Credibility of Various Indices of Sacrum in Identification of Sex of Sacrum

Shreekrishna HK[1]*, Yatiraj S[2], Vijayakumari N[1]

[1] Department of Forensic Medicine and Toxicology, Madha Medical College, Chennai, Tamilnadu, India
[2] Department of Forensic Medicine and Toxicology, Sree Mookambika Institute of Medical Sciences, Kulasekharam (K.K. Dist), Tamilnadu, India
[3] Department of Forensic Medicine and Toxicology, Annapoorana Medical College and Hospitals, Salem, Tamilnadu, India

A R T I C L E I N F O

A B S T R A C T

Background: Determination of sex from skeletal remains is of paramount importance for Forensic Experts for identification of the deceased. The task becomes more difficult when only a single bone is available. Though most bones exhibit clear cut sexual variation in morphology but to determine sex with 100% accuracy, one has to use metric measurements to study various indices. These indices exhibit significant variation in range according ethnicity & geographic location, hence is suggested to arrive at Demarking Point (D.P.) for these parameters which greatly help in sexing of a bone. Sacrum has been considered amongst ideal bones to determine sex of individual because of its functional morphological variation in both sexes by virtue of its contribution to pelvis. Numerous indices have been reported to determine sex of sacra but of it none have proved to effectively & singularly differentiate sex. Hence is advised to not rely on a single index but use maximum possible indices to determine sex of sacrum. Also to be taken in consideration is fact that values of these indices so is their D.P. varies according to geographical location. Hence studies such as this are carried out to calculate anthrometric data regarding various measurements & indices for a particular region.

Method: 150 sacra of known sex from Tamil Nadu of South India were studied for metrical parameters for determination of sex. Efforts were made to find Demarking point for each parameter and then compared with similar studies.

Results: It was evident from present study that sacral index is the most important parameter as far as the sex determination of sacrum is concerned as it could singularly identify 56% male and 78% female bones. Sacral index for population under study was observed to be 99.21 for males and 119.94 for females.

Conclusion: The present study highlight importance of certain parameters like sacral index while also demonstrating insignificance other parameters, but basic fact remains that as far as the sex determination of sacrum is concerned no single parameter could identify sex in 100% of the bones and hence, it can be concluded that for sex determination of the sacrum with 100% accuracy is possible only when maximum number of parameters are taken into consideration.

▶*Implication for health policy/practice/research/medical education:*
Various Indices of Sacrum in Identification of Sex of Sacrum

1. Introduction:

Determination of sex from the skeletal remains is of medico-legal importance for establishing the identity of a deceased. If whole skeleton is available it becomes easy to identify the sex, but difficulty arises when a single bone is available. Among various bones sacrum has always attracted the attention of medico-legal experts for establishing sex, possibly because of its contribution to pelvic girdle and associated functional sex differences. It has long been customary among forensic experts, anatomists and anthropologist to judge the sex of skeletal material by non-metric observations. Lately, sexual divergence has been based upon actual measurement in different regions. The determination of sex of deceased is first step in skeletal analysis since estimation of age at death, race and stature depends on sex of the deceased.

Metrical study of sacrum done by various authors like Wilder (1), Faweet (2), Davivongs (3) and Singh and Gangrade (4) have reported that even within the same general population, mean value may be significantly different in bones from different zones. Jit and Singh (5) advocated importance of the demarking point (D.P.), which identifies the sex with about 100% accuracy. Singh and Singh (6) have shown that D.P. should be calculated separately for population of different

Corresponding author: Shreekrishna HK, MD. Associated Professor, Department of Forensic Medicine and Toxicology, Madha Medical College, Chennai, Tamilnadu, India.
E-mail: krishnashree61@yahoo.com

regions because the mean of a parameter differ in values in different regions.

Though various literature is available about study of India sacra like studies by Singh and Raju (7), Jana *et al* (8), Singh *et al* (9), Raju *et al* (10), Mishra *et al* (11), Kanika *et al* (11), Mazumdar et al (13) etc; however these studies are conducted in Northern and Eastern India. Hence, the present study is undertaken with a view to study the sex differences in sacra of South Indian Peninsula.

2. Materials and Methods:

The materials for the present study consisted of 150 adult sacra (75 males and 75 females) of known sex available in the Department of Anatomy, Madha Medical College, Chennai and Sree Mookambika Institute of Medical Sciences, Kulasekharam (Dist. Kanya Kumari). These sacra are selected after rejecting the bones, having fractures, pathology or wear and tear. With the help of a stainless steel sliding caliper and flexible steel tape, the following measurements were taken (each linear measurement was recorded to the nearest millimeter).

1. Maximum length of sacrum (Wilder's mid-ventral Straight length)

It is measured along the mid-line of sacrum with the sliding caliper from the middle of anterosuperior margin of the last sacral vertebra.

2. Maximum breadth of sacrum

It is measured with the sliding caliper by taking points at the upper part of auricular surface anteriorly (or lateral most part of ala of sacrum); thus, maximum breadth is measured on anterior aspect of sacrum.

3. Curved length of sacrum (Mid-ventral curved length)

It is measured along with the midline of the anterior surface of the sacrum (from middle of anterosuperior margin of promontory to middle of anteroinferior margin of the last sacral vertebra) by the flexible steel tape.

4. Antero-posterior diameter of the body of 1st sacral vertebra

It is the maximum possible diameter of 1st sacral vertebra. It is measured with the sliding caliper by taking one point on anterosuperior border and another point on the posterosuperior border of 1st sacral vertebral body.

5. Transverse diameter of the body of 1st sacral vertebra

It is the maximum transverse diameter of 1st sacral vertebra, measured with the sliding caliper by taking one point on each side of the lateral most point on the superior surface of body of 1st sacral vertebra.

6. Length of ala

It is measured on both sides with the sliding caliper by taking one point on the lateral most point of superior surface of body of 1st sacral vertebra and another point on the lateral most point of ala of sacrum.

By using the above measurements, the following indices were calculated.

1. Sacral index:

$$\text{Sacral Index} = \frac{\text{Width}}{\text{Straight Length}} \times 100$$

2. Curvature index:

$$\text{Curvature Index} = \frac{\text{Straight Length}}{\text{Mid-ventral Curved Length}} \times 100$$

3. Index of body 1st Sacral Vertebra:

$$\text{Index of body of 1}^{st}\text{ Sacral vertebra} = \frac{\text{AP diameter of body of S1}}{\text{Transverse diameter of body of S1}} \times 100$$

4. Corpo-basal index:

$$\text{Corpo-basal Index} = \frac{\text{Transverse diameter of body of S1}}{\text{Width of Sacrum}} \times 100$$

5. Alar index:

$$\text{Alar Index} = \frac{\text{Length of Ala}}{\text{Transverse diameter of body of S1}} \times 100$$

The D.P. of all the above parameters were calculated according to the work of Jit and Singh (5) and percentage of bones identified by each parameter were worked out.

3. Results:

The range, mean, calculated range (mean +3 S.D.), Demarking Points (D.P.) of various parameters and the percentage of bones in which sex could be identified by them, are given in Table 1.

Table 1 shows that the sacral index is the most important parameter as far as the sex determination of sacrum. It is concerned because 56% of male bones and 78% of female bones could be identified by using the D.P. for the above parameter.

Table 2 compares the findings of present study with various other similar studies.

4. Discussion:

Sexing of the skeletal remains is mainly a medico-legal work, where 100% accuracy is required. Previously many studies have been done to determine the sex of bones, but most studies recommended to have separate D.P. for specific region or population. Jit and Singh (5) found that the maximum and minimum units of parameter values which is determined on the basis of mean±3 S.D. and which they have named Demarking Point would be of great value of determining the sex of sacrum with almost 100% accuracy.

The mean sacral index of the male sacra of the present study falls under dolichohieric group (narrow sacrum with sacral index up to 99.9). Similar observation was reported by Jana *et al* (8) (in their study of sacra of

Table 1: Various Indices for sex determination of Sacrum.

Sr. No.	Indices	Sex	Range	Mean	S.D.	't' value	'p' value	Calculated range	D.P.	% of bone identified by D.P.
1	Sacral index	M	93-108	99.21	4.10	9.30	<0.001	90.07-114.72	<93.98	56%
		F	104-130.25	119.94	8.66			93.98-145.94	>114.72	78%
2	Curvature index	M	90.47-98.33	94.72	1.91	3.51	0.001	88.95-107.44	>106.57	4%
		F	83.2-97.77	91.2	5.19			75.42-106.57	<88.95	10%
3	Corpobasal index	M	40-53.06	47.76	3.93	6.73	<0.001	35.95-59.57	>53.81	15%
		F	33.2-46.9	40.90	4.30			28.00-53.81	<35.95	8%
4	Alar index	M	44.2-59.5	51.57	5.23	12.47	<0.001	35.85-67.29	<44.15	8%
		F	62.0-97.5	76.93	7.69			44.15-109.7	>67.29	22%
5	Index of body of 1st sacral vertebra	M	56-72	64.33	6.43	3.68	0.001	49.97-78.69	<54.06	0%
		F	60-76	69.40	6.9			54.06-84.82	>78.69	14%

Burdwan region, West Bengal in 1988, mean sacral index of male being 95.7), and Singh *et al* (9). However, Davivongs (3) and Raju *et al* (10) reported that the male sacra of their study fall under sub-plathyhieric group.

The mean sacral index of the female bone of the present study falls under plathyhieric group, which is similar to the observations of Raju *et al* (10) and Davivongs (3). Martin (14) reported that in the European sacrum both male and female means fall into the plathyhieric group, being 112.4 in the male and 114.8 in the female. But an attempt to use the sacral index for ethnic discrimination is very doubtful (Davivongs). However, its importance in sex determination cannot be denied since the differences between the males and females are highly significant, statistically.

The mean curvature index of male sacra of the present study is slightly higher than that of the observations of Raju *et al* (10) and Davivongs (3), somewhat equal to findings of Mazumdar (13), but lower than those of Mishra (11). Mean of curvature index of female sacra was higher in comparison to all other studies.

The mean corpo-basal index of the male sacra in the present study is equal to that of Australian aboriginal population studied by Davivongs (3), but is higher than that of other Indian studies, whereas in the case of females the observations are similar to findings of Singh et al (9), Raju *et al* (10) and Mishra *et al* (11).

The mean alar index of the male sacra in present study is lower than those of findings in Agra population whereas it is higher for female sacra.

The mean for index of body S1 vertebrae of male sacra for present study tallies with that of Davivongs (3) and Singh *et al* (9), is slightly higher than findings of Mishra (11) but significantly lower than those of

Table 2: Comparison with other studies.

Sr. No.	Indices	Sex	Present Study (Southern India)	Davivongs [3] (Australia)	Singh et al [9] (Jammu)	Raju et al [10] (Varanasi)	Mishra et al [11] (Agra)	Kanika et al [12] (Northern India)	Mazumdar et al [13] (Eastern India)
1.	Sacral index	M	99.21	104.16	100.85	100.85	98.21	100.24	94.9
		F	119.94	115.49	113.39	111.39	117.84	111.74	109.8
2.	Curvature index	M	94.72	92.46	92.77	92.77	95.72	91.59	94.0
		F	91.2	90.80	88.51	88.51	90.72	87.87	87.9
3.	Corpobasal index	M	47.76	47.72	44.94	44.94	46.54	43.22	43.8
		F	40.90	43.62	40.96	40.96	40.47	43.84	41.7
4.	Alar index	M	51.57	--	--	--	56.1	--	--
		F	76.93	--	--	--	72.6	--	--
5.	Index of body of 1st sacral vertebra	M	64.33	63.03	64.42	--	61.73	--	71.6
		F	69.40	62.84	65.52	--	68.60	--	70.7

Mazumdar (13) however for female sacra it exceeds values of Davivongs (3), Singh *et al* (9) and comes in range of Mishra (11) and Mazumdar (13).

4. Conclusions:

The present study shows that certain parameters are insignificant as far as the sex determination of sacrum is concerned while certain other parameters are much useful. However, not a single parameter could identify sex in 100% of the bones. Hence, it can be concluded that for sex determination of the sacrum with 100% accuracy is possible only when maximum number of parameters are taken into consideration.

It also substantiates observation of Singh and Gangrade (4) that sacrum or for that matter all bones show significant variations according to geographic location.

Continuance of such studies in a defined geographic area over a period of time will definitely help in establishing 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.

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