

Morphometric Evaluation of the Iliac Crest in Dry Human Hip Bones: A Cross-sectional Study

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ABSTRACT

Introduction: The human bony skeleton comprises the appendicular and axial skeletons. The hip bone is a part of the appendicular skeleton. This massive bone is formed by the fusion of three individual bones: the ilium, ischium, and pubis. These three parts unite at the acetabulum to form the hip joint. The need for present study lies in its potential to aid clinicians in reconstructive surgeries and bone graft procedures, particularly in the treatment of osteonecrosis of the femoral head.

Aim: To evaluate detailed morphometric parameters of the iliac crest along with important bony distances related to the iliac crest.

Materials and Methods: The present cross-sectional study was conducted on 50 dry adult hip bones (25 right and 25 left) of unknown sex, obtained from the Department of Anatomy, SGT Medical College, SGT University, Gurugram, Haryana. The thickness of the iliac crest was measured at three distinct points: the most anterior point, the midpoint, and the most posterior point. These measurements were recorded for both right and left hip bones to ensure a comprehensive morphometric analysis.

The range and mean with standard deviation of all parameters were calculated and presented in tabulated form. Observations were recorded separately for the right and left sides, along with t-values. Statistical significance was determined using a p-value of less than 0.05.

Results: At the most anterior point, the right side showed a mean±SD (Standard Deviation) thickness of 10.2±6 mm, while the left side showed a mean of 8.3±4.2 mm (p=0.06). At the midpoint, the right side had a mean of 7.6±6.2 mm and the left side had a mean of 7.8±4.4 mm (p=0.08). At the most posterior point, the right side showed a mean of 10±6.3 mm and the left side had a mean of 12±3.1 mm (p=0.2).

Conclusion: The present study examined morphometric parameters of the iliac crest, including various critical bony distances, to provide an accurate and detailed anatomical description of both sides of the hip bone in the North Indian population. These findings may be beneficial for clinicians and reconstructive surgeons, particularly during bone graft procurement, which is commonly utilised in the treatment of osteonecrosis of the femoral head.

Keywords: Bone graft, Ilium, Morphometry, Osteonecrosis

INTRODUCTION

The pelvic bone is a large, irregular bone of the human skeleton, and the hip bones on both sides together form the pelvic girdle. The hip bone is part of the appendicular skeleton and is formed by the fusion of three bones: the ilium, ischium, and pubis [1,2]. The pelvic bone, also known as the os coxae, is of great anthropological, anatomical, and forensic importance due to its unique shape and marked sexual dimorphism [3].

The largest of the three pelvic bones is the ilium. The most prominent feature of the ilium is the iliac crest, which serves as the attachment site for several important muscles, including the latissimus dorsi and gluteus maximus, the chief extensor of the hip [4,5].

The iliac crest runs in an upward convex curve from the anterior superior iliac spine to the posterior superior iliac spine [6,7]. The ventral segment comprises the anterior two-thirds of the crest, while the dorsal segment forms the posterior one-third. The intermediate zone divides the crest into outer and inner lips [8].

The outer lip, also known as the tubercle of the iliac crest, projects approximately 5 cm posterior to the anterior superior iliac spine. The iliac crest is the most commonly used site for harvesting autologous bone grafts, making it essential in orthopaedic and reconstructive procedures [9].

The Posterior Superior Iliac Spine (PSIS) serves as a reliable anatomical landmark for free-hand sacroiliac screw placement into the second sacral vertebra and for precise botulinum toxin injections in the management of psoas muscle spasticity. Therefore, understanding PSIS morphology is clinically valuable [10-12].

The ilium presents three surfaces: the iliac fossa, sacropelvic surface, and gluteal surface. The concave inner surface forms the iliac fossa, while the iliac crest constitutes its superior margin. The posterior medial border separates the sacropelvic surface from the iliac fossa [13].

The iliac crest has a rich bone marrow supply, making it a preferred site for bone marrow transplantation. Additionally, injections into the sacroiliac joint are effective in managing sacroiliac pain and disorders [13,14].

The pelvic girdle plays a crucial role in anthropometry and sex determination. Besides the pubis and acetabulum, several studies have evaluated the iliac crest and associated bony measurements for forensic identification [15,16].

However, limited data exist regarding the detailed anatomical relationships of the anterior and posterior aspects of the iliac crest. Therefore, the present study was undertaken to evaluate morphometric parameters of the iliac crest, including its thickness at different points and related bony distances.

MATERIALS AND METHODS

The present cross-sectional study was conducted in the Department of Anatomy, Faculty of Medicine and Health Sciences, SGT University, Gurugram, Haryana, from May 2024 to October 2024. Institutional Ethics Committee (IEC) approval was obtained (SEC/FMHS/M.Sc/10/04/24-6).

All hip bones were examined grossly for side determination and general anatomical features. The information related to the bones

was anonymised and coded to delink them from any identifiable source, in accordance with the Indian Council of Medical Research (ICMR) National Ethical Guidelines for Biomedical and Health Research Involving Human Participants (2017, Section 5, Box 5.2) [17].

Inclusion criteria: Adult dry hip bones of both sexes and bones without gross deformities or fractures.

Exclusion criteria: Grossly deformed or broken bones and bones with visible damage that could affect measurement accuracy and bones with unclear side determination or missing structural features.

Study Procedure

Morphometric parameters: Detailed morphometric parameters and bony distances [Table/Fig-1a] of the iliac crest were measured as follows:

- Distance from the Anterior Superior Iliac Spine (ASIS) to the highest point of the Mid Iliac Crest (MIC) [Table/Fig-2b].
- Distance from the Posterior Superior Iliac Spine (PSIS) to the highest point of MIC [Table/Fig-2c].
- Distance between ASIS and the iliac tubercle [Table/Fig-1b].
- Distance between ASIS and Anterior Inferior Iliac Spine (AIIS) [Table/Fig-1c].
- Distance between PSIS and Posterior Inferior Iliac Spine (PIIS) [Table/Fig-1d].
- Distance from the iliac tubercle to the midpoint of the ilio-pubic eminence [Table/Fig-1e].
- Distance from MIC to PIIS [Table/Fig-2a].
- Distance from PSIS to the midpoint of the auricular surface [Table/Fig-4].

Thickness measurement: The thickness of the iliac crest at the most anterior point, midpoint, and most posterior point was measured using a digital vernier caliper. Measurements were taken on both right and left hip bones. Each parameter was measured twice, and the mean value was recorded to minimise error and bias [Table/Fig-3a-c].



[Table/Fig-1]: a) Bony distances; b) Distance between anterior superior iliac spine to the iliac tubercle; c) Distance from ASIS and AIIS; d) Distance between PSIS and PIIS; e) Distance from iliac tubercle till the middle of ilio-pubic eminence.



[Table/Fig-2]: a) Distance from mid iliac crest to PIIS; b) Distance from ASIS to highest point of MIC; c) Distance between PSIS to highest point of MIC.

STATISTICAL ANALYSIS

Descriptive analysis was performed using Statistical Packages of Social Sciences (SPSS) software version 21.0 to calculate the mean and Standard Deviation (SD) of the parameters studied. Comparisons between variables were conducted using the Student's t-test, and p-values were calculated to assess statistical significance.

RESULTS

Anterior most point: The mean thickness on the right side was 10.2 mm (SD=6), while on the left side it was 8.3±4.2 mm. The difference was not statistically significant at the 0.05 level [Table/Fig-5].

PSIS to MIC distance: The mean distance was 80.3±6.5 mm on the right side and 82.2±7.9 mm on the left side. The p-value of 0.0003 indicated a statistically significant difference between the two sides [Table/Fig-6].

DISCUSSION

The detailed morphometric evaluation of the iliac crest presented in present study serves as a preliminary database for the North Indian population. The findings are likely to be beneficial for clinicians not only in diagnosing pathological conditions of the ilium, such as sacroiliac joint disorders, but also in planning and selecting appropriate therapeutic interventions.

In a study by Demar M et al., the mean maximum distance between AIIS and PIIS was reported as 117.51±7.70 mm, and the distance between the iliac tubercle and ASIS was 60.33±10.15 mm, both of which were greater than those observed in the present study [18].

Morphometric values from various population groups have been summarised in [Table/Fig-7] [19-21]. Additionally, the mean distance between AIIS and ASIS (41.46±5.02 mm) was higher than in the present study, while the mean distance between PSIS and PIIS (29.10±5.25 mm) was lower [Table/Fig-8] [18,22].

The importance of the pelvic girdle in anthropometry and sex determination is well recognised. Beyond the pubis and acetabulum, numerous studies have examined iliac crest dimensions and associated bony landmarks for forensic identification. Furthermore, the iliac crest contains abundant bone marrow, making it an ideal site for bone marrow grafting.



[Table/Fig-3]: a) Thickness of iliac crest at the most anterior end; b) Thickness of iliac crest at midpoint; c) Thickness of iliac crest at most posterior end.



[Table/Fig-4]: Distance from PSIS to middle of auricular surface.

In another study performed by Pullanna B et al. in 2019, observed morphometric parameters on 100 dry human adult hip bones, including 49 male and 51 female bones & observed the mean value of the distance between the ASIS and PSIS is 143.8 mm in males and 135.0 mm in females [23].

A study by Tufegdzcic M et al., (2015) analysing Computed Tomography (CT) scans of adult hip bones reported a mean ASIS-PSIS distance of 164.775 mm and an AIIIS-PIIS distance of 127.614 mm [24].

Limitation(s)

The study was conducted on a relatively small sample of 50 hip bones (25 right and 25 left), which may limit the generalisability of the findings to broader populations. The study only used dry adult hip bones, excluding living subjects or those with variations due to age, disease, or other factors, which may impact the measurement accuracy and applicability to clinical settings. The bones used in the study were of unknown sex, which could limit the ability to compare sex-specific differences in iliac crest morphometry and may affect the application of the findings in forensic or anthropological contexts. The study primarily focused on bilateral measurements (right vs. left), and did not assess more detailed regional variations or differences based on other factors such as age or ethnicity.

CONCLUSION(S)

An accurate anatomical description of the morphometry of the iliac crest is essential for preparing geometric models and surgical screws

S. No.	Thickness of the iliac crest at various levels	Range (mm)		Mean±SD (mm)		t-value	p-value
		Right	Left	Right	Left		
1	At anterior-most point	9.8-11.7	7.9-9.8	10.2±6	8.3±4.2	2.01	0.06
2	In the middle	6.4-9.5	7.2-8.2	7.6±6.2	7.8±4.4	1.78	0.08
3	At the most posterior point	9.9-11.2	11.8-13.2	10±6.3	12±3.1	4.45	0.2

[Table/Fig-5]: Thickness of iliac crest at various levels.

Parameters on bony distances	Range on right side	Range on left side	Average right	Average left	t-value	p-value
ASIS to MIC	77.1-99.9	80.1-107	93.1±6	93.4±5.8	0.55	0.3
PSIS to MIC	69.2-97.7	66.9-97.8	80.3±6.5	82.2±7.9	4.2	0.0003*
ASIS to iliac tubercle	41.2-71.6	42.8-66.6	52±7.6	54.2 ±6.2	3.42	0.004*
ASIS to AIIIS	28.8-48	26.1-47.8	36.2±4.1	36.5±6.1	2.33	0.02
PSIS to PIIS	18.9-45.8	26.8-52.1	34.2±6.4	36.8±6.5	1.75	0.05*
PIIS to MIC	81.2-106.2	100.8-102.5	90.7± 2.3	101±7.2	2.25	0.6
PSIS to middle of auricular surface	34.5-45.3	46.3-49.9	37.5±4.1	47.7±2.2	3.32	0.2
Iliac tubercle to iliopectic eminence	80.5-94.2	88.5-90.1	85.2±6.1	87.3±5.5	4.53	0.4

[Table/Fig-6]: Parameters on bony distances.

Parameters	Authors (year)	Population group	No. of sample	Sex	Mean value (mm)	
Distance from ASIS to AIIIS	Kanabur V (2012) [22]	South Indian	65	Male	Rt.	33.1
				Female	Lt.	30.8
	Demar M et al., [18] (2018)	Turkish	72	-	41.46±5.02	
				Present study	North Indian	50
					Lt.	36.5±6.1

[Table/Fig-8]: Comparative analysis of Distance from ASIS to AIIIS among other population group [18,22].

Parameters	Authors (year)	Population group	No. of sample	Sex	Mean value (mm)
Distance from ASIS to PSIS	Patriquin ML et al., [20] (2005)	South African	400	Male	163.15
				Female	160.99
	Ajay M et al., [19] (2022)	Gujarat	88	Male	141.7±10.0
				Female	142.5±7.4

Distance from ASIS to mid iliac crest	Present study (2025)	North Indian	50	Unknown sex	Rt side	93.1±6
					Lt side	93.4±5.8
Mid iliac crest to PSIS					Rt side	80.3±6.5
					Lt side	82.2±7.9

[Table/Fig-7]: Comparative analysis regarding morphometry of various bony distances among other population groups [19-21].

used in surgical procedures, such as screw placement performed by surgeons. Moreover, the present study regarding morphometric parameters of the iliac crest in the hip bone will not only be helpful for clinicians but also for reconstructive surgical techniques while procuring bone graft, which is one of the most utilised techniques in the therapy of osteonecrosis of the femoral head.

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AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? No
- For any images presented appropriate consent has been obtained from the subjects. No

PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: May 15, 2025
- Manual Googling: Oct 29, 2025
- iThenticate Software: Nov 01, 2025 (2%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

Date of Submission: **Apr 29, 2025**

Date of Peer Review: **Aug 12, 2025**

Date of Acceptance: **Nov 03, 2025**

Date of Publishing: **May 01, 2026**