

Morphometry of Iliac Bones – A Useful Guide for Harvesting Bone Grafts

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Abstract: Iliac crest is common site for harvesting bone grafts. Morphometry of iliac crest is of vital importance in orthopedic surgery. Measurements were done on male (n=85) and female (n=85) hip bones. Length of iliac crest, thickness of iliac crest and ilium were measured. Thickness was measured at pre-defined points on crest and ilium 2 cm apart starting from anterior superior iliac spine (ASIS). Ilium was measured at a depth of 2.5 cm from crest. Statistical analysis was done. Iliac crests were longer in male bones. Ventral iliac crest was thickest at 6 cm from ASIS in both sexes. While iliac crest bore minimum thickness at 12 cm and 10 cm from ASIS in male and female bones respectively, however at 2.5 cm below iliac crest surface ilium was thickest at 4 cm from ASIS and at ASIS in male and female bones respectively. In case of male bones, dorsal part of iliac crest was thickest at 2.15 ± 1.29 cm from posterior superior iliac spine (PSIS) while in females it was at 1.78 ± 1.31 cm from PSIS. In dorsal part of ilium, it was observed at 2.31 ± 1.47 cm and 1.9 ± 1.79 cm from PSIS for male and female bones respectively. This study provided detailed variable morphometry and significant sexual dimorphism observed in iliac crest and ilium. Thickest safe zones in both sexes are a useful guide for harvesting appropriate bone grafts.

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Introduction

The iliac bones of patients play an important role as one of the best sources of autologous bone graft. Morphometry of iliac bones would help orthopedic and spine surgeons to plan and harvest different types of bone graft as per indication, whether a good tricortical graft for interbody spinal fusion or adequate quantity of cancellous and cortico-cancellous grafts for filling in bone defects or for treating non-union of fractures of long bones (Grotz et al., 2005; Balogh et al., 2007; Garden et al., 2012).

Bone graft may be harvested during surgery with the patient in supine and sometimes lateral position or spine surgeons may need to harvest iliac crest graft in prone position, hence morphometry of the entire ilium from anterior to the posterior end is necessary.

Historically morphometry of the iliac crest has been explored but in isolated aspects (Xu et al., 1996; Ebraheim et al., 1997; Mahato, 2011). This study was designed to provide the surgeon with comprehensive quantitative data on length and thickness of the entire adult iliac crest and ilium with special emphasis on the variability in these parameters between sex and laterality. This study presents thorough information to orthopedic surgeons to determine thickness of different sites of the iliac crest for harvesting appropriate size of tricortical iliac bone grafts specially for anterior cervical discectomy and fusion (ACDF) with patient in supine for anterior approach of cervical spine or anterior interbody fusion of thoracic spine by transthoracic approach in lateral position or for

harvesting slivers of cortico-cancellous bones for posterior spinal fusion in prone position.

Material and Methods

Study was conducted on 170 dry human hip bones present in the osteological museum of the Department of Anatomy, Maulana Azad Medical College, New Delhi. While 83 bones were of right side comprising of 43 male and 40 female iliac bones, 87 bones were of left side comprising of 42 male and 45 female iliac bones. Thus, there were equal number of male and female iliac bones, 85 from each sex. Data concerning body height, age, pelvic width, and sex of iliac bones was not available. Sex of iliac bones was determined using metrical parameters like chilitic line, acetabulum-pubis index, and non-metrical parameters like ischiopubic rami and pre-auricular sulcus (Tubbs, 2016). Length of iliac crest was measured from anterior to posterior superior iliac spine (ASIS, PSIS).

To measure the thickness of iliac crest, ASIS was identified and thereafter points were marked at a regular interval of two cm starting from the ASIS to PSIS both on the surface of iliac crest as well as 2.5 cm below iliac crest (i.e. in the upper third of ilium) (Figure 1).

The thickness of iliac crest and ilium was measured at these defined points using micrometer/screw gauge and mean, standard deviation and range were calculated from data. All parameters were measured by two researchers in isolated settings. Each individual

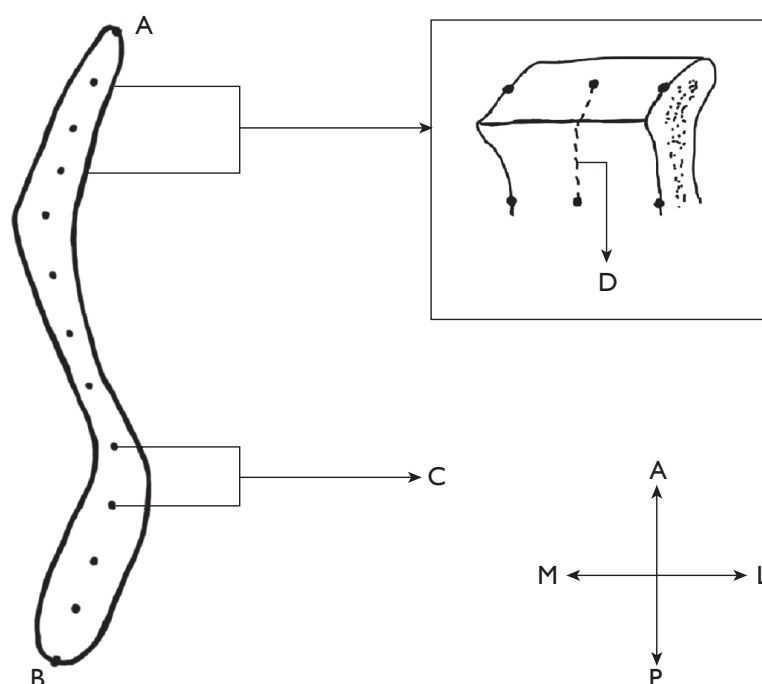


Figure 1: Schematic diagram of superior view of left hip bone to show points marked on iliac crest at regular intervals of two cm starting from anterior superior iliac spine (ASIS) to posterior superior iliac spine (PSIS). Inset shows points marked on ilium 2.5 cm below iliac crest to measure its thickness. A – ASIS; B – PSIS; A–B – length of iliac crest; C – predefined points two cm apart on iliac crest where thickness of iliac crest was measured; D – predefined point 2.5 cm from point on iliac crest where thickness of ilium was measured.

Table 1: Length of iliac crest (mean, SD, and range)

	Total	Male	Male (R)	Male (L)	Female	Female (R)	Female (L)
Mean length ± SD (in cm)	20.84 ± 2.05	21.92 ± 1.46	21.43 ± 1.49	22.42 ± 1.25	19.75 ± 1.99	19.98 ± 1.76	19.56 ± 2.17
Range max–min (in cm)	25.5–14.5	25.5–19	25.5–19	25–20	23–14.5	22.5–15.5	23–14.5

SD – standard deviation; R – right; L – left; p-value for male and female is < 0.0001, for male R and L is 0.01, for female R and L is 0.33

did measurements thrice and mean was recorded as final value.

The thickness of iliac crest and ilium at different sites were compared for any statistically significant difference between two sexes, as well as for variation among right and left bones in either sex, using independent sample t-test (SPSS version 17 [trial version]). P-value < 0.05 was taken as significant.

This study was conducted with prior ethical approval from the Institutional Ethics Committee. All local and international ethical guidelines and laws that pertain to the use of human bones in anatomical research were followed.

Results

The length of iliac crest measured from ASIS to PSIS is depicted in Table 1 with maximum, minimum and mean length of iliac crests in both sexes. Length of iliac crest in males was greater than that of females and the difference was statistically significant (p-value < 0.001). Left male iliac crest (mean: 22.42 ± 1.25 cm)

was significantly longer than right (21.43 ± 1.49 cm) (p-value = 0.01). Within female hip bone cohort however right iliac crest (19.98 ± 1.76 cm) was longer than left (19.56 ± 2.17 cm) but not significantly.

The mean thickness of iliac crest and ilium at the predefined points in both male and female hip bones is tabulated in Table 2 (Figure 2). In both male and female hip bones, site of maximum thickness of iliac crest was found to be located six cm from ASIS, on both sides. Average thickness of male iliac crests was significantly (p-value < 0.001) greater than female iliac crests at this location. The mean thickness of thinnest portion of iliac crests in males was 0.85 ± 0.15 cm. However, thinnest point on male iliac crests differed among right and left sides at different locations. Ventral segment of male iliac crests was thinnest on left side, located 12 cm from ASIS (mean value = 0.84 ± 0.15), while on right side it was thinnest at ten cm distance (mean value = 0.86 ± 0.22 cm). In female iliac crests, thinnest site was located ten cm from the ASIS (mean value of 0.74 ± 0.14 cm) symmetrically on both sides. At thinnest point too, male iliac crests were significantly thicker than female iliac crests (p-value < 0.001).

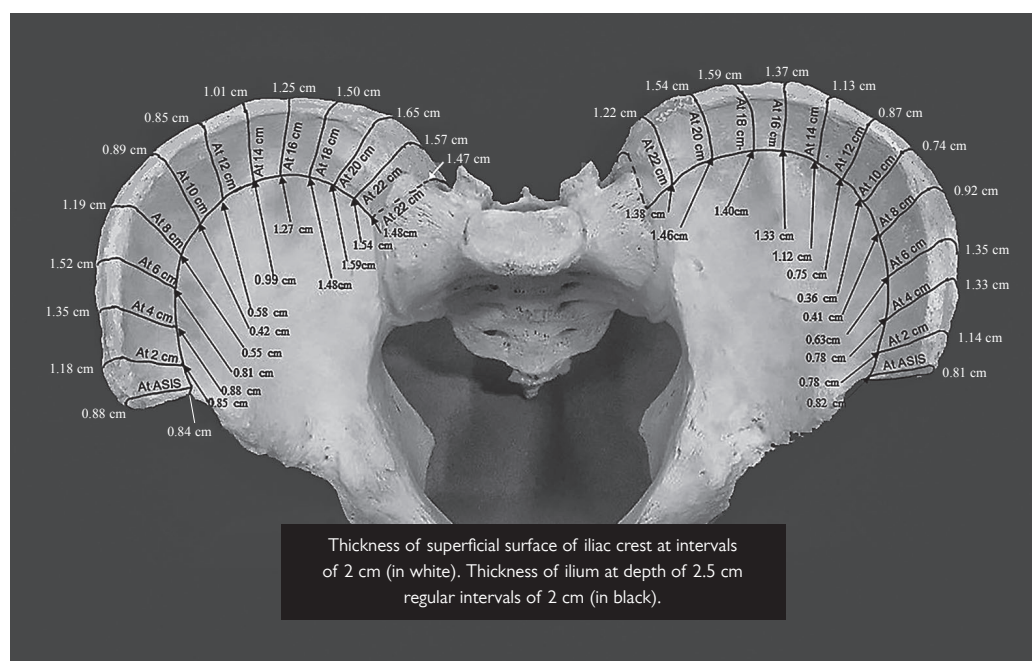


Figure 2: Pictorial representation of thickness of iliac crest (in white) and ilium (in black) in males (left) and females (right) at intervals of 2 cm.

Table 2: Mean thickness of iliac crest and ilium at the predefined specific points

Distance from ASIS (in cm)	Mean thickness of iliac crest with SD (in cm), n=85		P-value	Mean thickness of male ilium with SD (in cm), n=85		P-value
	male	female		male	female	
0	0.88 ± 0.18	0.81 ± 0.20	0.030	0.84 ± 0.17	0.82 ± 0.16	0.350
2	1.18 ± 0.19	1.14 ± 0.19	0.190	0.85 ± 0.14	0.78 ± 0.15	0.010
4	1.35 ± 0.26	1.33 ± 0.22	0.650	0.88 ± 0.20	0.78 ± 0.21	0.010
6	1.52 ± 0.24	1.35 ± 0.29	<0.001	0.81 ± 0.25	0.63 ± 0.25	<0.001
8	1.19 ± 0.33	0.92 ± 0.23	<0.001	0.55 ± 0.27	0.41 ± 0.21	0.010
10	0.89 ± 0.23	0.74 ± 0.14	<0.001	0.42 ± 0.23	0.36 ± 0.19	0.100
12	0.85 ± 0.15	0.87 ± 0.20	0.600	0.58 ± 0.35	0.75 ± 0.40	0.010
14	1.01 ± 0.25	1.13 ± 0.23	0.010	0.99 ± 0.39	1.12 ± 0.33	0.030
16	1.25 ± 0.27	1.37 ± 0.23	0.010	1.27 ± 0.31	1.33 ± 0.24	0.100
18	1.50 ± 0.33	1.59 ± 0.31	0.070	1.48 ± 0.31	1.40 ± 0.25	0.090
20	1.65 ± 0.35	1.54 ± 0.35	0.070	1.59 ± 0.31	1.46 ± 0.31	0.020
22	1.57 ± 0.36	1.22 ± 0.39	0.010	1.54 ± 0.32	1.38 ± 0.37	0.110
24	1.47 ± 0.51			1.48 ± 0.31		

ASIS – anterior superior iliac spine; SD – standard deviation

Difference in thickness of ilium between male and female bones was statistically significant at 2, 4, 6, 8, 12, 14 and 20 cm (Table 2). In male hip bones, ventral part of ilium was thickest at 4 cm from ASIS with mean of 0.88 ± 0.20 cm. Values however showed a wide range between 0.36 and 1.47 cm. On the other hand, in female hip bones thickest point was just beneath ASIS (zero cm) with mean thickness of 0.82 ± 0.16 cm while thinnest part of the ilium was at 10 cm from ASIS. Values ranged between 0.07 and 1.08 cm with mean value of 0.39 ± 0.21 cm. Surprisingly, this point was similar for entire cohort. Mean value of thinnest dimension in male ilium was 0.42 ± 0.23 cm, while in female ilium it was 0.36 ± 0.19 cm. This difference was not statistically significant (p -value = 0.1). In 12 bones, five males and seven females, ilium thickness was less than or equal to 0.1 cm at ten cm from ASIS.

Dorsal segment of iliac crest was thickest at 2.15 ± 1.29 cm from the PSIS in case of male hip bones. Values ranged from maximum of 2.62 cm to minimum of 1.18 cm with value of 1.82 ± 0.28 cm on an average. However, in female iliac bones, the site of maximum thickness was located 1.78 ± 1.31 cm from PSIS, with mean value of 1.67 ± 0.29 cm. Difference between two sexes was statistically significant (p -value < 0.001) (Table 3).

In dorsal part of ilium, maximum thickness of male hip bones was observed at 2.31 ± 1.47 cm from PSIS with mean value of 1.74 ± 0.28 cm. Values ranged between 1.16 and 2.42 cm. Male hip bones were

significantly thicker than female hip bones (p -value = 0.01). However, thickest site for female hip bones was located at 1.9 ± 1.79 cm from PSIS. Difference between two sides was not statistically significant in any subset (Table 4).

Table 4 provides comparative measurements of the thickness of iliac crest and ilium of the right and left sides. In both male and female hip bones, the thickness was variably more on right than left side, although these values were not statistically significant.

Discussion

Before puberty and adolescent spurt of growth there is almost no difference between hip bones of boys and girls. Characteristic changes of shape, angulation and thickness occur after puberty, with male bones becoming thicker than female bones (Bryce, 1915; Crockford and Converse, 1972). Literature however, states that there are no statistically significant differences between various morphometric parameters in male and female hip bones (Mahato, 2011). In contrast, we observed some significant differences between the two sexes on extensive mapping of 170 dry adult hip bones.

Zaker Shahrak et al. (2014) measured the length of iliac crest as 24.75 cm with a range of 21.95 to 27.36 cm with male iliac crests being significantly longer than female. Similarly, we too found a variation in length of iliac crest between male and female,

Table 3: Mean thickness of iliac crest and ilium at the predefined specific points

Distance from ASIS (in cm)	Mean thickness of male iliac crest with SD (in cm), n=85		P-value	Mean thickness of female iliac crest with SD (in cm), n=85		P-value
	right	left		right	left	
0	0.91 ± 0.18	0.84 ± 0.18	0.06	0.84 ± 0.18	0.79 ± 0.20	0.20
2	1.18 ± 0.20	1.17 ± 0.18	0.91	1.16 ± 0.20	1.12 ± 0.17	0.38
4	1.36 ± 0.25	1.34 ± 0.27	0.63	1.36 ± 0.23	1.31 ± 0.22	0.32
6	1.49 ± 0.24	1.56 ± 0.24	0.16	1.36 ± 0.30	1.35 ± 0.28	0.87
8	1.10 ± 0.30	1.28 ± 0.34	0.06	0.91 ± 0.21	0.93 ± 0.26	0.68
10	0.86 ± 0.22	0.93 ± 0.23	0.16	0.74 ± 0.14	0.75 ± 0.14	0.82
12	0.87 ± 0.15	0.84 ± 0.15	0.35	0.88 ± 0.22	0.86 ± 0.17	0.60
14	1.08 ± 0.24	0.94 ± 0.24	0.06	1.15 ± 0.27	1.12 ± 0.20	0.48
16	1.27 ± 0.27	1.23 ± 0.27	0.46	1.37 ± 0.24	1.38 ± 0.23	0.94
18	1.56 ± 0.37	1.44 ± 0.28	0.10	1.58 ± 0.32	1.60 ± 0.29	0.70
20	1.65 ± 0.40	1.66 ± 0.30	0.95	1.60 ± 0.35	1.49 ± 0.36	0.25
22	1.55 ± 0.38	1.60 ± 0.34	0.58	1.11 ± 0.38	1.38 ± 0.35	0.13
24	1.29 ± 0.48	1.56 ± 0.54	0.48			

Distance from ASIS (in cm)	Mean thickness of male ilium with SD (in cm), n=85		P-value	Mean thickness of female ilium with SD (in cm), n=85		P-value
	right	left		right	left	
0	0.84 ± 0.19	0.84 ± 0.14	0.89	0.79 ± 0.15	0.85 ± 0.17	0.09
2	0.86 ± 0.14	0.83 ± 0.14	0.33	0.79 ± 0.12	0.78 ± 0.18	0.81
4	0.88 ± 0.17	0.88 ± 0.23	0.95	0.79 ± 0.21	0.77 ± 0.21	0.75
6	0.75 ± 0.23	0.86 ± 0.25	0.04	0.63 ± 0.27	0.63 ± 0.23	0.99
8	0.50 ± 0.23	0.60 ± 0.31	0.12	0.42 ± 0.24	0.39 ± 0.19	0.60
10	0.43 ± 0.23	0.40 ± 0.23	0.11	0.37 ± 0.20	0.36 ± 0.18	0.87
12	0.68 ± 0.40	0.48 ± 0.24	0.12	0.70 ± 0.39	0.79 ± 0.41	0.30
14	1.11 ± 0.43	0.86 ± 0.31	0.10	1.14 ± 0.33	1.10 ± 0.33	0.56
16	1.32 ± 0.31	1.21 ± 0.31	0.13	1.34 ± 0.24	1.33 ± 0.23	0.91
18	1.52 ± 0.34	1.43 ± 0.27	0.18	1.41 ± 0.27	1.40 ± 0.24	0.90
20	1.56 ± 0.32	1.62 ± 0.30	0.39	1.45 ± 0.33	1.46 ± 0.29	0.91
22	1.52 ± 0.33	1.56 ± 0.31	0.67	1.36 ± 0.42	1.43 ± 0.31	0.68
24	1.34 ± 0.09	1.53 ± 0.36	0.24			

ASIS – anterior superior iliac spine; SD – standard deviation

Table 4: The average maximal thickness of the dorsal iliac crest and ilium in male and female hip bones of both sides along with standard deviation and range (as measured from the PSIS)

	Male			Female		
	mean		p-value	mean		p-value
	right	left		right	left	
Dorsal iliac crest	1.84 ± 0.3 (range: 2.62–1.28)	1.80 ± 0.28 (range: 2.26–1.81)	0.54	1.72 ± 0.28 (range: 2.35–1.19)	1.64 ± 0.30 (range: 2.11–0.88)	0.21
Dorsal ilium	1.74 ± 0.28 (range: 2.42–1.19)	1.73 ± 0.28 (range: 2.38–1.16)	0.98	1.62 ± 0.2 (range: 2.05–1.26)	1.52 ± 0.26 (range: 2.22–0.87)	0.06

PSIS – posterior superior iliac spine

however mean the iliac crest length in Indian subset is 20.84 ± 2.05 cm, much smaller than Caucasian crest. Depending on the type and/or purpose for which bone graft is needed, bone is obtained from either posterior ilium or anterior ilium or iliac crest. Ebraheim et al. (2001) reported that the ideal site for cortico-cancellous bone graft is either 3 cm posterior to ASIS or 6 cm anterior to PSIS, while tricortical iliac crest grafts are better obtained in supine position 3 cm posterior to ASIS. In a biomechanical analysis of iliac crest loading after bone graft harvest, Schmitz et al. (2018) emphasized the importance of iliac crest and iliac blade as sites of attachment of abdominal muscles, muscles of the back, glutes, and muscles of the thigh namely sartorius, rectus femoris and tensor fascia lata. Thus, removal of block of harvested bone impairs transmission of force produced by the contraction of these muscles along iliac crest and ilium which predisposes the bone to avulsion fractures. Hence the location from where the bone is harvested and the size is crucial to maintaining mechanical integrity of the bone.

Ebraheim et al. (1997) reported the thickness of ilium at 2 and 3 cm from ASIS and at iliac tubercle as 1.06 ± 0.18 cm, 1.17 ± 0.18 cm, and 1.69 ± 0.23 cm, respectively and the anterior point of iliac tubercle was measured to be situated 3 cm posterior to ASIS. In the present study, the maximum thickness of anterior iliac crest was observed at 6 cm from ASIS in both sexes. The value was 1.52 ± 0.24 cm and 1.35 ± 0.29 cm in male and female bones respectively. Compared to our study, the dimensions reported by Ebraheim et al. (1997) are more possibly due to Caucasian study set and they advocated that bone graft is best taken from iliac tubercle where the bone was thickest and found no statistical difference with reference to sex or side. Contrary to this we have found statistically significant difference between the two sexes. We too propose that best site for taking bone graft is from around the iliac tubercle. Hwang et al. (1997) mapped 58 iliac bones for surgeons to localize the site of harvesting and also observed that the maximum thickness of ventral segment of iliac crest and ilium was present between ASIS and iliac tubercle. Although male hip bones were thicker in comparison to female in their study, difference was not statistically significant except at a few sites in the intermediate part near the crest (Hwang et al., 1997). Hu et al. (1995) based on their biomechanical analysis advocated that harvesting bone graft from ilium at ASIS or just 1.5 cm posterior to it resulted in decreased stability of the crest. The same when done 3 cm behind, preserves the strength 2.4 times more. Ropars et al. (2014) also postulated that safe distance from ASIS for harvesting was 2 cm posterior to it and an ideal graft length should not be

more than 47 mm and must be from anterior to a line passing through the thickest part of iliac tubercle. The authors also compared their dissected specimen results with computed tomographic analysis and found no difference between the two. More recently Schmitz et al. (2018) also corroborated the fact that harvesting bone at a distance of 2–2.5 cm posterior to the ASIS would also suffice to reduce risk of fractures. They also concluded that it is advisable to maintain integrity of the crest and extract bone from ilium.

Mahato (2011), advocates that the ideal site of bone harvesting in Indian population is anterior to iliac tubercle in the ventral segment of iliac crest. He observed that the area of ilium located more than 45 mm from ASIS is the widest and contains the maximum thickness and volume of cancellous bone. He reported that the amount of bone in female ilium was lesser but not significantly so and proposed that harvesting should be done 3 cm posterior to the ASIS both in males and females.

On the basis of morphometric thickness of iliac crest and ilium measured in the present study we hypothesize that the optimum area to obtain cortico-cancellous grafts in Indian population varies depending on the sex. In male population ilium bone is thickest (0.88 ± 0.2 cm) at 4 cm posterior to ASIS; at 2 cm posterior to ASIS bone thickness is 0.85 ± 0.14 cm and at 6 cm bone is 0.81 ± 0.25 cm and thereafter thins out to 0.55 ± 0.27 cm at 8 cm and is the thinnest at 10 cm with mean value of 0.42 ± 0.23 cm. In fact, in 12 bones in our study sample, 5 males and 7 females, the ilium was papery thin (less than or equal to 0.1 cm) at 10 cm from ASIS. It is advisable therefore to harvest bone between 2 and 4 cm posterior to ASIS in males which can be easily extended to 6 cm if a greater length of the bone is needed. The thickness of the iliac crest varies from 1.18 ± 0.19 at two cm, 1.35 ± 0.26 at four cm to the thickest dimension of 1.52 ± 0.24 cm at six cm. Thus, “thickest safe zone” of iliac crest for harvesting bone grafts in male hip bones is 2–6 cm posterior to the ASIS.

On the other hand, in female hip bones, ilium is thickest immediately beneath ASIS. Harvesting bone at this site would however predisposes to stress fractures (Hwang et al., 1997; Mason et al., 2005). The next thickest segment of ilium is located at 2 and 4 cm (0.78 ± 0.15 and 0.78 ± 0.21) from ASIS. Iliac blades subsequently thin out substantially at six cm (0.63 ± 0.25 cm), eight cm (0.41 ± 0.21 cm) and is thinnest at ten cm (0.36 ± 0.19 cm). “Thickest safe zone” in females is more anteriorly placed as compared to males and is located between two cm to four cm posterior to ASIS. Thickness of iliac crest at two cm and four cm posterior to ASIS in females is 1.14 ± 0.19 cm and 1.33 ± 0.22 cm, although it is

thickest at six cm posterior to ASIS (1.35 ± 0.29 cm). Thus, our data suggests that safe zone for harvesting the ilium is anterior to the iliac tubercle in males and females and is two–four cm posterior to ASIS, extendable to six cm in males but not in females. Surgeons need to exercise caution since safe zones appear similar, yet there is a significant difference in thickness of ilium between males and females.

Posterior ilium is preferred site for bone graft harvesting especially when patient position during surgery is prone and is associated with less mortalities (Ropars et al., 2014). Xu et al. (1996) measured thickness of posterior iliac blade in six cadavers and 30 dry bones and categorized it into three zones. They reported zone 1 to be the safest to obtain graft with average thickness reported as 1.71 ± 0.22 cm. This zone extended along the posterior iliac crest from PSIS to the apex of sacroiliac articulation. The authors have documented a maximum of 2.2 cm and a minimum thickness of 1.4 cm in this zone. The thickness surprisingly for the dorsal segment was lesser than our Indian population. In the present study, the thickest region of posterior iliac crest in male bones is located at 2.15 ± 1.29 cm from PSIS (mean value: 1.82 ± 0.28 cm). Thus, the zone of maximum thickness in our study in male iliac crests was from 0.86 cm anterior to PSIS to 3.44 cm anterior to PSIS. Similarly, the thickest zone for dorsal segment ilium was on an average at 2.31 ± 1.47 cm anterior to PSIS with a mean thickness of 1.74 ± 0.28 cm. Thus, the thickest zone was from 0.84 to 3.78 cm anterior to PSIS. In female ilium this point was present at 1.9 ± 1.79 cm from PSIS having a mean thickness of 1.56 ± 0.24 cm. Female iliac crest was thickest at 1.78 ± 1.31 cm from PSIS (mean value: 1.67 ± 0.29 cm). The zone of maximum thickness in female iliac crest was from 1.38 to 1.96 cm anterior to PSIS. This zone for female ilium was from 1.32 to 1.8 cm anterior to PSIS. Again, dorsal segment of iliac crest and ilium were also significantly thicker in males as compared to females (p-value: < 0.001 and 0.01 , respectively).

The thickest part of the bone needs to be identified to avoid cortical table penetration (Schmitz et al., 2018). As per our findings, the thickest portion of iliac blade was from ASIS till four–five cm posterior to it at a depth of 2.5 cm from the crest.

Lack of comparison between different age groups was one of the limitations of our study. Another difficulty which we encountered while comparing data was that thickness of ilium measured by different authors was at different depths whereas as the strength of this study is meticulous morphometric mapping at frequent intervals of the entire iliac bone.

Conclusion

In Indian population, a significant morphometric dimorphism is noted among male and female pelvic bones. Iliac crest was significantly longer and thicker in male, though point of maximal iliac crest thickness (six cm posterior to ASIS) was same in both sexes. In both male and females, the ventral ilium is thickest, anterior to the thickest part of iliac crest. Based on the observations of the present study, for taking bone graft from ventral ilium, the point of harvesting should be anterior to the thickest part of iliac crest, at a safe zone of two–four cm posterior to ASIS, extendable to six cm in males, but not in females. If a larger size graft is needed in females, then other bones like fibula should be considered. The thickest part of anterior ilium for females is just beneath the ASIS, which is not an ideal site for harvesting bone graft. Dorsal segment of iliac crest and ilium are also significantly thicker in males as compared to females.

With the exhaustive data on iliac bone offered by the present study, surgeons should be able to select appropriate site of ilium and harvest appropriate dimension of bone graft as per their indication.

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