



## Significance of Sacral Index in Estimation of Sex of Sacrum Inhadoti Rajasthan

William F Masih<sup>1</sup>, Ashok Pratap Singh<sup>2</sup> and Kunj Bihari Rathore<sup>3\*</sup>

<sup>1</sup>Professor, Department of Anatomy, Govt. Medical College Kota, Rajasthan, India

<sup>2</sup>Professor, Department of Anatomy, SSR medical college Mauritious, Rajasthan, India

<sup>3</sup>Senior Demonstrator, Department of Anatomy, Govt. Medical College Kota, Rajasthan, India

\*Corresponding Author: Kunj Bihari Rathore, Department of Anatomy, Govt. Medical College Kota, Rangbari Yojna Kota, Rajasthan, India.

Received: July 01, 2017; Published: September 20, 2017

### Abstract

**Introduction:** Anatomists, anthropologists and forensic experts judge the sex of the skeletal material by non-metric observations. Sex-dependent differences have been noted in the pelvic bone anatomy, and so differences exist in male and female sacrum. Over the years different authors had carried various types of measurements on human sacra of different races. The well-known method for determination sex of the individual has always ideally been the Sacral Index, method as explained in the Hrdlicka's Practical Anthropometry. The formula for Sacral Index is:  $\text{Sacral Index} = \text{Width of Sacrum} \times 100 / \text{Length of Sacrum}$ .

**Aims:** The aim of this study was to collect data regarding morphometric measurements of maximum length and breadth of sacrum and to find out possible variations of sacral index in different individuals in relation to sex.

**Material and Methods:** A Cross-sectional, analytical type of study was conducted in the department of Anatomy, Govt. medical college Kota on 75 (seventy-five) adult human dry sacra of unknown sex. The sacral bones were distributed into male and female groups by discriminant functional analysis. The study sample was studied morphologically for sacral length and sacral breadth with digital sliding Vernier caliper.

**Results:** The men sacral index in male and female were  $97.88 \pm 6.16 \%$  and  $112.69 \pm 10.17 \%$  respectively. Female has the greater sacral index than male ( $P < 0.001$ ).

**Conclusion:** The bones of the body are the last to pass away after death, next to enamel of teeth. Medico legal experts, anatomists and anthropologists use the skeletal materials for giving their opinion in respect to sex, age and stature for establishing the personal identity. Sacral index method is relevant and significant for determination of sex.

**Keywords:** Discriminant function analysis; Gender; Sacral index; Sex determination; sacrum

### Introduction

Establishing the identity of the human remains is one of the most important and challenging. Forensic expert and anatomist have to give their opinion for the unknown and mutilated dead body. It was by Taylor in his Book of medical jurisprudence, that the accuracy of estimating the sex from skeletal remains depends upon number of bones available [1]. That is Skull and Femur 97.35%, Coccyx and Sacrum 97.18 %, Pelvis 95 %, Skull alone 91.38 %, Femur 39.84 %, Atlas vertebra 31.18%. The high accuracy of sex assessment (88.3 %) by the discriminant analysis of the sacral base is a valid method of estimating the sex of skeletal remains from a range of populations. The sacrum is a large, triangular irregular type of bone, situated in the lower part of the vertebral column, where it is inserted like a wedge between the two hip bones [2]. Sacrum meaning 'Temple' in Greek and 'Sacred' in Latin is a large vertebral bone housing all the caudal spinal nerves [3]. The geometry of sacral length and breadth also varies among different populations leading to variations in average sacral index [1,4]. Anatomists, anthropologists and forensic experts judge the sex of the skeletal material by non-metric obser-

variations. Sexual divergence has been based upon actual measurements in different bones. There is paucity of metrical data available for sacral bone [1,5]. Sex differences exist in the male and female sacrum [6]. The sacrum can be used for sexual dimorphism as in anthropological work. The well-known method for determination sex of sacrum has always ideally been the Sacral Index method as explained in the Hrdlicka's Practical Anthropometry [7,8].

The formula of Sacral Index is:

$\text{Sacral Index} = \text{Width of Sacrum} \times 100 / \text{Length of Sacrum}$ .

### Materials and Methods

Sacral index was measured by taking the breadth and length of individual sacrum with the help of Vernier Digital Caliper and adopting the method as demonstrated in Hrdlicka's Practical Anthropometry [7,8]. The stem of caliper was applied to upper surface of the body of first sacral vertebra and measurement of maximum breadth was taken across the greatest expanse of lateral masses of the bone as shown (Figure 1, 2 and 3).



Figure 1: Digital Vernier Caliper.



Figure 2: Measurement of sacral Length with digital vernier caliper.

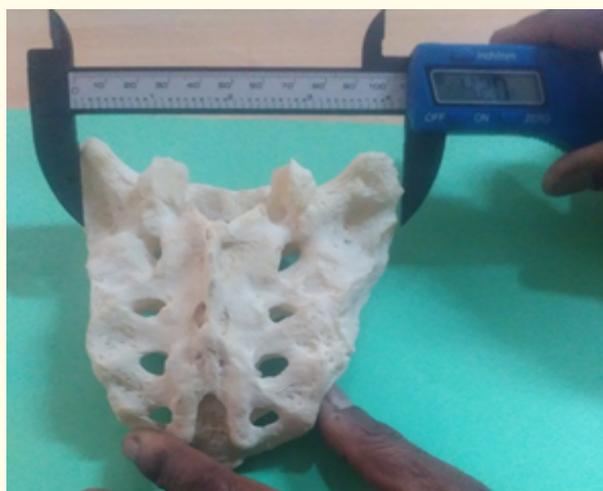


Figure 3: Measurement of sacral Length with digital vernier caliper.

A total of 75 (seventy-five) dried completely ossified, grossly normal adult human sacra of unknown sex were assessed. The sacra were collected from Department of Anatomy of Govt. Medical College Kota. The study samples were distributed in male and female sex groups by discriminant function analysis. With the help of digital Vernier calipers different measurements were recorded in millimetres. Measurement of maximum length of sacrum was recorded by the distance from antero-superior margin of promontory to the middle of antero-inferior margin of the last sacral vertebra. Maximum breadth of sacrum was measured by taking two points at the upper part of auricular surface anteriorly.

The sacral index (SI) is calculated with formula:

$$\text{Sacral Index} = \frac{\text{Width of Sacrum} \times 100}{\text{length of Sacrum}}$$

Differences between length and breadth done by paired Student 't' test and comparison between sex done by unpaired Student 't' test.

P-value < 0.05 was considered statistically significant.

#### Ethical Clearance

This study was approved by the Ethical Review Committee of Govt. Medical College Kota

#### Results

The mean length of sacrum in male and female was  $107.44 \pm 6.95$  mm and  $91.65 \pm 7.03$  mm respectively and the mean breadth of sacrum in male and female was  $104.63 \pm 6.41$  mm and  $102.77 \pm 6.57$  mm respectively. Sacral index in male and female is  $97.88 \pm 6.16$  and  $112.69 \pm 10.17\%$  respectively.

In case of male sacral length is greater than breadth and opposite was found in female i.e. breadth is greater than length ( $P < 0.001$ ) (Table 1).

Differences between length and breadth done by paired Student's 't' test and comparison between sex done by unpaired Student's 't' test was significant (Table 2).

Mean sacral index in male and female were  $97.88 \pm 6.16\%$  and  $112.69 \pm 10.17\%$  respectively. Female has the greater sacral index than male ( $P < 0.001$ ).

Sacrl Length in Male (Mms)	Sacral Breadth in Male (Mms)	Sacral Index in Male	Sacrl Length in Female (Mms)	Sacral Breadth in Female (Mms)	Sacral Index in Female
107.44 SD ± 6.95	104.63 SD ± 6.41	97.88 SD ± 6.16%	91.65 SD ± 7.03	102.77 SD ± 6.57%	112.69 SD ± 10.17%

Table 1: Length and breadth of sacrum in male and female.

	Sacrum Length	sacrum Breadth	Mean ± SD value	Minimum-maximum	P value
Male	107.44 SD ± 6.95	104.63 SD ± 6.41	107.44 ± 6.95	87.80 - 117.38	< 0.001
Female	91.65 SD ± 7.03	102.77 SD ± 6.57%	91.65 ± 7.03	73.17 - 114.57	< 0.001

Table 2: Sex- wise Length (mm), Breadth (mm), Mean ± SD, Minimum-maximum, P value.

Discussion

	Mean Male sacral length	Mean Male sacral breadth	No. of sacrum	Mean Female sacral length	Mean Female sacral breadth	Mean Sacral index male	Mean sacral index female
Davivongs (1963) [4] Australian aborigine	96.5 ± 0.88	88.1 ± 0.687	100	99.9 ± 0.5	101.2 ± 0.51	104.16 ± 8.93	115.49 ± 10.39
Flander (1978) [14]	White Americans	-	100	-	-	106.49 ± 10.4	108.69 ± 13.59
	Black Americans	-	100	-	-	106.17 ± 10.36	112.35 ± 11.03
Mishra SR <i>et al</i> (2003) [1] AGRA (U.P)	107.53 ± 7.03	90.58 ± 4.42	116	105.34±6.222	105.16 ± 6.322	98.21 ± 4.89	117.84 ± 7
Math SC [10] MM (2006)	117.00	104.20		86.00	106.30 mm	94.24%	113.19%
Patel MM (2006) [7] (Gujrat)	-	-	64	-	-	90.5 - 106% Mean 96.25%	104.8 - 131% Mean 113.25%
Arora AK <i>et al</i> (2010) [9] (Punjab)	109.74 ± 11.66	91.22 ± 6.348	40	101.44 ± 8.96	114.13 ± 9.67	93.69 ± 11.57	125.35 ± 11.47
Sachdeva K <i>et al</i> (2011) [12] (Punjab)	10.41 ± 1.26	91.8 ± 0.71	50	10.31 ± 0.78	10.1 ± 0.7	100.24 ± 12.54	111.14 ± 14.6
Mazumdar S <i>et al</i> (2012) [11] (Indian Bengal)	100.8 ± 11.5	87.3 ± 7.4	250	96.3 ± 7.4	95.6 ± 5.7	94.9 ± 4.8	109.8 ± 7.3
Ravichandran D (2013) [16] (Tamilnadu and Andhra)	97.8	93.7	123	90.96	92.91	96.32 ± 5.40	102.29 ± 4.0
Bindra <i>et al</i> (2015) [15] Indians (Haryana region)	106.85	90.89	60	108.24	106.87	101.3	117.56
YadavN <i>et al.</i> (2015) [13] Indian (Maharashtra)	104.7 ± 5.94	102.93 ± 4.83	140	92.6 ± 6.1	104.77 ± 6.48	98.44 ± 4.69	113.23 ± 5.61%
PRESENT STUDY 2017 (Central Rajasthan)	107.44 SD ± 6.95	104.63 SD ± 6.41	75	97.88	102.77 SD ± 6.57%	97.88 SD ± 6.16%	112.69 SD ± 10.17%

Table 3: Comparative Study of Sacral Index by different authors in different population.

Mishra., *et al.* [1] 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 [10] described that ventral straight length in male was 117.00 mm and that for female was 86.00 mm. Mean length of male sacra was significantly higher than in female which was similar to the present study. The mean (± SD) breadth of sacrum in present study in male and female was 107.44 SD ± 6.95 mm and 102.77 ± 6.57 mm respectively are similar to the findings of Arora [9]. Our reading is higher than Davivong., *et al.* [4] in Australian aborigine.

Math [10] described that width of sacrum in male was 104.20 mm and that for female 106.30 mm. He also described that sacrum with maximum length measuring above 117.00 mm is definitely a male and below 86.00 mm is definitely a female.

Arora [9] 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 ± 9.67 mm. The mean breadth of sacrum in male in present study was similar to the values reported by Math [10] and almost equal to Yadav., *et al.* [13] but higher than Mishra., *et al.* [1] Mazumdar *et al.* [11], Bindra., *et al.* [16] and Ravichander., *et al.* [16].

The mean sacral index in male and female in present study are  $97.88 \pm 6.16\%$  and  $112.69 \pm 10.17\%$  respectively. Female has the greater sacral index than male and the difference was statistically highly significant ( $< 0.001$ ). Our study was similar to Patel [7] who had reported the range of sacral index for males as 90.5 - 106% (Mean sacral index 96.25%) and in case of female's sacral index 104.8 - 131% (Mean sacral index 113.25%). Sacral index according to Davivong, et al. [4] in Australian aborigine is higher in both male and female than present study.

Our present study is similar to Math [10], Arora, et al. [7] Mazumdar, et al. [11] who had reported average value for sacral index in male were 94.24% and for females were 113.19% and Yadva N., et al. [13] of Maharashtra but lower than Sachdeva, et al. [12] and Bindra, et al. [15] in Haryana.

Flander [12] 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 the average sacral index varies among different populations.

## Conclusion

Sexing of sacrum, by sacral index method is relevant and significant. The average sacral index identified in the present study would be of use to forensic experts, anthropologists and anatomists of central part of Rajasthan. We recommend future studies with larger sample size.

## Bibliography

- Mishra SR, et al. "Identification of sex of sacrum of Agra region". *Journal of the Anatomical Society of India* 52.2 (2003): 132-136.
- Sugar O. "How the sacrum got its name". *JAMA* 257.15 (1987): 2061-2063.
- Newell RLM, et al. "Gray's Anatomy the Anatomical Basis of Clinical Practice". Paris: Churchill Livingstone (2008): 724-728.
- Davivongs V. "The pelvic girdle of the Australian aborigines- sex difference and sex determination". *American Journal of Physical Anthropology* 21.4 (1963): 443-455.
- Krishan K. "Anthropometry in forensic medicine and forensic science-forensic anthropometry". *The Internet Journal of Forensic Science* 2.1 (2007): 1-12.
- Cheng JS and Song JK. "Anatomy of the Sacrum". *Neurosurgeon Focus* 15.2 (2003): 1-9.
- Patel MM, et al. "Sexing of sacrum by sacral index and kimura's base wing index". *Jiafm* 27.1 (2005): 971-973.
- Krogman WM and Iscan MY. "The Human Skeleton in Forensic Medicine 2<sup>nd</sup> Edition". Charles C Thomas, Springfield, Illinois, USA. (1986): 224-226.
- Arora KA, et al. "Significance of sacral index in estimation of sex in sacra of cadavers in Punjab". *Journal of Indian Academy of Forensic Medicine* 32.2 (2008): 104.
- Math SC. "Sexual dimorphism in sacrum". MS Rajiv Gandhi University of Health Sciences, Karnataka, Bangalore (2006): 59-69.
- Mazumdar S, et al. "Sexual dimorphism and regional difference insize of sacrum: A study in Eastern India". *Al Ameen Journal of Medical Sciences* 5.3 (2012): 298-307.
- Sachdeva K, et al. "Role of sacrum in sexual dimorphism- A morphometric study". *Journal of Indian Academy of Forensic Medicine* 33.3 (2011): 206-210.
- Yadav N, et al. "Determination of sex using dry adult human sacrum-morphometric study". *International Journal of Current Research and Review* 7.3 (2015): 22-23.
- Flander LV. "Univariate and multivariate methods for sexing the sacrum". *American Journal of Physical Anthropology* 49.1 (1978): 103-110.
- Bindra GS and Mohan A. "Sacral Index: Application in sex determination of sacrum". *International Journal of Scientific Study* 2.10 (2015): 79-81.
- Ravichandran D, et al. "A Study on Sacral Index in Tamil Nadu and Andhra Pradesh Population of Southern India". *Journal of Clinical and Diagnostic Research* 7.9 (2013): 1833-1834.

**Volume 1 Issue 4 September 2017**

**© All rights are reserved by Kunj Bihari Rathore, et al.**