

## Original Research Paper

# A Study of Sacral Index and Its Interpretation in Sex Determination in Madhya Pradesh

<sup>1</sup>Shailendra Patel, <sup>2</sup>Manish Nigam, <sup>3</sup>Pradeep Mishra, <sup>5</sup>Chandra Shekhar Wagmare

### Abstract

Various parameters and indices are available based on which the sex can be determined using sacrum. These parameters and indices vary region wise also. Therefore we undertook the study in Madhya Pradesh region. Total 126 dry human adult sacra of known sex (76 male & 50 female) were obtained from various Medical Colleges of Madhya Pradesh. Maximum length and maximum width of sacrum were studied. Sacral index (SI) arrived from the measured parameters. Demarking Point (DP) helps in sexing the sacrum with certainty. Maximum length of sacrum is found statistically significant ( $p < 0.0001$ ,  $t = 8.67$ ), DP for maximum length for male sacrum is  $> 124.40$  mm and for female is  $< 81.92$  mm. Maximum width of sacrum is found statistically not significant ( $p = 0.99$ ,  $t = 0.018$ ). The SI is found statistically significant ( $p < 0.0001$ ,  $t = 9.63$ ) for sexing the sacrum in the present study. DP of SI for male is  $< 84.20$  and for female is  $> 123.06$  and 6.57% male and 12% female sacra fall beyond DP.

**Key Words:** Sacrum, Sex determination, Sacral Index, Demarking point

### Introduction:

Establishing the Identity of human remains is one of the most important aspect in which a Forensic Medicine expert has to give his opinion for an unknown and mutilated dead body. Especially when an unknown skeleton is been supplied for its opinion regarding the identification, sacral bone carries much of the importance for sex determination.

The exact establishment of identity of sex in archaeological and medico legal samples of bone depends on the number of bones sent for examination. It was observed by Taylor in his book of Medical jurisprudence, that:

a	Skull + Femur	97.35%
b	Coccyx + sacrum	97.18%
c	Pelvis alone	95.00%
d	Skull alone	91.38%
e	Femur alone	39.84%
f	Atlas vertebra	31.18%

Krogman gave the opinion that the accuracy of sex identification based on the study of complete skeleton was 100% and skull with pelvis 98%, pelvis alone 95%, skull alone 90% and long bones alone 80%.

### Corresponding Author:

<sup>1</sup>Post Graduate III<sup>rd</sup> Year,  
Department of Forensic Medicine and Toxicology,  
SAIMS, Indore, Madhya Pradesh, India-453111  
E-mail: medicare2002@gmail.com,

<sup>2</sup>Prof & HOD,

<sup>3</sup>Assoc. Prof,

<sup>4</sup>Post Graduate III<sup>rd</sup> Year

DOR: 25.02.2014 DOA: 17.04.2014

He subsequently made an estimate to reduce the above figures by 5-10% depending upon completeness of the material to be sexed.

Both the above authors have worked on the sexing of the bones using the various statistical analysis. However identification of sex using observations on multiple bones using different parameter is recommended than using a single bone. [1-3]

The geometry of sacra (length and breadth) also varies among different populations leading to variations in average sacral index (SI) among different population. [4, 5]

Calculation of Demarcating Point (DP) for the parameters used in sex identification increases the accuracy by 100% [6] and DP was calculated for each and every population to get accurate results in the process of identifying the sex. [7]

### Materials and Methods:

In present study 126 sacra of known sexes (76 male and 50 female sacra) were collected from Sri Aurobindo Medical College, Indore M.P, MGM Medical College, Indore, M.P, R. D. Gardi Medical College, Ujjain, M.P and N.S.C.B. Medical College, Jabalpur, M.P.

#### Instruments used were:

1. Sliding digital Vernier calliper.
2. Standardized flexible ribbon tape.

In order to avoid manual errors, sufficient care was taken and all parameters were measured accurately. From each sacrum, following metrical data was recorded as in the

manner described below:

a. **Maximum length of Sacrum (Wilders mid-ventral Straight length):**

It was measured along the mid-line of sacrum with the Vernier calliper from middle of antero-superior margin of promontory to middle of antero-inferior margin of the last sacral vertebra. (Fig. 1)

b. **Maximum breadth of sacrum:**

It was measured with the Vernier calliper by taking two points at the upper part of auricular surface anteriorly (or lateral most part of ala of sacrum), thus maximum breadth was measured on anterior aspect of sacrum. (Fig. 2)

By using the above measurements, the sacral index was calculated:

**Sacral index:** Widthx100/Straight Length

The Demarking Points [D.P.] suggested by Jit and Singh [6] were used for identification of sex of sacrum with 100% accuracy.

For identification of male sacrum, the D.P. of a particular measurement was more than 3 S.D of the female mean value. Similarly, for identification of female sacrum, the D.P. of the same measurement was less than 3 S.D. of the male mean value.

**Demarking Point and Calculated Range:**

Mean and standard deviation were calculated for the ranges of each parameter of both the sexes. Using these values calculated range was arrived at by the formula '**Mean +/- 3SD**'.

Generally parameters are higher in males in comparison to females, in such parameters, for a given male, calculated range of 'a to b' and female calculated 'x to y'.

Values of 'a' (min. in male range) and 'y' (max. in female range) were chosen as 'demarking points'. But parameters which are less in males in comparison to females, in such parameters, for a given male, calculated range of 'a to b' and female calculated 'x to y'. Values of 'a' (max. in male range) and 'y' (min. in female range) were chosen as 'demarking points'.

**Fig. 1: Maximum length of Sacrum is being measured**



**Fig. 2: Maximum Width of Sacrum is being measured**



**Result:**

In this study the Mean value, Calculated range, 'P' value for statistical significance, Demarking point and % of bones identified with the help of demarking point for maximum length, maximum width and Sacral index (SI) for both the sex was analyzed and tabulated. (Table 1)

Maximum length of sacrum is found statistically significant ( $p < 0.0001$ ,  $t = 8.67$ ), demarking point for maximum length for male sacrum is  $>124.40$  mm and for female is  $<81.92$  mm. Maximum width of sacrum is found statistically not significant ( $p = 0.99$ ,  $t = 0.018$ ).

The Sacral Index is found statistically significant ( $p < 0.0001$ ,  $t = 9.63$ ) for sexing the sacrum in the present study. Demarking point for sacral index for male is  $<84.20$  mm and for female is  $>123.06$  mm. Maximum samples for maximum length of sacra of male fall in the range of 100-110 and 110-120 i.e. 31 and 30 respectively and samples of female fall in the range of 90- 100 i.e. 19 sacrum. (Fig. 3)

Our study showed that the maximum samples for maximum width of male and female sacra fall in the range of 100-110 i.e. 48 and 19 respectively. (Fig.4) while the maximum samples for sacral index of male sacra fall in the range of 90-100 i.e. 31 and samples of female fall in the range of 100-110 i.e. 19 sacrum. (Fig. 5)

**Discussion:**

In present study average value for sacral index in males was 97.61 and that for females was 113.40. Mean value of female was significantly higher than male. 6.57% male and 12% female bones fall beyond Demarking Point. Difference between male and female mean was statistically highly significant.

The mean value of Sacral index for male sacra (97.61) in this study was higher than that of Kolkata region (94.9) studied by Mazumdar et al [11], Amritsar region (93.69) studied by Arora et al [9], Gulbarga region (94.24) studied by Math Sailaja C [8], Dhapate SS (94.58) [13],

Singh et al (94.32) [7], Jana et al [14] (91.27) and Bagde (94.75). [15]

It was lesser than that of Amritsar region (100.24) studied by Sachdeva K et al [10], Shreekrishna HK et al [12], Tamilnadu (99.21), Varanasi region (100.85) studied by Raju et al [19], Flander white (106.49) Black (106.17) [17], Davivongs (104.16) [4], Charnalia (105.1) [16], Grays Anatomy (105.1) [20] and it was very close to that of Patel et al [1] Jamnagar (96.25), Agra region (98.21) studied by Mishra et al. [2]

The mean value of Sacral index for female sacra (113.40) in present study was higher than that of Kolkata region (109.8) studied by Mazumdar et al [11], Amritsar region (111.74) studied by Sachdeva K et al, Dhapate SS (104.27) [13], Singh et al (104.81) [7], Jana et al (103.89) [14], Varanasi region (111.39) studied by Raju et al [19] and Flander white (108.69). [17]

It was lesser than that of Shreekrishna HK et al [12] in Tamilnadu (119.94), Amritsar region (125.35) studied by Arora et al [9], Agra region (117.84) studied by Mishra et al [2] and Davivongs (115.49) [4] and it was very close to Gulbarga region (113.19) studied by Math Sailaja C [8], Patel et al [1] Jamnagar (113.25), Bagde(112.05) [15], Flander Black (112.35) [17] and Charnalia (112). [16] All studies including present study found sacral index for sex determination statistically significant except Flander [17] study for Black population.

### Conclusion:

Since sacrum is a component of pelvic girdle with functional differences between the two sexes, it itself becomes important for identification of sex in the human skeletal system. Sacral index (SI) is the best parameter for identification of sex. Maximum length of sacrum is found statistically significant.

Maximum width of sacrum is found statistically not significant. The Sacral Index is found statistically significant for sexing the sacrum in the present study. However, not a single parameter could identify sex in 100% of the bones. Hence, it can be concluded that sex determination of the sacrum with 100% accuracy is possible only when maximum number of parameters are taken into consideration.

Continuance of such studies in a defined geographic area over a period of time will definitely help in establishing the anthropometric standards. Such studies will also be useful to observe the changing trends if any, in the metric measurements which is influenced by environmental, socioeconomic factors, physical stress and genetic factors.

### References:

1. **Patel MM, Gupta BD, Singel TC.** Sexing of sacrum by sacral index and kimura's base wing index. JIAFM. 2005; 27 (1): 5-9.
2. **Mishra SR, Singh PJ, Agrawal AK, Gupta RN.** Identification of sex of sacrum of Agra region. J Anat Soc Ind. 2003; 52(3): 132-36.
3. **Stewart TD.** Measurement of Bones In: Hrdlicka's Practical Anthropometry: 4th edition. The Wistar Institute of Anatomy & Biology, Philadelphia. 1952: pp.172
4. **Davivongs V.** The pelvic girdle of the Australian aborigines-sex difference and sex determination. American Journal of Physical Anthropology. 1963; 21: 443-55.
5. **Singh S and Gangrade KC.** Sexing of adult clavicle verification and applicability of demarking point. Journal of Indian Academy of Forensic Science. 1968; 7: 20-30.
6. **Jit I and Singh S.** Sexing of the adult clavicle. Indian Journal of Medical Research. 1966; 54: 551-71
7. **Singh H, Singh J and Bargoetra RN.** Sacral index as observed anthropometrically in the region of Jammu. Journal of Anatomical Society of India. 1988; 37: pp.1
8. **Math SC, Nandyal VB, Shetty VB, Pawar JD, Rajkumar KR.** Study of sexual dimorphism in human sacrum-in North Karnataka. Indian Journal of Forensic Medicine and Pathology 2010; 3(1):13-19.
9. **Arora AK, Gupta P, Mahajan S, Kapoor, SS.** Significance of Sacral Index in Estimation of Sex in Sacra of Cadavers in Punjab. J Indian Acad Forensic Med 2010; 32(2):104-107.
10. **Sachdeva K, Kumar Singla R, Kalsey G, Sharma G.** Role of Sacrum in Sexual Dimorphism-A Morphometric Study. J Ind Acad Forensic Med 2011; 33(3):206-210.
11. **Mazumdar S, Ray A, Mazumdar A, Majumdar S, Sinha A, Vasisht S.** Sexual Dimorphism and Regional Difference in Size of Sacrum: A Study in Eastern India. Al Ameen Journal of Medical Sciences 2012; 5(3):298-307.
12. **Shreekrishna HK, Yatiraj S, Vijayakumari N.** Credibility of Various Indices of Sacrum in identification of Sex of Sacrum . International J of Medical Toxicology and Forensic Med 2013; 3(2):58-63.
13. **Dhapate SS.** MS Dissertation, S.R.T.R. Medical College, Amba Jogai, 1997.
14. **Jana TK, Bhandra P, Koley T, Shah SB, Basu SK.** Variation in sacral hiatus and significance of hiatal index in sexing of sacrum. J Anat Soc Ind 1978; 36:(1). Proc. of Anat. Soc. of Ind. (Abstract) pp42
15. **Bagde KG.** Determination of sex from axial skeleton M.S. Dissertation-Marathwada University Aurangabad, 1981
16. **Charnalia VM.** Sex difference and determination in human sacra in South India. J Ant Soc Ind 1967; 16 :( 1):33.
17. **Flander LB.** Univariate and multivariate methods for sexing the sacrum, Am J Phys Anthrop, 1978; 49: 103-110.
18. **Singh S, Gangarde KG.** Sexing of adult clavicles, Verification and applicability of demarking points, J Forensic Sci 1968;7:20-30.
19. **Raju P B, Singh S, Padamnabhan R,** Sex determination and sacrum, Journal of Anatomical Society of India 1981; 30:13-15.
20. **Gray's Anatomy.** 39th Edition, Elsevier Churchill Livingstone, 2005:796-797

**Fig. 3: Maximum Length of Sacrum (wilders mid – ventral straight length) in mm**

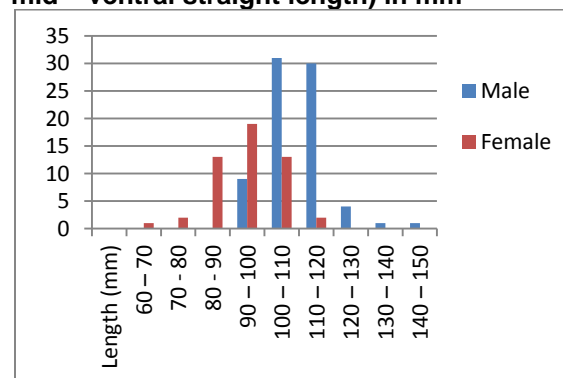


Fig. 4: Maximum Breadth of Sacrum in mm

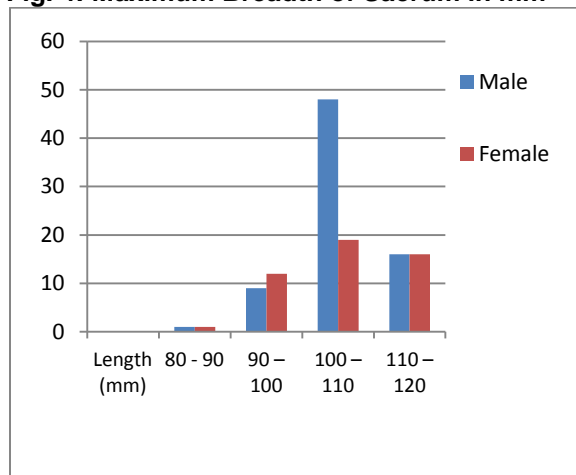


Fig. 5: Sacral Index

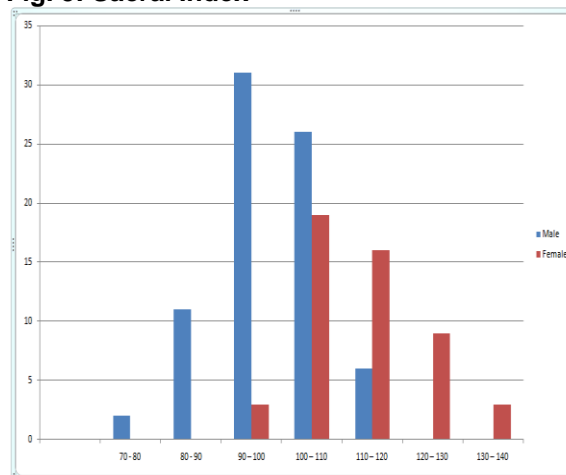


Table 1  
Various Parameters of Sacrum and their Statistical Analysis

S. N.	Parameters	Sex	Range	Mean	S.D.	t' value	p' value	Calculated range Mean+ S.D.	D.P.	% of bone identified by D.P.
1	Length of sacrum (mm)	M (76)	94.54-145.95	109.47	9.18	8.67	<0.0001	81.92 - 137.02	>124.4	5/76
		F (50)	68.84-118.18	94.46	9.98			64.52 - 124.4	<81.92	4/50
2	Width of sacrum (mm)	M (76)	88.0-125.02	106.42	6.64	0.018	0.99	86.49 - 126.36	<81.64	0/76
		F (50)	88.5-128.66	106.45	8.27			81.64 - 131.26	>126.36	1/50
3	Sacral index	M (76)	72.02-112.71	97.61	8.48	9.63	<0.0001	72.16 - 123.06	<84.20	5/76
		F (50)	93.01-139.34	113.4	9.73			84.20 - 142.60	>123.06	6/50

Table 2  
Comparative Number & Percentage of Bones in which Sex could be Identified using Demarking Points as the Parameter

S.N.	Parameters	Sex	Present study	Mishra et al	Raju et al	Arora et al	Patel et al	Shreekrishna et al	Mazumdar et al	Shailja et al
1	Length of Sacrum	M	6.57	71.60	42.40	60	-	-	7.90	14.43
		F	8	23.08	-	0	-	-	-	15.39
2	Width of Sacrum	M	0	0	9.10	0	-	-	0	0.57
		F	2	0	-	0	-	-	-	0
3	Sacral index	M	6.57	39.20	0	45	62.50	56	9.40	0
		F	12	80	0	40	68.75	78	44.70	0