

SEX DETERMINATION OF ADULT HUMAN SACRUM IN VIDHARBH REGION OF
MAHARASHTRAWalulkar S.M.^{1*}, Walulkar M.S.² and Paikrao V.M.³¹Associate Professor, Department of Anatomy, NKP Salve Institute of Medical Sciences and Research Centre, Nagpur, Maharashtra.²Assistant Professor, Department of Physiology, NKP Salve Institute of Medical Sciences and Research Centre, Nagpur, Maharashtra.³Lab Incharge, Department of Anatomy, NKP Salve Institute of Medical Sciences and Research Centre, Nagpur, Maharashtra.***Corresponding Author: Dr. Sanjay M. Walulkar**

Associate Professor, Department of Anatomy, NKP Salve Institute of Medical Sciences and Research Centre, Nagpur, Maharashtra.

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ABSTRACT**Aim:** To find out similarities and differences in the metrical values of different sacral parameters in males and female and also to highlight the best parameters that could be used to study sexual dimorphism of sacrum.**Material and methods:** The average values of sacrum for ventral straight length was found to be 103.94±5.82 mm in male and 92.13±6.03 mm in female, maximum breadth was 102.31±4.26 mm in male and 103.21±6.37 mm in female and sacral index was 97.89±4.35 mm in male and 112.92±5.43 mm in female. The average values of first sacral vertebra for transverse diameter was 48.13±4.14 mm in male and 40.32±3.46 mm in female, antero-posterior diameter was 28.87±2.29 mm in male and 26.82±2.30 mm in female and index was 59.84±4.64 mm in male and 65.89±5.01 mm in female. **Conclusion:** Sacral index was found to be the best criterion for sex determination of sacrum using sacral index alone 28.31% of bones in males and 58.2% of bones in females could be identified. However not a single parameter could identify 100% of the bones.**KEYWORDS:** Sacrum, Sacral index, First sacral vertebra.**INTRODUCTION**

Determination of sex is integral part and first step in the development of the biological profile in human osteology. Sex determination is necessary to make age, ancestry and stature estimation. Anatomists and anthropologists since long acknowledged the importance of sacrum in identifying the sex of a deceased person. Sexual dimorphic characters of sacrum can be studied both morphologically and metrically.

Sacrum is a large triangular bone forming the posterosuperior wall of the pelvic cavity, wedged between the two innominate bones. It is formed by fusion of the five sacral vertebrae and forms the caudal end of the vertebral column.

The wellknown method for determination of male or female type of sacrum has always been the "Sacral Index". The Sacral Index is calculated by the following formula.

$$\text{Sacral Index} = \frac{\text{Width of sacrum}}{\text{Height of sacrum}} \times 100$$

The present study was undertaken to find out similarities and differences in the metrical values of different sacral parameters in males and female and also to highlight the

best parameters that could be used to study sexual dimorphism of sacrum.

The present study was performed on 150 (90 male and 60 female) adult human sacra of known sex. Sacra were dry and free from deformity and fully ossified. Sacra were obtained from Department of Anatomy, NKP Salve Institute of Medical Sciences and Research Centre Nagpur, Government Medical College Nagpur, Indira Gandhi Government Medical College Nagpur and students of NKP Salve Institute of Medical Sciences and Research Centre Nagpur, Maharashtra. Each sacrum was studied for different features of sexual dimorphism. The parameters were measured using sliding vernier calipers, pair of divided and steel measuring scale. The following parameters were considered.

1. Maximum length of sacrum (Ventral straight length) was measured from the midpoint of the anterosuperior margin of sacral promontory, in the midsagittal plane, to the midpoint of anteroinferior margin of the last sacral vertebra. (Photograph 1)

2. Maximum breadth of sacrum was noted at midpoint of left and right alae of sacrum. (Photograph 2)

3. Sacral index for each sacrum was calculated using formula.

Sacral index = (sacral width / sacral ventral straight length) x 100

4. Maximum transverse diameter of first sacral body (T-S1) was recorded. (Photograph 3)

5. Maximum antero-posterior diameter of first sacral body (AP-S1) was noted. (Photograph 4)

6. Index for body of first sacral vertebra was calculated using formula.

Index for body of first sacral vertebra = A-P Diameter of body of S1 / Transverse diameter of S1 x 100.

For identification of male sacrum, the demarking point (D.P.) of particular measurement was more than 3S.D. of mean value for female and for identification of female sacrum, D.P. of same measurement was less than 3S.D. of mean value for male. Data were tabulated and statistically analyzed for mean, standard deviation, range, student t test, demarking points and percentage of identified bones.



Fig. 1(a): Vernier Calliper.



Fig. 1(b): Measurement of ventral straight length of male and female sacrum.

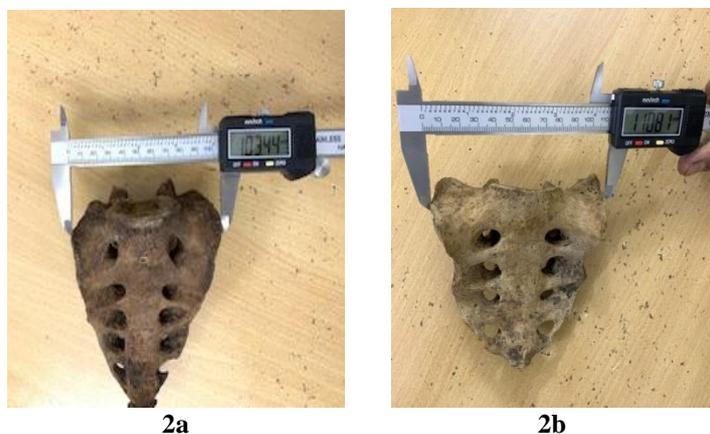


Fig. 2(a,b): Photograph 2a and 2b-showing measurement of maximum breadth of male and female sacrum.

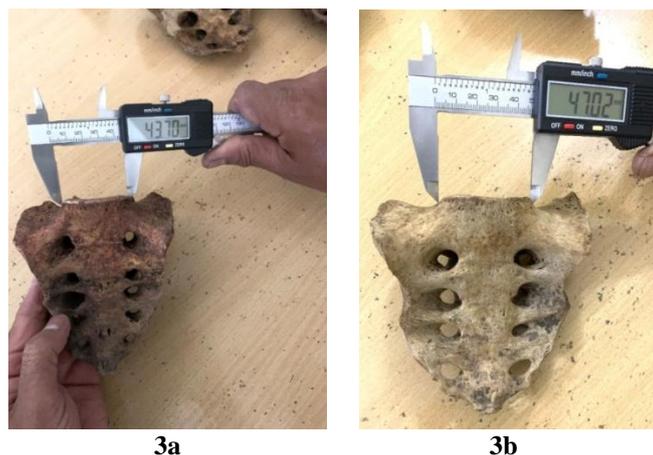


Fig. 3(a,b): photograph 3a and 3b- showing transverse measurement of body of first sacral vertebra.

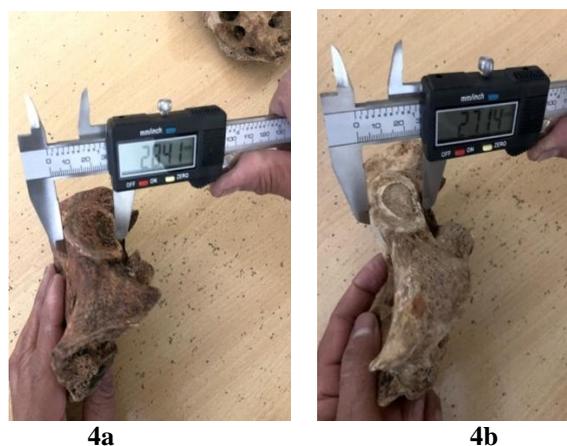


Fig. 4(a,b): Photograph 4a and 4b-showing antero-posterior measurement of body of first sacral vertebra.

Statistically Methods

After completing measurements, they were tabulated and analyzed by statistical methods which included univariate statistics and discriminant function analysis.

A standard computer program was used to analyse the data. The data was summarized into range (minimum-maximum), mean and standard deviation sex wise. Comparison of each study factor was done by applying Student's 't' test (unpaired).

For identification of male sacrum, the demarking point (D.P.) of particular measurement was more than 3S.D. of mean value for female and for identification of female sacrum, D.P. of same measurement was less than 3S.D. of mean value for male. Data were tabulated and statistically analyzed for mean, standard deviation, range, student t test, demarking points and percentage of identified bones.

OBSERVATION

Our observations are tabulated as below.

Table 1: Displaying result for ventral straight length, maximum breadth and sacral index. (H.S- highly significant, N.S- not significant, measurements in millimeters).

Parameters	Ventral straight length		Maximum breadth		Sacral index	
	M	F	M	F	M	F
No of bones	90	60	90	60	90	60
Range	91.15-123.17	82.10-102.32	90.57-114.74	88.35-125.65	86.68-115.39	98.76-122.93
Mean	103.94	92.13	102.31	103.21	97.89	112.92
Standard Deviation	5.82	6.03	4.26	6.37	4.35	5.43
Mean± 3S.D.	86.43-121.78	74.89-110.14	87.94-116.86	84.93-123.87	84.77-112.21	95.84-129.76
Demarking Points	>110.23	<86.32	>123.93	<87.95	<95.6	>112.11
Percentage of bones Identified	17.79	19.85	0	0	28.31	58.2
t value	11.54		1.746		16.6	
p value	<0.0001 (H.S.)		<0.0546 (N.S)		<0.0001 (H.S)	

Table 2: Displaying results for maximum transverse diameter (T-S1), maximum antero-posterior diameter (A-S1) and index of body of first sacrum vertebra. (H.S,- highly significant,Measurements in millimeters).

Parameters	T-S1		AP-S1		Index of body 1 st sacral vertebra	
	M	F	M	F	M	F
No of bones	90	60	90	60	90	60
Range	39.84-61.81	33.76-47.92	22.86-37.32	22.82-30.12	47.87-72.69	55.78-76.82
Mean	48.13	40.32	28.87	26.82	59.84	65.89
Standard Deviation	4.14	3.46	2.29	2.30	4.65	5.01
Mean±3S.D.	35.15-60.93	29.87-51.88	21.23-36.12	20.17-32.32	44.9-74.86	50.83-80.94
Demarking Points	>50.98	<35.24	>32.31	<21.30	<51.02	>45.13
Percentage of Bones identified	17.96	10.14	2.10	0	1.53	0.78
t value	11.28		5.457		7.185	
p value	<0.0001 (H.S)		<0.0001 (H.S.)		<0.0001(H.S.)	

Table 3: Showing Comparison Of Present Study With Other Studies For Ventral Straight Length, Maximum Breadth And Sacral Index.

Parameter	Sample Size		Ventral straight length		Maximum breadth		Sacral index	
	M	F	M	F	M	F	M	F
Studies								
Grays anatomy	-	-	-	-	-	-	105	115
Davivongs (1963)	50	50	9.65±0.88	9.99± 0.5	8.81±0.687	10.12± 0.51	104.16±8.93	115.49±10.39
Flander (1978) White	50	50	-	-	-	-	106.49 ± 10.4	108.69 ±13.59
Flander (1978) Black	50	50	-	-	-	-	106.17± 10.36	112.35 ±11.0
Raju et al (1980)	33	11	10.5± 0.864	9.27± 0.561	105.± 0.531	10.3± 0.36	100.85± 8.71	111.39 ±7.67
Jana et al (1987)	27	27	-	-	-	-	91.27	103.89
Singh et al	26	12	-	-	-	-	94.32	104.81
Mishra SR et al (2003)								
Patel MM et al (2005)	32	32	-	-	-	-	96.25±4.6	113.25 ±5.74
Shailaja MC(2010)	190	64	11±0.84	9.45±0.85	10.42±0.9	10.6±0.69	94.24±11.78	113.19 ±10.26
Arora AK et al (2010)	20	20	109.74±11.66	91.22±6.348	101.44±8.96	114.13±9.67	93.69±11.57	125.35 ±11.47
Sachdeva K et al (2011)	40	10	10.41±1.26	9.18±0.71	10.31±0.78	10.1±0.7	100.24±12.54	111.14 ±14.6
Mazumdar S et al (2012)	127	123	100.8±11.5	87.3±7.4	96.3±7.4	95.6±5.7	94.9±4.8	109.8 ±7.3
Nisha yadav et al (2015)	83	57	104.7±5.94	92.6±6.1	102.93±4.83	104.77±6.48	98.44±4.69	113.23 ±5.61
Present study	90	60	103±5.82	92.13 ±6.03	102.31 ±4.26	103.21 ±6.37	97.89 ±4.35	112.92 ±5.43

Table 4: Showing comparison of present study with other studies for parameters like transverse diameter (T-S1), antero-posterior diameter (AP-S1) and index of body offirst sacral vertebra.

Parameter Mean \pm Standard deviation								
Studies	Sample size		T-S1		AP-S1		Index of body-1 st sacral vertebra	
	M	F	M	F	M	F	M	F
Davivongs (1963)	50	50	4.74 ± 0.399	4.41 ± 0.368	2.98 ± 0.229	2.76 ± 0.148	63.03 ± 4.4	62.84 ± 6.25
Raju et al (1980)	33	11	4.73 ± 0.509	4.21 ± 0.509	3.3 ± 0.288	2.76 ± 0.28	64.64 ± 7.48	65.52 ± 6.27
Mishra SR et al (2003)	74	42	49.12 ± 3.27	42.81 ± 3.04	30.04 ± 2.58	29.29 ± 2.15	61.73 ± 4.07	68.60 ± 4.92
Sachdeva K et al(2011)	40	10	4.76 ± 0.71	4.55 ± 0.48	3.15 ± 0.41	2.85 ± 0.23	-	-
Kothapalli J et al (2012)	-	-	-	-	-	-	66.79 ± 9.1	70.7 ± 5.8
Mazumdar S et al (2012)	127	123	41.6 ± 8.5	39.7 ± 5.2	29.4 ± 3.8	27.9 ± 2.7	71.6 ± 9.1	70.7 ± 5.8
Shree Krishna et al (2013)	75	75	-	-	-	-	64.33 ± 6.43	69.40 ± 6.9
Nisha Yadav etal (2015)	83	57	48.48 ± 4.21	40.75 ± 3.51	29.12 ± 2.47	26.93 ± 2	60.28 ± 4.96	66.36 ± 5.04
Present study	90	60	48.13 ± 4.14	40.32 ± 3.46	28.87 ± 2.29	26.82 ± 2.30	59.84 ± 4.65	65.89 ± 5.01

DISCUSSION

While teaching sex differences in bones much stress is laid on the importance of sacrum. Actually, very little data is available to test the validity of the number of parameters describe to identify the sex of sacra (Davivongs, 1963).

The demarking points of various parameters, if crossed by any sacrum will identify the sex with certainty, which is of paramount importance in medicolegal cases. However, it is not necessary for any bone to cross the D.Ps of all the parameters before sex could be identified. Any single D.P. for any of the parameters, if crossed would detect the sex with 100% accuracy (Singh and Raju, 1977).

In the present study, most of the values for parameters like sacral index, index of first sacral vertebra, width of sacrum higher in female and other parameters like length of sacrum and diameters of first sacral vertebra were higher in male. The mean value of sacral index was 97.89 in males and 112.92 in females. The demarking points in males was < 95.6 and > 112.11 in females. Of the specimens studied, 27.71% of bones in males and 57.9% of bones in females were identified correctly using this parameter alone with high level of significance ($P < 0.0001$).

Mishra., et al examined 116 adult human dry sacra (74 males and 42 females) of Agra region and showed that mean length was greater in male (107.53 ± 7.03 mm) than female (105.34 ± 6.222) which was similar to the present study. Math described that ventral straight length in male was 117.00mm and that for female was 86.00mm. He described that width of sacrum in male was 104.20 mm

and that for female 106.30mm. He also described that sacrum with maximum length measuring above 117.00 mm is definitely a male and below 86.00 is definitely a female.

Jit and Singh (1966) identified sex of sacrum with 100% accuracy by calculating demarking points from the observed values. They suggested for identification of male sacrum, the D.P. of a particular measurement was more than 3 S.D. of mean value for female, and, for identification of Female sacrum, the D.P. of same measurement was less than 3 S.D. of mean value for male.

Gray's Anatomy (40th edition) gives the mean value of sacral index to be 105 in males and 115 in females.

Mishra SR et al (2003) obtained mean value of sacral index to be 98.21 in males and 117.84 in females in their study conducted on 74 male and 42 female sacra.

Patel MM et (2005) in their study on 32 males and 32 females sacra found the mean value to be 96.25 in males and 113.25 in females.

Shailaja MC et al (2010) in their study on 190 male and 64 female sacra showed the mean value to be 94.24 in males and 113.19 females.

Flander reported the average sacral index in white males was 106.49 and in white female 108.69. in blacks, he reported the average was 106.17 in males and 112.35 in females. Thus, from the above discussion it is clear that average sacral index varies among different population.

Arora examined sacra of Punjab region and showed that maximum breadth of male sacrum was 91.22 ± 6.348 mm and in female was 114.13 ± 9.57 mm.

Sacral index remains to be the best parameter for sex determination amongst the parameters studied. Other parameters studies showed low level of significance compared to sacral index. Perhaps sacral index can be used in combination with other parameters to improve the accuracy of sex determination.

CONCLUSION

The present study shows that the sacral index is the best criterion for sex determination of sacrum using sacral index alone 28.31% of bones in males and 58.2% of bones in females could be identified. Other parameters studies like ventral straight length, maximum breadth, diameters and index of first sacral body were less significant for sex determination of sacrum. However not a single parameter could identify 100% of the bones. Hence it could be concluded that for determination of sex of sacrum, maximum number of parameters should be taken into consideration to attain 100% accuracy.

The variable figures of same parameter or index in different areas or races tell us that anthropometric standards, although studied in past extensively need to be evaluated from time to time as external influences like physical stress, nutrition and life style are always changing.

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