çankaya, Ankara, Türkiye

Mehmet Ülkir: <https://orcid.org/0000-0001-5615-8913>

Hasan Barış Ilgaz: <https://orcid.org/0000-0003-2507-5810>

#### ABSTRACT

**Objective:** The aim of this study is to reveal the morphological and morphometric features of the acetabulum and to compare them with the current literature.

**Materials and Methods:** A total of 57 coxae (29 left, 28 right) were examined. The anterior ridge of the acetabulum was classified as curved, straight, angular, and irregular according to its morphological features and the transverse diameter of the acetabulum (TD), the vertical diameter of the acetabulum (VD), the anteroposterior diameter of the acetabulum (APD), acetabular depth (AD), acetabular notch width (ANW) and os coxae height (CH) were measured.

**Results:** The types of the anterior ridge of the acetabulum were found as 19 (33.3%) straight, 18 (31.6%) curved, 14 (24.6%) angular, and 6 (10.5%) irregular in shape. The mean values of the TD, VD, APD, ANW, AD and CH were 50.67±3.12 mm, 52.21±3.52 mm, 52.66±3.73 mm, 22.64±2.67 mm, 29.75±2.28 mm and 206.33±11.70 mm respectively. No significant difference was found between the right and left coxae in terms of the measured parameters ( $p>0.05$ ). There was only a difference between the shapes and the depth of the acetabulum ( $p<0.05$ ).

**Conclusion:** Knowing the normal anatomy of the acetabulum is important in preventing complications during surgical procedures of this area.

**Keywords:** Acetabulum, anatomy, anterior ridge, hip prosthesis, morphometry

#### ÖZ

**Amaç:** Bu çalışmanın amacı acetabulum'un morfolojik ve morfometrik özelliklerini ortaya koymak ve literatürde yapılan benzer çalışmalar ile karşılaştırmaktır.

**Materyal ve Metot:** Toplam 57 os coxae (29 sol, 28 sağ) incelendi. Acetabulum'un ön kenarı morfolojik özelliklerine göre kavisli, düz, açılı ve düzensiz olarak sınıflandırıldı ve acetabulum'un transvers çapı (TÇ), acetabulum'un vertikal çapı (VÇ), acetabulum'un ön-arka çapı (ÖAÇ), incisura acetabuli genişliği (İAG), acetabulum derinliği (AD) ve os coxae yüksekliği (CY) ölçüldü.

**Bulgular:** Acetabulum ön kenarı coxa'ların 19'unda (%33,3) düz, 18'inde (%31,6) kavisli, 14'ünde (%24,6) açılı, 6'sında (%10,5) düzensiz şekilli olarak bulundu. TÇ, VÇ, ÖAÇ, İAG, AD ve CY'nin ortalama değerleri sırasıyla 50,67±3,12 mm, 52,21±3,52 mm, 52,66±3,73 mm, 22,64±2,67 mm, 29,75±2,28 mm ve 206,33±11,70 mm idi. Sağ ve sol acetabulum ölçümleri arasında anlamlı fark bulunamazken ( $p>0,05$ ), acetabulum derinliği ile acetabulum ön kenar şekli arasında anlamlı fark bulundu ( $p<0,05$ ).

**Sonuç:** Acetabulum'un normal anatomisinin bilinmesi bu bölgenin cerrahi işlemleri sırasında komplikasyonları önlemede önemlidir.

**Anahtar Kelimeler:** Acetabulum, anatomi, kalça protezi, morfometri, ön kenar

#### Sorumlu Yazar / Corresponding Author:

Mehmet Ülkir  
Department in Anatomy, Faculty of Medicine, Hacettepe University,  
Sıhhiye, Çankaya, Ankara, Türkiye  
Tel: +90 542 534 11 65  
E-mail: mehmet.ulkir@hotmail.com

#### Yayın Bilgisi / Article Info:

Gönderi Tarihi/ Received: 22/06/2022  
Kabul Tarihi/ Accepted: 18/05/2023  
Online Yayın Tarihi/ Published: 06/06/2023

## INTRODUCTION

The acetabulum, the anterior and downward pit on the outer surface of the os coxae, transmits body weight to the femur via the lunate surface. The concave shape of the acetabulum shows harmony with the head of the femur, allowing whole movements around the hip joint.<sup>1</sup> Various movement disorders of the joint may occur in the pathologies of this region.<sup>2</sup> The normal anatomical morphology of the acetabulum is important in terms of some clinical pathologies' diagnosis or surgical success applied in this region and decreasing the risk of complications.<sup>3</sup> For example, pathologies of the hip joint, such as acetabular dysplasia or pincer-type femoral acetabular impingement, are associated with morphological abnormalities of the acetabulum, including diameter, depth and orientation.<sup>4</sup> Han et al. conducted a radiological study and presented the radiological parameters for acetabular dysplasia diagnosis.<sup>5</sup> And also, clinically, it is very important to know the morphology of the anterior acetabular ridge during total hip arthroplasty.<sup>6</sup> The shape of the acetabulum may be relevant in the design and implantation of hip implants.<sup>7</sup> Maruyama et al. evaluated the morphology of the anterior acetabular ridge to perform the hip joint implants correctly.<sup>3</sup> For these reasons, it is necessary to know the anatomy of the acetabulum to diagnose hip diseases and to make appropriate surgical treatments.

This study aims to reveal the morphological and morphometric features of the acetabulum, compare

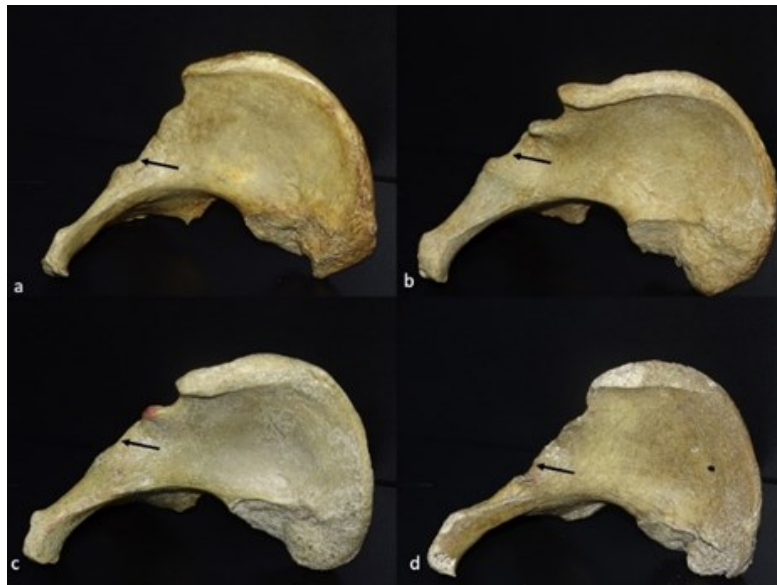
them with the current literature, and extend the data set.

## MATERIALS AND METHODS

**Ethical Status:** Ethics committee approval was obtained from Hacettepe University Non-Interventional Clinical Research Ethics Committee (date: 10.052022, decision no: 2022/08-43). The study was conducted in accordance with the principles of the Declaration of Helsinki.

**Cases:** A total of 57 coxae (29 left, 28 right) from the Anatolian adult population of unknown gender and age were examined and included in the Hacettepe University Faculty of Medicine, Department of Anatomy collection. The specimens showed no obvious signs of physical damage or pathological trauma. The anterior ridge of the acetabulum was classified as curved, straight, angular and irregular according to its morphological features (Figure 1).<sup>6,8-11</sup> In addition, six parameters of the acetabulum were measured. These are:

1. The transverse diameter of the acetabulum (TD): the maximum distance on the acetabular margin in horizontal plane,<sup>10</sup>
2. The vertical diameter of the acetabulum (VD): the maximum distance on the acetabular margin in vertical plane,<sup>10</sup>
3. The anteroposterior diameter of the acetabulum (APD): the maximum distance on the acetabular margin in anteroposterior axis,<sup>10</sup>
4. The acetabular depth (AD): Maximum vertical



**Figure 1.** The view of the morphology of the anterior acetabular ridge. a) angular; b) curved; c) straight; d) irregular.

distance from the margin of the acetabulum to the deepest point in the acetabular cavity,<sup>12</sup>

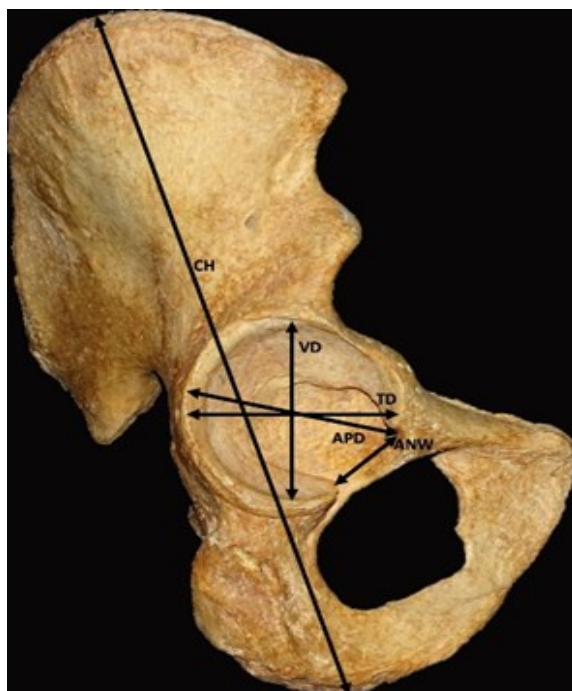
5. Acetabular notch width (ANW): distance between the two ends of lunate articular surface,<sup>10</sup>

6. Os coxae height (CH): the maximum distance between the iliac crest and the ischiopubic ramus.<sup>13</sup>

Figure 2 shows these parameters.

A sliding digital calliper with a 0.01 millimetre (mm) accuracy was used for linear measurements. Length measurements were expressed as mean±standard deviation and in mm.

**Statistical Analysis:** SPSS (Statistical Package for the Social Sciences) 23.0 program was used for statistical analysis. The distribution of the data was evaluated with “Kolmogorov Smirnov and Shapiro-Wilk normality tests”; then, for normal distribution, Student's t-test was used for the difference between the two groups and one-way ANOVA test was used to determine whether there was a difference between more than two independent groups. The correlation of the data was evaluated with Pearson coefficient analysis. The significance level was set at  $p < 0.05$ .



**Figure 2.** Demonstration of the measurement of the parameters.

TD: the transversal diameter of the acetabulum; VD: the vertical diameter of the acetabulum; APD: the anteroposterior diameter of the acetabulum; ANW: acetabular notch width; CH: os coxae height.

## RESULTS

Based on our morphometric study of the shape of the 57 acetabula's anterior ridge, four distinct types could be identified. The straight-type acetabulum was observed on 19 samples (33.3%). 18 (31.6%), 14 (24.6%), and 6 (10.5%) were curved, angular and irregular subtypes, respectively (Figure 3).

The mean values of the TD, VD, APD, ANW, AD, and CH were 50.67±3.12 mm (R: 51.14±3.42 mm, L: 50.21±2.80 mm), 52.21±3.52 mm (R: 52.87±3.36

mm, L: 51.56±3.60 mm), 52.66±3.73 mm (R: 52.93±3.40 mm, L: 52.40±4.06 mm), 22.64±2.67 mm (R: 22.03±2.43 mm, L: 23.23±2.79 mm), 29.75±2.28 mm (R: 29.80±2.24 mm, L: 29.70±2.36 mm) and 206.33±11.70 mm (R: 208.29±12.39 mm, L: 204.45±10.85 mm) respectively. In the statistical analysis, no significant difference was found between the right and left coxae in terms of the measured parameters ( $p > 0.05$ ) (Table 1).

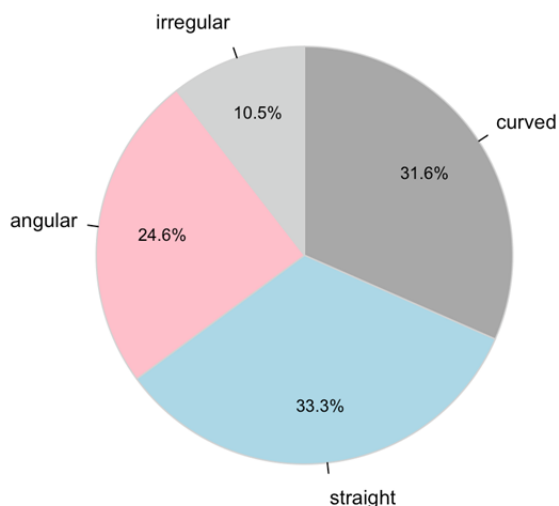


Figure 3. Distribution schema of the anterior acetabular ridge morphology.

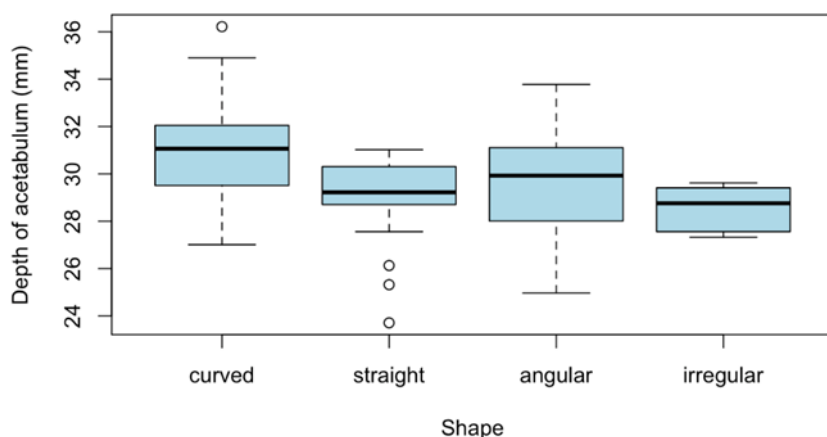
Table 1. Shows the descriptive values of the right and left acetabulum.

Parameters	Side	n	Mean±SD	p-values
TD	L	29	50.21±2.80	0.27
	R	28	51.14±3.42	
	T	57	50.67±3.12	
VD	L	29	51.56±3.60	0.16
	R	28	52.87±3.36	
	T	57	52.21±3.52	
APD	L	29	52.40±4.06	0.59
	R	28	52.93±3.40	
	T	57	52.66±3.73	
ANW	L	29	23.23±2.79	0.09
	R	28	22.03±2.43	
	T	57	22.64±2.66	
AD	L	29	29.70±2.36	0.87
	R	28	29.80±2.24	
	T	57	29.75±2.28	
CH	L	29	204.45±10.85	0.22
	R	28	208.29±12.39	
	T	57	206.33±11.69	

TD: Transverse diameter; VD: Vertical diameter; APD: Anteroposterior diameter; AD: Acetabular depth; ANW: Acetabular notch width; CH: Os coxae height; R: Right, L: left; T: Total, n: Sample size; SD: Standard deviation.

There was only a difference between the shapes and the depth of the acetabulum ( $p < 0.05$ ). It was about the curved and angular types of the acetabula. The curved types were more in-depth than the angular ones (Figure 4).

In addition, a high positive correlation ( $R \sim 0.80$ ) was found between CH and TD, VD, APD and AD.



**Figure 4.** Schematic view of the correlation between the acetabular depth and anterior acetabular ridge morphology.

## DISCUSSION AND CONCLUSION

Various movement disorders of the joint may occur in the pathologies of the acetabulum, such as osteoarthritis. Osteoarthritis is a common pathology that originates from many different reasons.<sup>2</sup> Acetabular dysplasia is one of the main causes of this clinical condition. Acetabular dysplasia correlates with the depth of the acetabulum. Acetabulum that is less than or equal to 9 mm in depth is defined as dysplastic.<sup>6</sup> In this case, a smaller surface area is revealed for weight bearing. Therefore, more force is applied per unit area, so more load is placed on the acetabulum. As a result, degeneration occurs in the hip joint.<sup>14</sup> The pathologies of the hip joint, such as acetabular dysplasia or pincer-type femoral acetabular impingement, are associated with morphological abnormalities of the acetabulum, including diameter, depth and orientation.<sup>4</sup> In treating patients who consult the physician with these clinical conditions, hip prostheses are used in progressive degenerations besides symptomatic treatments.<sup>15</sup> The morphology of the anterior acetabular ridge is clinically important for total hip arthroplasty.<sup>3,6,7,11</sup> The morphology of the anterior ridge of the acetabulum may differ depending on the populations living in different geographies, and this differentiation affects the anteversion of the acetabulum. These morphological differences observed in different people should be considered to reduce complications during surgical procedures such as acetabular prosthesis.<sup>3</sup> Positioning of the acetabular component is one of the most important steps in total hip arthroplasty; It must be done with care and requires mastery of acetabular morphology, as incorrectly positioned components can cause dislocations, impact and limited range of motion.<sup>11</sup>

The posterior acetabular ridge is almost always a simple semicircle. However, the anterior acetabular ridge is variable, and due to these variations, the

amount of anteversion is affected by the measurement point along the anterior ridge.<sup>3,6,11</sup> The anterior acetabular ridge is classified as curved, straight, angular and irregular.<sup>6-11</sup> In studies in which the anterior ridge of the acetabulum was typed in populations living in different geographies, Devi and Philip (60%), Bahl et al. (44.1%), Gwala et al. (34.04%), Singh et al. (45.7%) and Govsa et al. (43.36%) in their study, the anterior ridge of the acetabulum was found the curved type most frequently,<sup>6,8,9,11</sup> while Indurjeeth et al. found angular type (41%).<sup>7</sup> In this study, the anterior ridge of the acetabulum was most commonly found in the straight type (33.3%). Devi and Philip (4%), Indurjeeth et al. (14%), Bahl et al. (5.9%), and Govsa et al. (11.94%) found the straight type as the least frequently in their study,<sup>6-8,11</sup> while this study (10.5%) and Gwala et al. (20.23%) and Sing et al. (13%), the irregular type was detected as the least frequently.<sup>9,10</sup>

When studies conducted in different geographical regions were searched, the minimum and maximum values of the morphometric measurements of the acetabulum were observed as 47.2 mm and 56.15 mm for TD, 48.00 mm and 54.84 mm for VD, 15.49 mm and 31.30 mm for AD, 18.08 mm and 23.98 mm for ANW. While the measurements made in our study were between these minimum and maximum values, the APD measurement in our study (right: 52.93±3.40 mm, left: 52.40±4.06 mm) compared to the study of Sing et al. in India (right: 48.70±4.54 mm, left: 48.86±3.68 mm) was found to be higher.<sup>6-8,10,11,16,17</sup>

As expected, no significant difference was found between the right and left coxae in terms of the measured parameters ( $p>0.05$ ). To our knowledge, there is no clinically oriented difference between the sides and the other parameters.

Also, in our study, there was a difference between the shape and the depth of the acetabulum ( $p<0.05$ ).

The curved types were greater in-depth than the angular types. We could not find any study or evaluation about whether this difference, which we did not observe in other studies, has clinical significance.

In conclusion, knowing the acetabulum's normal anatomical structure and morphometric values is important in preventing possible complications during surgical procedures applied to this region. We think that this study will be beneficial for surgeons and clinicians in surgical approaches to the coxae and will contribute to future studies. The study has some limitations. Since the age and gender of the bones used in the study were not known, age and gender differences of the coxae could not be revealed in this study. Also, the sample size was limited to 57 bones in this study.

**Ethics Committee Approval:** Ethics committee approval was obtained from Hacettepe University Non-Interventional Clinical Research Ethics Committee (date: 10.5.2022, decision no: 2022/08-43).

**Conflict of Interest:** No conflict of interest was declared by the authors.

**Author Contributions:** Concept - MÜ, HBI; Supervision - MÜ, HBI; Materials - MÜ, HBI; Data Collection and/or Processing - MÜ, HBI; Analysis and/or Interpretation - MÜ, HBI; Writing - MÜ, HBI.

**Peer-review:** Externally peer-reviewed.

## REFERENCES

1. Susan S. Gray's anatomy: the anatomical basis of clinical practice. 41st ed. London, UK: Elsevier; 2016:1340.
2. Murray R. The aetiology of primary osteoarthritis of the hip. *Br J Radiol.* 1965;38(455):810-824.
3. Maruyama M, Feinberg JR, Capello WN, D'Antonio JA. Morphologic features of the acetabulum and femur: anteversion angle and implant positioning. *Clin Orthop Relat Res.* 2001;Dec(393):52-65.
4. Zeng Y, Wang Y, Zhu Z, Tang T, Dai K, Qiu S. Differences in acetabular morphology related to side and sex in a Chinese population. *Journal of anatomy.* 2012;220(3):256-262. doi:10.1111/j.1469-7580.2011.01471.x. Epub 2012 Jan 11
5. Han CD, Yoo JH, Lee WS, Choe WS. Radiographic parameters of acetabulum for dysplasia in Korean adults. *Yonsei Med J.* 1998;39(5):404-408.
6. Devi TB, Philip X. Acetabulum-morphological and morphometrical study. *Res J Pharm Biol Chem Sci.* 2014;5(6):793-799.
7. Indurjeeth K, Ishwarkumar S, De Gama B, Ndlazi Z, Pillay P. Morphometry and morphology of the acetabulum within the black African population of South Africa. *Int j morphol.* 2019;37(3):971-976. doi:10.4067/S0717-95022019000300971
8. Bahl I, Jyothi K, Shailaja S. Morphological and morphometrical study of the human acetabulum and its clinical implications. *Int J Cur Res Rev.* 2020;12(10):1-4. doi:10.31782/IJCRR.2020.12101
9. Gwala FO, Munguti J, Ongeti K, Awori K. Sex differences in the anterior acetabular ridge morphology. *Rev Arg de Anat Clin.* 2020;12(3):118-123.
10. 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 Anat Soc India.* 2020;69(4):220-225. doi:10.4103/JASI.JASI\_214\_19
11. Govsa F, Ozer MA, Ozgur Z. Morphologic features of the acetabulum. *Arch Orthop Trauma Surg.* 2005;125(7):453-461. doi:10.1007/s00402-005-0020-6
12. Dhindsa GS. Acetabulum: a morphometric study. *J Evol Med Dent Sci.* 2013;2(7):657-666.
13. White TD, Black MT, Folkens PA. Human osteology. 3th edition. Oxford, UK: Elsevier; 2012:235.
14. Umer M, Thambyah A, Tan W, De SD. Acetabular morphometry for determining hip dysplasia in the Singaporean population. *J Orthop Surg (Hong Kong).* 2006;14(1):27-31. doi:10.1177/230949900601400107
15. Ranawat CS, Atkinson R, Salvati E, Wilson Jr P. Conventional total hip arthroplasty for degenerative joint disease in patients between the ages of forty and sixty years. *J Bone Joint Surg Am.* 1984;66(5):745-752
16. Uzun GB, Değermenci M, Uçar İ, Arslan A, Nisari M. Morphometric evaluation of acetabulum. *J Surg Med.* 2020;4(7):555-557. doi:10.28982/josam.752997.
17. Baharuddin MY, Zulkifly AH, Kadir MRA, Saat A, Aziz AA, Lee MH. Morphometric study of the acetabular in Malay population normal hips and its clinical applications. *J Med Sci.* 2011;11(5):213-219. doi: 10.3923/jms.2011.213.219