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Original Article

Functional anthropometric measurements of Indian pelvis

Shailendra Singh MBBS MS Orthopaedics^a, Santosh Kumar MBBS^b,
Surabhi Rohilla BPO^c, Lalit Maini MBBS MS Orthopaedics^{c,d,*}

^a Department of Orthopaedics, Chitra Medical Centre, Lakhimpur, India

^b PG Orthopaedics Student, Department of Orthopaedics, Maulana Azad Medical College & LNJP Hospital, New Delhi, India

^c Project Fellow-UGC, Department of Orthopaedics, Maulana Azad Medical College & LNJP Hospital, New Delhi, India

^d Professor, Department of Orthopaedics, Maulana Azad Medical College & LNJP Hospital, New Delhi, India

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ABSTRACT

Purpose: To determine the normal values of several radiographic measurements of hip and pelvis in individuals of Indian population.

Material and methods: We conducted a cross-sectional study of Indian population and calculated mean and variation seen in different parameters in Indian pelvis. We took the plain X-ray of randomly selected hundred patients in identical position with 20% magnification factor. Different parameters including acetabular inclination angle, cup size, tear drop position, neck shaft angle, neck offset, abductor lever arm and head size were drawn on the X-rays and values measured.

Results: 100 subjects were taken (63 male and 37 female). The mean of acetabular inclination angle was $37.70 \pm 3.82^\circ$ ($30\text{--}47^\circ$). The mean neck shaft angle was $131.53 \pm 7.70^\circ$ ($114\text{--}158$) the most commonly occurring value was 131° . The mean abductor lever arm was $38.48 \text{ mm} \pm 5.77$ ($23\text{--}54$) with the mode of 40. The mean cup size was $48.9 \pm 3.67 \text{ mm}$ ($34\text{--}58$) with the most commonly occurring value as 50. The mean angle from tip of trochanter to center of head was 80.2 ± 9.1 ($62\text{--}110$). Among all the seven parameters correlations were drawn. There were in all 22 correlations out of which 14 were statistically significant. **Conclusion:** Since there is significant difference between the neck shaft angles and other measurements of Indian population than to the European population, an evaluation in the design of the implant by the Indian manufacturers is recommended. Also this study proposes that the normal values of our own population be used as reference values in interpreting standard radiographs of pelvis with both hips.

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* Corresponding author. 22, Samachar Apartment, Mayur Vihar Phase I, Delhi 110091, India. Tel.: +91 (0) 9811604224.

E-mail address: lalit_maini@rediffmail.com (L. Maini).

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1. Introduction

In total hip replacement, accurate implantation of the components is critical to the stability of the prosthesis. Knowing the normal and variation in the different anatomical parameters is of utmost importance in the preoperative planning and templating the type of implant to be used. Although world references are available and the methods of calculating these are also available, no X-ray based study has been done for Indian population in relation to anthropometry of pelvis.^{1,2} We conducted a cross-sectional study of the Indian population regarding the anthropometric measurements on plain X-rays of pelvis with both hip.

2. Material and method

The study is a cross-sectional study of a randomly selected adult Indian population. The subjects were selected randomly with otherwise normal hips. Every third person coming to the department of radiology for barium meal X-ray was subjected to X-ray pelvis with both hip, after informed consent. All the X-rays considered for study were of skeletally mature persons. The X-rays were taken in the identical position with subject supine and both the lower limbs parallel and knee in full extension. The medial border of both the feet were rested over the 15–15° preformed frame (Figs. 1 and 2) to produce the 15° internal rotation at hip. The beam was centered over the symphysis pubis. Magnification was 20%. Hundred such X-rays were collected. The X-rays were marked regarding various parameters and values calculated. The parameters were acetabular inclination angle, neck shaft angle, abductor lever arm, cup size, neck offset, trochanteric tip to center of head angle, head size and level of lesser trochanter in relation to inter-ischial tuberosity line (Fig. 3). Acetabular inclination angle is the angle formed between the horizontal formed by joining the two tear drops and the line joining the inferior tear drop with the superolateral edge of the acetabulum.³ Neck shaft angle was the angle between the central axis of the femur and the axis of the femoral neck.⁴ Abductor lever arm was the perpendicular distance from the center of rotation of

Fig. 2 – 15–15° frame being used to place the hips in identical position.

head to the line between the anterior superior and posterior superior iliac spine at the point one third of the way from the posterior to anterior superior spine.⁵ Cup size was taken by using the Zimmer THR templates. The acetabular template was placed just lateral to the lateral edge of the tear drop at a 45° angle. The cup size completely covering the bone was taken. Head size was also taken using the same template and the center of the head was marked. The neck offset is the perpendicular distance from the neutral long axis of the femur and the center of rotation of hip. The tip to center of head angle was taken as the angle between the anatomical axis at the level of trochanteric tip to the line joining the center of head. The parameters were marked and measured on both right and left side.

The data collected was statistically analyzed using the t test for significances and Pearson's method for correlation. The mean, median, mode and standard deviation were calculated for all the seven parameters. The correlation between all the seven parameters was drawn from Pearson's correlation coefficient.

Fig. 1 – 15–15° frame being used to place the hips in identical position.

Fig. 3 – X-ray showing the various markings.

Table 1 – Case summaries.

	Acetabular angle	Neck shaft angle	Abductor lever arm	Cup size	Neck offset	Trochanteric tip to center of head angle	Head size
N	200	200	200	200	200	200	200
Minimum	30	114	23	34	15	62	34
Maximum	47	158	54	58	64	110	50
Range	17	44	31	24	49	48	16
Mean	37.70	131.53	38.48	48.94	40.27	82.01	41.97
Std. deviation	3.826	7.770	5.778	3.672	7.060	9.130	3.393
Median	38.00	131.00	38.00	50.00	41.00	80.00	42.00
Std. error of mean	0.306	0.622	0.463	0.294	0.565	0.731	0.272

3. Result

100 subjects were taken of which 63 male and 37 were female. The age range was from 19 years to 53 year with mean age of 36.8 years. The mean of acetabular inclination angle was $37.70 \pm 3.82^\circ$ (30–47°). The most commonly occurring value was 38°. The difference in male and female value was 1.46° with females having higher angle with the value of 38.65. The mean neck shaft angle was $131.53 \pm 7.70^\circ$ (114–158) the most commonly occurring value was 131°. Females tend to have less neck shaft angle than male (female – 129.24, male – 132.75). The mean abductor lever arm was $38.48 \text{ mm} \pm 5.77$ (23–54) with the mode of 40. The mean cup size was $48.9 \pm 3.67 \text{ mm}$ (34–58) with the most commonly occurring value as 50. Females had smaller cup size (female – 46, male – 50). The mean neck offset was $40.27 \pm 7.06 \text{ mm}$ (15–64). The mean angle from tip of trochanter to center of head was 80.2 ± 9.1 (62–110). The most commonly

occurring value was 80°. Female had lesser angle the males (female – 77.73, male – 84.47). The mean head size was $41.97 \pm 3.39 \text{ mm}$ (34–50). The most common head size was 44. Females tend to have lesser head size (female – 39.93, male – 43.03). Among all the seven parameters correlations were drawn. There were in all 22 correlations out of which 14 were statistically significant (Tables 1–3).

4. Discussion

With the increasing trends for hip arthroplasty and broader indications coming into scenario, THR is now a routinely performed surgery with most of the surgeons doing it. The success of the procedure starts from the planning itself. The type of patient, type of implant, the requirements and demand patient is going to put on implant; all are key to

Table 2 – Male and female variations.

Sex		Acetabular angle	Neck shaft angle	Abductor lever arm	Cup size	Neck offset	Trochanteric tip to center of head angle	Head size
Female	N	74	74	74	74	74	74	74
	Minimum	30	118	23	34	24	67	36
	Maximum	47	156	50	56	64	98	46
	Range	17	38	27	22	40	31	10
	Mean	38.65	129.24	38.06	46.72	38.94	77.37	39.93
	Std. deviation	4.089	7.660	5.578	3.897	6.866	7.668	2.983
	Median	38.00	128.00	38.00	46.00	38.50	74.50	38.00
	Std. error of mean	0.556	1.042	0.759	0.530	0.934	1.044	0.406
Male	N	126	126	126	126	126	126	126
	Minimum	30	114	25	44	15	62	34
	Maximum	47	158	54	58	59	110	50
	Range	17	44	29	14	44	48	16
	Mean	37.20	132.75	38.71	50.12	40.97	84.47	43.05
	Std. deviation	3.599	7.587	5.896	2.949	7.094	8.913	3.097
	Median	37.00	132.00	38.00	50.00	41.00	84.00	44.00
	Std. error of Mean	0.356	0.751	0.584	0.292	0.702	0.883	0.307
Total	N	200	200	200	200	200	200	200
	Minimum	30	114	23	34	15	62	34
	Maximum	47	158	54	58	64	110	50
	Range	17	44	31	24	49	48	16
	Mean	37.70	131.53	38.48	48.94	40.27	82.01	41.97
	Std. deviation	3.826	7.770	5.778	3.672	7.060	9.130	3.393
	Median	38.00	131.00	38.00	50.00	41.00	80.00	42.00

Table 3 – Correlations.

		Acetabular angle	Neck shaft angle	Abductor lever arm	Cup size	Neck offset	Trochanteric tip to center of head angle	Head size
Acetabular angle	Pearson correlation	1	−0.144	−0.143	−0.191 ^a	−0.004	−0.049	−0.222 ^b
	Sig. (2-tailed)		0.072	0.075	0.017	0.957	0.546	0.005
	N		200	200	200	200	200	200
Neck shaft angle	Pearson Correlation		1	−0.393 ^b	0.087	−0.269 ^b	0.545 ^b	0.149
	Sig. (2-tailed)			0.000	0.280	0.001	0.000	0.063
	N			200	200	200	200	200
Abductor lever arm	Pearson Correlation			1	0.343 ^b	0.594 ^b	−0.439 ^b	0.264 ^b
	Sig. (2-tailed)				0.000	0.000	0.000	0.001
	N				200	200	200	200
Cup size	Pearson Correlation				1	0.405 ^b	0.176 ^a	0.842 ^b
	Sig. (2-tailed)					0.000	0.028	0.000
	N					200	200	200
Neck offset	Pearson Correlation					1	−0.096	0.354 ^b
	Sig. (2-tailed)						0.234	0.000
	N						200	200
Trochanteric tip to center of head angle	Pearson Correlation						1	0.255 ^b
	Sig. (2-tailed)							0.001
	N							200
Head size	Pearson Correlation							1
	Sig. (2-tailed)							
	N							

^a Correlation is significant at the 0.05 level (2-tailed).

^b Correlation is significant at the 0.01 level (2-tailed).

successful surgery. This depends on the precise knowledge of the anatomy around pelvis and hip. Although quite many European references are available, there are no studies on the Indian population and that too addressing the complete anatomy.⁴

In our study we have taken 100 randomly selected subjects and taken their X-rays and evaluated them for the anatomical parameters that form the most important part of planning a THR. Although we have taken the X-rays with the limbs parallel and 15° internal rotation some authors suggest X-rays with beam centered over the hip.² Other suggestion for consistent internal rotation of hip for AP X-ray is to have the knees flexed at the end of the table.⁶ Out of all the parameters the neck offset and the neck shaft angle are the two parameters that form the most important part of the planning. The European references for this neck shaft angle are reported to be $124.7 \pm 7.4^\circ$.⁷ In our study the mean neck shaft angle is 131° . Since the level of neck resection depends on this angle and the angle of the prosthesis, a greater difference may lead to higher level of resection. The most of the prosthesis have neck shaft angle of $130\text{--}135^\circ$. Significant Linear correlation is seen between trochanteric tip to center of head angle and neck shaft angle indicating that patient having higher neck shaft angle tends to have more accurate to 90° values and thus can be considered for intraoperative evaluation. Significant negative linear correlation exists between abductor lever arm and neck offset. The clinical significances of this correlation is that when patient have higher neck shaft angle, the offset tends to decrease and thus can cause decrease abducted lever arm and abductor power and thus the increased forces across the implant. Same correlation is seen with the abductor lever arm. So if there is choice between two offsets the larger offset would give stronger abductor function.

Acetabular inclination angle in our study came out to be 37 ± 3.82 . The normal value in English literature is taken as 45° .² The lower values indicate dysplasia. Since no literature is available for the Indian population, it is difficult to say whether readings in our study indicate any type of dysplasia or it is a normal anthropometric variation.

Abductor lever arm is an important parameter deciding the life of the implant as it is directly related to the forces across the joint. No standard values or any recommendation are available for this. There is a positive linear correlation between the cup size, neck offset and abductor lever arm thus suggesting a use of higher size cup in order to increase the abductor lever arm efficiency.

The aim of any replacement surgery is to restore the normal offset without changing the length of the limb. Since there exists a positive linear correlation with the cup size the aim should be to use higher size cup and thus regain the normal offset. Also in the degenerated hip the offset changes and thus it should always be drawn in the normal side.

The angle between the tip of trochanter and center of head is an important landmark used preoperatively and intraoperatively to assess the level of the center of head. It is presumed that this angle is 90° . In our study it is seen that there is considerable variation in this angle with the mean of 82.03° . Thus it may not be an accurate guide to be used preoperatively. The values show positive linear correlation with neck shaft angle indicating that patients with higher neck shaft angle tends to have values nearer to perpendicular distance.

There has been significant difference between the male and female values. The neck shaft angle in females is lesser than that of males. This suggests that they tend to have higher offset. As the females have smaller size cup this smaller neck shaft angle helps in restoring the higher offset.

Although the readings of the same patients on two sides differed, they did not show any statistically significant difference. This implies that in deformed hips the templating of the normal hip is of great value in measuring the cup size and setting the correct offset without having the limb length discrepancy.

The level of inter-ischial line was seen to be above the level of lesser trochanter in 32 cases, at the level of lesser trochanter in 42 cases and below the level of lesser trochanter in 26 cases. Thus the level of lesser trochanter has shown wide variation in relation to the inter-ischial line thus making it unreliable for the use in cases with bilateral hip involvement.

5. Conclusion

With the present study the author would like to suggest that the trochanteric tip to center of head angle be precalculated in case that is to be used intraoperatively for assessing the center of rotation in deciding the neck length. Also the relation between the level of lesser trochanter to inter-ischial line be evaluated carefully, at least in cases where there is bilateral hip involvement. Since there is significant difference between the neck shaft angles of Indian population than to the European population, an evaluation in the design of the implant by the Indian manufacturers is recommended.

Conflicts of interest

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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