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EFFECT OF AGE & SEX ON MORPHOMETRIC ANALYSIS OF SACRAL VESTIBULE USING PLAIN COMPUTED TOMOGRAPHY

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Conflicts of Interest: Nil
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Abstract:

Background: The present study was aimed to study and develop in-depth understanding of the morphometry of sacral vestibule in North-West Indian population presenting to our institution, which will go a long way in planning to treat the posterior pelvic injuries with percutaneous screws, thereby reducing the morbidity associated with open fixation.

Methods: This study was conducted in the Department of Orthopaedics and Radiodiagnosis at Dr Rajendra Prasad Govt. Medical College, Kangra at Tanda over a period of one year. All the patients of the age >18 years and above submitting for either abdominal, lower spinal or non-orthopaedic pathology of pelvic region, presenting for computed tomography to the Department of Radiodiagnosis were included in the study.

Results: There was non-significant difference in coronal angulation of S1 (P=0.701) and S2 (P=0.913) between males and females. There was significant difference in axial angulation of S1 (P=0.000) and S2 (P=0.045) between males and females. Alar length & Alar width was not significantly different between age-groups

Conclusion: The present study, the first of its kind in Northern part of India arrived to help us anthropometric measurements of sacral vestibule, thereby, helping in development of local protocols for percutaneous fixation in sacral fracture.

Keywords: Sacral, Coronal angulation, Axial angulation.

Introduction

The sacral bone is an inverted triangle that sits obliquely between the two innominate bones of the pelvis at the distal aspect of the spinal column. It functions mechanically to convey axial load from the lumbar spine into the lower extremities for balanced locomotion. The ventral sacral body is concave and derived from five vertebrae. The transverse processes of the sacral vertebrae coalesce to form the sacral ala, which projects laterally from the upper sacral promontory.[1]

The standard treatment of unstable sacral fractures is surgical fixation duetoa high incidence of residual morbidity under conservative treatment. The primary goal is anatomic reduction, followed by a rigid fracture fixation. There are several operating techniques like fixation with iliosacral screws or plates, triangular osteosynthesis, ilioiliac (plates, internal fixators, and bars) and trans-sacral screws or bars. In recent years, sacroiliac screws and spinopelvic internal fixators have become the preferred implants for fixation of posterior pelvic ring fractures. Whereas full weight bearing is allowed for most spinopelvic fixations, none or partial weight bearing is recommended for iliosacral screw fixations.[2]

The present study was aimed to study and develop in-depth understanding of the morphometry of sacral vestibule in North-West Indian population presenting to our institution, which will go a long way in planning to treat the posterior pelvic injuries with percutaneous screws, thereby reducing the morbidity associated with open fixation.

MATERIALS AND METHODS

This study was conducted in the Department of Orthopaedics and Radiodiagnosis at Dr Rajendra Prasad Govt. Medical College, Kangra at Tanda over a period of one year. All the patients of the age >18 years and above submitting for either abdominal, lower spinal or non-orthopaedic pathology of pelvic region, presenting for computed tomography to the Department of Radiodiagnosis were included in the study. The patients were informed about the aims and methods of the study and once consent was given for participation, they were evaluated. The evaluation included clinical assessment for height. This helped draw comparison while arriving at morphometry of Sacral vestibule.

The following patients were excluded from the study

1. Age < 18 years.
2. The patient with pelvic ring dysmorphism.
3. Osteolytic pelvic lesions.
4. Fractures involving the posterior elements.
5. Post operated cases of above fracture
6. Not willing to participate in the study
7. Implants obscuring the lumbosacral junction.

Each patient and his attendants was adequately informed about the aims, methods, the anticipated benefits and potential risks of the study and the discomfort it might entail them and the remedies thereof. Every precaution was taken to respect the privacy of the patient, the confidentiality of the patient's information and to minimize the impact of the study on his/her physical and mental integrity and personality. The patients were given the right to abstain from participation in the study or to withdraw consent to participate at any time of the study without reprisal. Due care and caution were taken at all stages of the research to ensure that the patient was put to minimum risk, suffer from no irreversible adverse effects and generally, benefit from and by the research. Written informed consent was obtained from all the patients and attendants included in the study.

The subjects included in this study followed the protocol generally used by the Department of Radiodiagnosis for the conditions mentioned above. The subjects were placed in the supine position with fully extended knee joint with patella facing the sky for CT examination. 3D volume reconstruction of surface anatomy of bony pelvis was then performed using available CT data.

All CT scan were included scanning by anteroposterior tomogram as well as axial images of Sacral Vestibule. All angles were measured at the CT work station. Measurements of the angles were performed by a junior resident (the investigator) from the Department of Orthopaedics Dr. RPGMC Tanda and were supervised by consulting Orthopaedician and Radiologist.

Following parameters were noted in each patient according to the sex of the patient:

A. Coronal angulations

B. Axial angulations

C. Minimum Area of the vestibule

D. Maximum Length of vestibule

E. Width of vestibule

F. Alar indentation

G. Alar length

Statistical Analyses

Data were presented as frequency, percentages, and median (inter quartile range; IQR). Difference between quantitative variables was compared using Mann Whitney U test. Spearman correlation coefficient was used to find relation between two variables. P value <0.05 was considered significant. Statistical analyses were performed using SPSS v20.

RESULTS

The present study was aimed to perform morphometric analysis of sacral vestibule using CT at Department of Orthopaedics, Dr RPGMC Kangra at Tanda. A total of 610 patients were included in the study. Lower spinal pathology was the major cause for radiological assessment in 58.69% patients followed by pelvic pathology (22.95%), and abdominal pathology (18.36%).

Table 1: Comparative analysis of coronal angulation of S1 and S2 between age-category

	Age-group	Mean±SD	Min-Max	P Value
S1	18-30	21.59±6.23	11-33	>0.05
	31-40	22.60±6.86	11-33	
	41-50	22.22±6.71	11-33	
	51-60	22.00±6.67	11-33	
	>60	22.59±7.04	13-33	
S2	18-30	4.66±1.89	1-8	>0.05
	31-40	4.56±2.99	1-8	
	41-50	5.16±2.90	1-10	
	51-60	5.38±3.09	1-10	
	>60	7.17±1.90	5-10	

There was no significant difference between coronal angulation of S1 and age-groups i.e. 18-30, 31-40, 41-50, 51-60, and >60 years. We observed that there was a significant difference in coronal angulation between age-groups 18-30 and 51-60 years (4.66±1.89 vs. 5.38±3.09; P=0.010), age-groups 18-30 and >60 years (4.66±1.89 vs. 7.17±1.90; P=0.000), age-groups 31-40 and 51-60 years (4.56±2.99 vs. 5.38±3.09; P=0.037), age-groups 31-40 and >60 years (4.56±2.99 vs. 7.17±1.90; P=0.004), age-groups 41-50 and >60 years (5.16±2.90 vs. 7.17±1.90; P=0.020), age-groups 51-60 and >60 years (5.38±3.09 vs. 7.17±1.90; P=0.049).

Table 2: Comparative analysis of coronal angulation of S1 and S2 between Sex

		Male	Female	p-value
S1	Mean±SD	21.96±6.43	22.15±6.82	0.701
	IQR	7.75	8.0	
S2	Mean±SD	5.08±2.81	5.03±2.72	0.913
	IQR	6.0	5.0	

There was non-significant difference in coronal angulation of S1 (P=0.701) and S2 (P=0.913) between males and females.

Table 3: Comparative analysis of axial angulation of S1 and S2 between age-category

	Age-group	Mean±SD	Min-Max	P Value
S1	18-30	10.43±3.10	-1-8	>0.05
	31-40	10.87±3.51	-1-8	
	41-50	11.28±4.41	-1-8	
	51-60	11.26±3.74	-1-8	
	>60	12.33±4.70	-1-8	
S2	18-30	2.77±1.95	2-23	>0.05
	31-40	3.17±2.90	3-21	
	41-50	3.45±2.90	2-23	
	51-60	3.67±2.92	2-23	
	>60	3.0±3.46	5-21	

There was a significant difference in coronal angulation of S1 between age-groups 18-30 and 51-60 years (10.43±3.10 vs. 11.26±3.74; P=0.023). We also observed that there was a significant difference in coronal angulation of S2 between age-groups 18-30 and 41-50 years (2.77±1.95 vs. 3.45±2.90; P=0.018), age-groups 18-30 and 51-60 years (2.77±1.95 vs. 3.0±3.46; P=0.001).

Table 4: Comparative analysis of axial angulation of S1 and S2 between Sex

		Male	Female	p-value
S1	Mean±SD	11.57±3.88	10.23±3.40	0.001
	IQR	4	4	
S2	Mean±SD	3.33±2.84	3.76±2.92	0.0415
	IQR	5	5	

There was significant difference in axial angulation of S1 (P=0.000) and S2 (P=0.045) between males and females.

Table 5: Comparative analysis of vestibule length of S1 and S2 between age-category

	Age-group	Mean±SD	Min-Max	P Value
S1	18-30	112.13±6.02	98.6-128.1	>0.05
	31-40	110.93±5.59	99.8-124.8	
	41-50	111.92±5.80	99.7-128.2	
	51-60	112.39±6.67	99.2-128.2	
	>60	115.61±7.50	100.5-124.8	
S2	18-30	129.12±11.93	108-149	>0.05
	31-40	128.01±12.72	108-149	
	41-50	129.32±11.39	108-149	
	51-60	128.37±11.69	108-149	
	>60	122.50±12.24	108-149	

We observed that vestibule length of S1 and S2 was not significantly different between different age-groups.

Table 6: Comparative analysis of vestibule length of S1 and S2 between Sex

		Male	Female	p-value
S1	Mean±SD	112.83±6.12	111.02±6.19	0.001
	IQR	7.95	8.63	
S2	Mean±SD	127.77±11.83	129.77±11.81	0.041
	IQR	21.0	20.25	

There was significant difference in length of vestibule of S1 (P=0.001) and S2 (P=0.041) between males and females.

Table 7: Comparative analysis of vestibule area of S1 and S2 between age-category

	Age-group	Mean±SD	Min-Max	P Value
S1	18-30	400.11±36.49	330-460	>0.05
	31-40	398.10±33.30	339-460	
	41-50	393.60±38.46	330-460	
	51-60	394.22±38.23	331-459	
	>60	386.67±36.03	334-457	
S2	18-30	228.68±37.76	163-283	>0.05
	31-40	221.45±37.27	164-283	
	41-50	222.42±37.97	162-283	
	51-60	224.55±33.05	162-283	
	>60	225.34±40.45	169-283	

We observed that vestibule area of S1 and S2 was not significantly different between different age-groups.

Table 8: Comparative analysis of vestibule area of S1 and S2 between Sex

		Male	Female	p-value
S1	Mean±SD	396.67±38.39	395.13±35.36	0.629
	IQR	66.0	61.0	
S2	Mean±SD	224.99±35.99	224.40±36.43	0.872
	IQR	64.0	66.25	

There was non-significant difference in area of vestibule of S1 (P=0.629) and S2 (P=0.872) between males and females.

Table 9: Comparative analysis of Alar Length, Indentation, and Width between age-category

	Age-group	Mean±SD	Min-Max	P Value
Alar Length	18-30	35.46±2.35	31-39	>0.05
	31-40	35.70±2.37	31-39	
	41-50	35.50±2.41	31-39	
	51-60	35.72±2.37	31-39	
	>60	35.66±2.19	32-39	
Alar Indentation	18-30	5.07±0.78	4-6	>0.05
	31-40	5.09±0.78	4-6	
	41-50	5.04±0.82	4-6	
	51-60	4.87±0.80	4-6	
	>60	5.17±0.83	4-6	
Alar Width	18-30	30.46±3.19	25-36	>0.05
	31-40	30.17±3.60	25-36	
	41-50	30.25±3.66	25-36	
	51-60	30.49±3.35	25-36	
	>60	30.75±3.33	25-36	

Alar length was not significantly different between age-groups. Alar indentation was significantly different between 18-30 and 51-60 (5.07±0.78 vs. 4.87±0.80; P=0.012), 31-40 and 51-60 years (5.09±0.78 vs. 4.87±0.80; P=0.026), and 41-50 and 51-60 years (5.04±0.82 vs. 4.87±0.80; P=0.046). Alar width was not significantly different between age-groups.

Table 10: Comparative analysis of Alar Length, Indentation, and Width between Sex

		Male	Female	p-value
Alar length	Mean±SD	35.04±2.61	36.38±1.69	0.001
	IQR	4.0	3.0	
Alar Indentation	Mean±SD	5.03±0.80	4.96±0.79	0.278
	IQR	2.0	3.0	
Alar width	Mean±SD	30.52±3.41	30.21±3.41	0.271
	IQR	5.0	6.0	

Alar length was significantly (P=0.000) higher in females in comparison to males. Our study observed that Alar Indentation was non-significantly (P=0.278) higher in males in comparison to males. Our study observed that Alar width was non-significantly (P=0.271) higher in males in comparison to females.

DISCUSSION

The sacral vestibule refers to the three-dimensional (3D) screw space that is available in the narrowest part of the iliosacral screw channel. The sacral vestibule is located in the transition zone between the sacral wing and sacral body and serves as the entrance to the sacral vertebrae. The vestibule is divided into two components, the S1 and S2 vestibules. The smaller S2 vestibule is associated with limited tolerance for screw misdirection, which can increase the risk of nerve injury or spinal canal damage. Therefore, S2 vestibules are rarely used for screw replacement. The S1 vestibule, located above the sacral foramina and between the sacral foramina and the slope of the sacral wing, is the isthmus of the transition zone between the sacral wing and the S1 vertebrae.

The present study was aimed to morphometrically analyze sacral vestibule using CT at Department of Orthopaedics, Dr RPGMC Kangra at Tanda. A total of 610 patients were included in the study.

We also found that area of S1 and S2 vestibules were non-significantly higher in males in comparison to female counterparts. The similar findings have previously been reported by Dong et al[3]. Dong et al. showed that vestibule width and height were significantly higher in males when compared with females. The proper location to insert iliosacral screws is parallel to the long diameter with the inclination angle of the vestibule; therefore, these both parameters are very important references for the operation. Due to smaller size in these parameters, the insertion location, direction of the screw, and the position relationships between the screws are particularly limited for female patients. Sacral variations are common in Indian population[3]; however, these parameters are higher than Chinese populations[5]. We found no significant relation between area of S1 and S2 vestibule with age, and with interspinus distance. Racial differences in sacral anatomy around the world result in variability in the results of measurement of area of vestibule[5]. Therefore, the placement of iliosacral screws should be considered carefully based on the size, gender, and ethnicity of the patient.

Our measurements showed that length of S1 and S2 vestibule was 112.08±6.21 mm and 128.60±11.85 mm respectively which were significantly higher in males in comparison to females. We also observed that the length of S1 and S2 vestibule is not dependent with age. Kaiser et al. observed that S1 and S2 vestibule length was 119.2 ± 35.7 mm and 128.1 ± 20.4 mm respectively. The above-mentioned results were comparable to our study[5]

We observed that the axial angulation was significantly higher in the age-group of 51-60 years in comparison to 18-30 and 31-40 years of age. We observed that there was no significant relation between S2 axial angulation and interspinus distance with age. However, we observed that a significant relation of S1 axial angulation with the patients' age in age-group 18-30 years. We found that axial angulation increases significantly with age up to 30 years. We also found that S1 and S2 axial angulation was significant higher in males in comparison to females.

CONCLUSION

The present study, the first of its kind in Northern part of India arrived to help us anthropometric measurements of sacral vestibule, thereby, helping in development of local protocols for percutaneous fixation in sacral fracture

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