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Unique morphological features of acetabulum of hip bone: An Anatomical study

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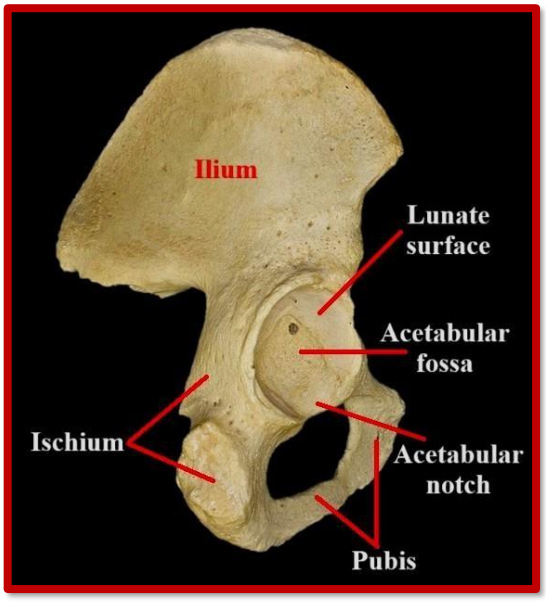
1. INTRODUCTION

The hip bone is a large and irregular bone. It is a part of pelvic girdle and is constricted in its central part but expanded above as well as below. It is made up of three small bones – Ilium, Ischium and Pubis which are united each other at the acetabulum. Acetabulum is a deep hemispherical cavity present on the lateral side of hip bone. A large foramen known as obturator foramen lies anteroinferior to acetabulum between pubis and ischium.[1, 2, 3]



Acetabular cavity is divided into 2 parts: articular and non-articular parts. Lunate surface forms articular part and acetabular fossa forms rough non-articular part. Lunate surface is deficient inferiorly to form acetabular notch which is bridged by transverse acetabular ligament. Acetabular labrum, a fibrocartilaginous rim attached to the acetabular margin increases the depth of acetabulum.[1, 2]

Structurally, acetabulum is thinner and has only one plate of compact bone in contrast to thicker areas of hip bone which have trabecular bone in between two layers of compact bone. However, in upper part of acetabulum, compact bone increases and trabecular bone adjacent to it shows two zones of pressure lamellae.[4] Spherical head of femur results in development of concavity of acetabulum, depth of which increases due to interstitial growth, appositional growth at margins of acetabular cartilage and periosteal reaction at rim of acetabulum.[5, 6]

Smooth unusual facets of three different shapes are often observed in dry bones in acetabular fossa anteroinferior to lunate articular surface. These facets were produced because of a specific posture that led to traction of ligaments or muscles attached to this area and were either limited to acetabulum or extend till superior pubic ramus beyond the rim of acetabulum. Piriform, oval and elongated facets were found, among which oval shaped facets were found to be most prevalent followed by piriform and elongated type[7]

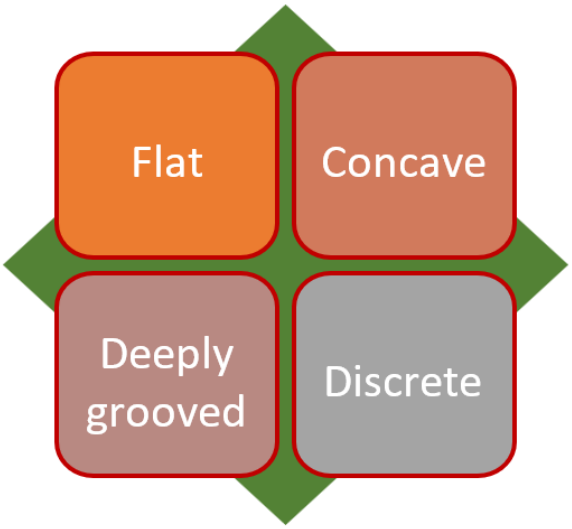


Fig 2: Different types of facets found in acetabular fossa

Sexual dimorphism is also observed in hip bones; in males, hip bones are bulky with prominent muscular impressions, inverted ischial spine, large and oval obturator foramen, deeper iliac fossa, everted and thick ischiopubic ramus and less conspicuous pre auricular sulcus.[8, 9] Whereas, in females these are lighter in weight with less prominent muscular impressions, small and triangular obturator foramen, inverted and thin ischiopubic ramus and conspicuous pre auricular sulcus.[2, 8, 9]

Males have narrower acetabular notch, smaller acetabular fossa and large lunate surface as compared to females. Also, males have laterally faced acetabulum whereas in females it is directed anteriorly .[10, 11]

Sometimes, there is an abnormal contact between femur and acetabulum that leads to supraphysiologic stress and causes labral tearing and cartilage abrasion or avulsion, eventually leading to osteoarthritis of hip.[12, 13, 14] Total hip arthroplasty (THA) is a reconstructive orthopaedic procedure in which femoral head and its proximal neck are surgically excised and acetabular cartilage and bone under it is removed. Excised parts are then replaced by prosthetic hip components that include a metal femoral implant and an acetabular component. It is most performed in severe osteoarthritis of hip joint and main objective of this surgery is to restore the actual biomechanics of hip joint.[15, 16] Despite the tremendous success, total hip arthroplasty is associated with many complications such as infection of hip implant, dislocation, septic/aseptic component loosening, bleeding, nerve damage, wear and heterotopic ossification.[17,18]

Among all the complications, aseptic loosening is the most common reason for failure of total hip arthroplasty.[19] Recent innovations and advances in total hip arthroplasty include 3D printing technology, computer navigated and robotic total hip arthroplasty.[16, 20]

A special classification of acetabular fossa has been described by Govsa F et al.[17] in 2005 after performing a study among 226 dry hip bones, 4 types of acetabular fossa were described

Type I: Clover leaf-like acetabular fossa, observed in 137 (60.62%) bones.

Type II: Semi-circular acetabular fossa, found in 65 (28.76%) bones.

Type III: Smooth compact or spongy bony surface covering the floor of fossa, present in 4 (1.77%) bones.

Type IV: Acetabular fossa with an isolated defect above the superior lobe, found in 20 (8.85%) bones.

Keeping all this in mind, the present study has been undertaken to find out the unique morphological variations of acetabulum in adult dry hip bones which will be very helpful to radiologists in diagnosing various pathological conditions especially femoroacetabular impingement syndrome (FAI). Also, apart from that, unusual morphological variabilities of acetabular fossa should be kept in mind by the clinicians, especially orthopedic surgeons while preparing prosthesis for hip arthroplasty and total hip replacement.

2. MATERIALS & METHODS

The present study was performed on 80 adult dry hip bones of both sides & of unknown sexes available in the Department of Anatomy, Faculty of Medicine & Health Sciences SGT University, Gurugram, Haryana over a period of 1 year. All the hip bones were examined grossly for side determination & for other generalized anatomical descriptions. Grossly deformed & broken bones were excluded from the study. The information regarding the bones was anonymized as coded to delinked from any identity source. Detailed morphological parameters of acetabular fossa were examined by visual inspection. Categorization of acetabular fossa was performed on according to shapes such as clover leaf; semicircular; inverted U; spongy bony surface & also isolated defect at superior lobe of fossa. Presence of bony spicules at lunate surface of acetabulum was also examined. Apart from this, unusual facet present on acetabular fossa was examined thoroughly to evaluate their shape as oval or piriform along with special emphasis on surface configuration. It was observed that; unusual facets were extending beyond acetabular margin to superior ramus of pubis & some were only confined to the acetabulum; both the observations were documented. The number & percentages of each observation were mentioned in tabulated form. Photography was performed for proper documentation of each observation.

Sample size

Sample size was calculated based on convenient sampling; samples available in the department of anatomy, FMHS, SGT University. A total of 80 bones were available in the department & morphological evaluation was performed on all 80 intact hip bones for detailed observation of acetabular fossa.

Results

In the present study, various morphological parameters of acetabular fossa in hip bone of both sides were observed. The data has been presented in **Table 1 & 2.** Similar results have been also displayed as images in figure 1 & 2 respectively**.**

S.No.	Types of acetabular fossa	n	%
1	Clover-leaf like	45	56.25
2	Semi-circular	18	22.5
3	Smooth compact or spongy bony surface covering the floor of fossa	4	5
4	Acetabular fossa with an isolated defect above superior lobe	11	13.75
5	Inverted elongated U-shape	2	2.5

Table 1: Displays incidence of various types of acetabular fossa in hip bone

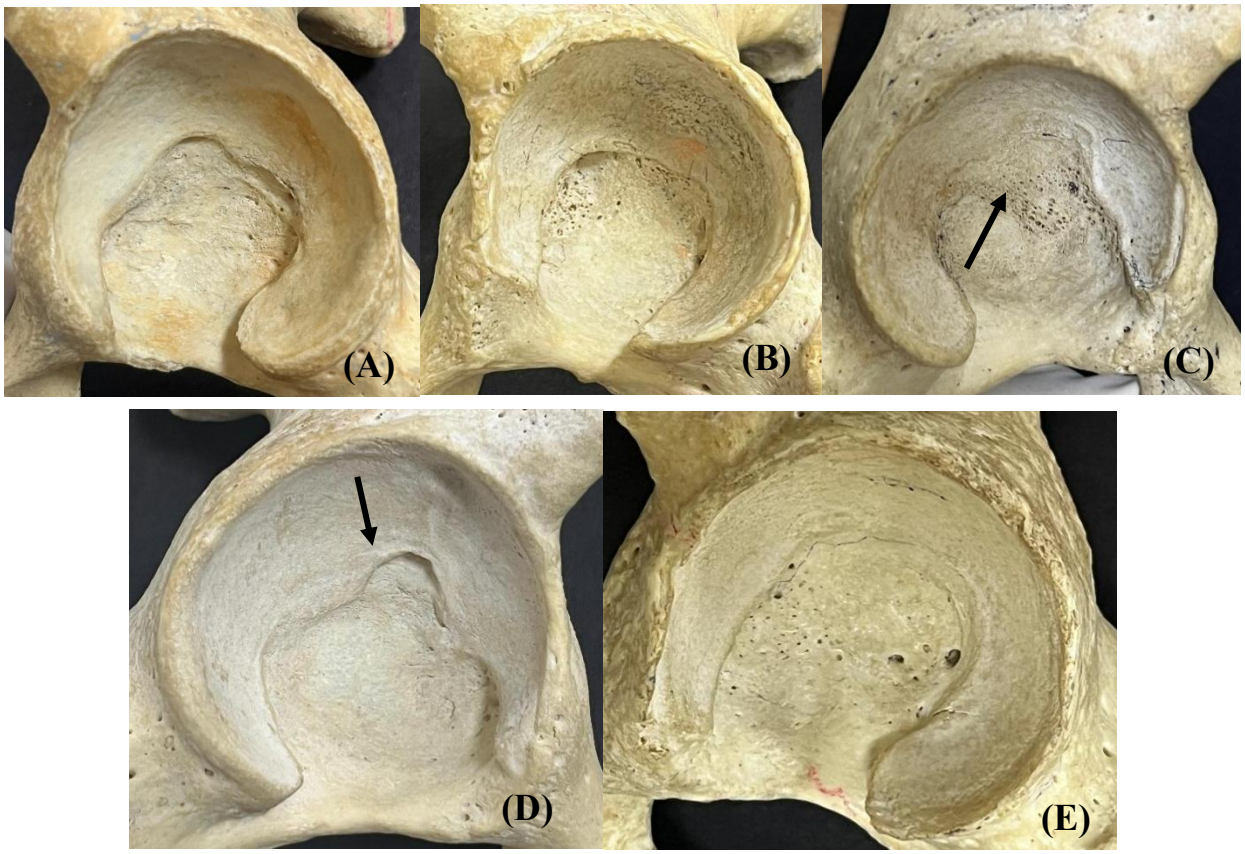


Figure 1: Shows various types of acetabular fossa (A) Cloverleaf like (B) Semi-circular (C) Spongy bony surface covering floor (D) Isolated defect above superior lobe (E) Inverted elongated-U

Bony unusual/ unique morphology

Morphologic parameter	**Present**		**Absent**	
	n	**%**	**n**	**%**
Bony spicules at the end of lunate surface	12	15	68	85
	16	20	64	80

Shape of facet		
	n	**%**
Oval	10	62.5
Piriform	6	37.5

Detailed morphology of unusual facets (shape; surface configuration & extent)	**Surface configuration of facet**			
		n	**%**	
	Flat	4	25	
	Concave	9	56.25	
	Convex	3	18.75	
	Extent of facet			
		n	**%**	
	Beyond acetabular margin to superior ramus of pubis	7	43.75	
	Confined to acetabulum	9	56.25	

Table 2: Displays incidence of various morphological changes in acetabulum of hip bone

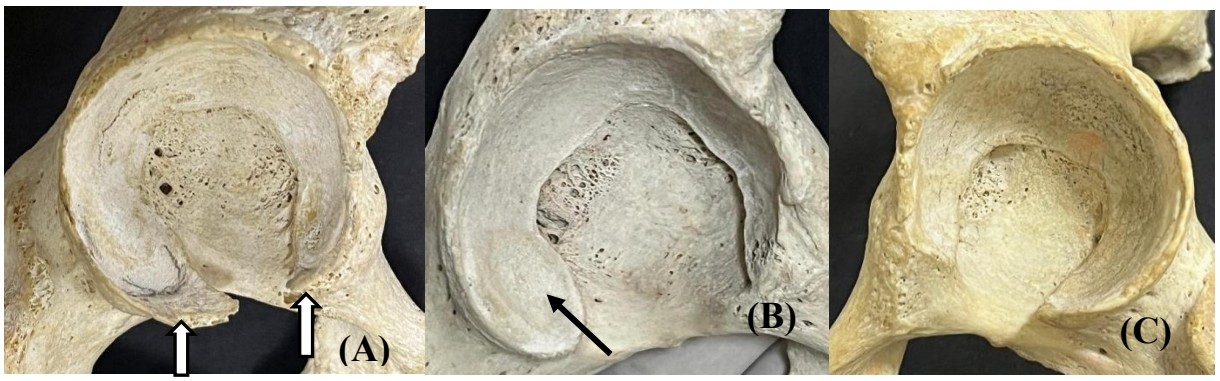


Figure 2: Shows (A) bony spicules at the end of lunate surface (B) Oval, concave facet limited by acetabular margin (C) Piriform, flat facet extending on the superior ramus

3. DISCUSSION

Acetabulum varies in size, shape and depth in both sexes. Various morphological abnormalities are found in shape of acetabulum[7, 17]

Previous studies have been undertaken to find out the variations in morphology of acetabular ridge of acetabulum among various population groups for the diagnosis of various pathological conditions such as femoroacetabular impingement; but very few studies have mentioned unusual or unique features of acetabulum in dry bones.

In a study done by Gupta V et al.[7] in 2001 on 315 dry hip bones, smooth unusual facets of three different shapes were found

in 48 (15.2%) bones in acetabular fossa anteroinferior to lunate articular surface. These facets were produced because of a specific posture that led to traction of ligaments or muscles attached to this area and were either limited to acetabulum or extend till superior pubic ramus beyond the rim of acetabulum. Piriform, oval and elongated facets were found, among which oval shaped facets were found to be most prevalent followed by piriform and elongated type.

Table 3: Incidence of various types of acetabular fossa among different population groups

Author & year	Population	No. of bones	Types of acetabular fossa (%)			
			Clover-leaf like	**Semi-circular**	**Smooth compact or spongy bony surface covering the floor of fossa**	**Acetabular fossa with an isolated defect above superior lobe**
Govsa F et al.[17] (2005)	Turkey	226	60.62	28.76	1.77	8.85
Present study (2025)	**Gurugram (North Indian)**	80	56.25	22.5	5	13.75

Present study showed presence of 5 types of acetabular fossa in contrast to earlier studies that showed only 4 types of acetabular fossa. 5th type of fossa is "Inverted elongated U-shape", found in 2 (2.5%) bones.

Author & year	Population	Total No. of bones	No. of bones with facet	Shape of facets (%)		
				Oval	**Piriform**	**Elongated**
Govsa F et al.[17] (2005)	Turkey	226	62	32.26	45.16	22.58
Gupta V et al.[7] (2001)	New Delhi	315	48	56.3	22.9	20.8
Present study (2025)	**Gurugram (North Indian)**	80	16	62.5	37.5	_

Table 4: Incidence of various shapes of facet on the non-articular part of the acetabulum inferior to the anterior end of the lunate surface among different population groups

Author & year	Population	Total No. of bones	No. of bones with facets	Surface configuration of facets (%)			
				Flat	**Concave**	**Convex**	**Grooved**
Govsa F et al.[17] (2005)	Turkey	226	62	30.64	37.10	6.45	25.81
Gupta V et al.[7] (2001)	New Delhi	315	48	29.2	43.7	_	27.1
Present study (2025)	**Gurugram (North Indian)**	80	16	25	56.25	18.75	_

Table 5: Incidence of surface configuration of facets among different population groups

Author & year	Population	Total No. of bones	No. of bones with facet	Extent of facet (%)	
				Beyond acetabular margin to superior ramus of pubis	**Confined to acetabulum**
Govsa F et al.[17] (2005)	Turkey	226	62	59.68	40.32
Gupta V et al.[7] (2001)	New Delhi	315	48	37.5	62.5
Present study (2025)	**Gurugram (North Indian)**	80	16	43.75	56.25

Table 6: Incidence of extent of facets among different population groups

In another study performed by Govsa F et al.[17] in 2005 on 226 dry hip bones, similar unusual facets were found in 62 acetabula with piriform shaped facet to be most prevalent followed by oval and elongated type.

Prior to the advent of modern anesthesia, surgical treatment of hip osteoarthritis included proximal femoral resection or limb amputation. Further advancements in the understanding of hip anatomy and joint biomechanics led to partial arthroplasties of the femoral head. Later with time, total hip arthroplasty was introduced[18]. THA is the treatment of choice for osteoarthritis of hip joint. It is a reconstructive surgical procedure in which femoral head and its proximal neck are surgically exercising and acetabular cartilage and bone under it is removed. Excised parts are then replaced by prosthetic hip components that includes a metal femoral implant and an acetabular component[19]

THA is a reconstructive orthopaedic procedure in which femoral head and its proximal neck are surgically excised and acetabular cartilage and bone under it is removed. Then a canal is made in proximal medullary part of femur and a metal femoral implant containing a small- diameter head and stem is inserted in this canal. An acetabular component lined by polyethylene, metal or ceramic is inserted proximally into patient's acetabular bone.[20, 21]

Both components are fixed to the bone by cemented or uncemented techniques. It is most performed in severe osteoarthritis of hip joint but is also indicated in conditions like developmental hip dysplasia, osteonecrosis of femoral head, Paget's disease, and many more. Main objective of this surgery is to restore the actual biomechanics of hip joint.[22, 23.] Recent innovations and advances in total hip arthroplasty include 3D printing technology, computer navigated and robotic total hip arthroplasty.[24, 25]

4. CONCLUSIONS

Over the last decade, robotic total hip arthroplasty (THA) has gained momentum as an avenue for reducing surgical error and improving the accuracy of implant positioning compared to conventional manual THA. But because of some limitations such as substantive installation costs, additional radiation exposure, steep learning curves for gaining surgical proficiency, and compatibility of robotic technology with a limited number of implant designs.

There was a paucity of literature regarding unique morphology of acetabulum in hip bone among North Indian population. So, observation of the present study on the unique morphological variabilities of acetabulum will serve as a reference base for clinicians to diagnose and to plan treatment procedure for various conditions such as femoroacetabular impingement & primary osteoarthritis of hip joint.

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Authors contribution:

Research concept- Susmita Saha, Prachi Saffar Aneja

Research design- Susmita Saha, Prachi Saffar Aneja

Supervision- Susmita Saha, Prachi Saffar Aneja

Data collection- Sanya Khurana, Jahanvi, Geetika

Data analysis & interpretation-Akanksha Deshwal, Sanya Khurana

Literature search- Sanya Khurana, Jahanvi, Geetika

Article writing- Susmita Saha, Sanya Khurana

Critical review- Prachi Saffar Aneja, Susmita Saha

Article editing- Akanksha Deshwal

Final approval- Susmita Saha, Prachi Saffar Aneja

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