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A Study on Morphometric Analysis of Sacral Vestibule Using Plain Computed Tomography

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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: Coronal angulation of S1 and S2 ranged from 11° to 33° with a mean value of 22.04°±6.59° and from 1° to 10° with a mean of 5.06°±2.77° respectively. Axial angulation of S1 and S2 ranged from 2° to 23.0° with a mean value of 11.01°±3.74° and from -1° to 8° with a mean of 3.51°±2.88° respectively. Length of vestibule of S1 and S2 ranged from 98.60 to 128.2 mm with a mean value of 112.08±6.21 mm and from 108.20 to 128.60 mm with a mean of 128.60±11.85 mm respectively. Alar length ranged from 31.0 to 39.0 with a mean value of 35.60±2.37. Alar Indentation ranged from 4.0 to 6.0 with a mean value of 4.99±0.80. Alar width ranged from 25.0 to 36.0 with a mean value of 30.39±3.41.

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 word sacrum was derived from Greek word hieron osteon and was first used by Romans. A more plausible explanation may be that the holiness of the sacral bone was an attribute borrowed from the ancient Egyptians, who considered this bone sacred to Osiris, the god of resurrection and agriculture.[1] The sacrum in human anatomy is a large, triangular bone at the base of the spine, that forms by the fusing of sacral vertebrae S1–S5 between 18 and 30 years of age.[2]

The iliosacral screw technique has reliable fixation strength, small wound, decreased bleeding and low infection rate. This technique establishes an effective fixation between the middle and posterior columns which properly fits biomechanical characteristics. However, this technique requires high precision for the direction and location of screws.[3] A change in trajectory by only 4 degrees can result in cortical perforation.[4] Improper positioning of screws may damage neurovascular bundle.[5] Therefore surgeons who perform the operation must understand the anatomy and the spatial configuration of sacral screw channels.

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.

The mean age of patients was 42.95 years. Maximum number of patients (n=356/610; 58.4%) were males and remaining (n=254/610; 41.6%) were females. Majority of the patients (n=462/610; 75.7%) belonged to rural region while remaining (n=148/610; 24.3%) patients hailed from urban region.

Table 1. Coronal Angulation

	S1	S2
Minimum	11°	1°
Maximum	33°	10°
Mean	22.04°±6.59°	5.06°±2.77°
Median	22	5
IQR	16	3

Coronal angulation of S1 and S2 ranged from 11° to 33° with a mean value of 22.04°±6.59° and from 1° to 10° with a mean of 5.06°±2.77° respectively.

Table 2. Axial Angulation

	S1	S2
Minimum	2°	-1°
Maximum	23°	08°
Mean	11.01°±3.74°	3.51°±2.88°
Median	10	3
IQR	10	3

Axial angulation of S1 and S2 ranged from 2° to 23.0° with a mean value of 11.01°±3.74° and from -1° to 8° with a mean of 3.51°±2.88° respectively.

Table 3. Length of vestibule

	S1	S2
Minimum	98.60	108.20
Maximum	128.2	128.60
Mean	112.08±6.21	128.60±11.85
Median	111.5	128
IQR	111.5	128

Length of vestibule of S1 and S2 ranged from 98.60 to 128.2 mm with a mean value of 112.08±6.21 mm and from 108.20 to 128.60 mm with a mean of 128.60±11.85 mm respectively.

Table 4. Area of vestibule

	S1	S2
Minimum	330.0	162.0
Maximum	460.0	283.0
Mean	396.03±37.13	224.74±36.14
Median	397	226
IQR	397	226

Area of vestibule of S1 and S2 ranged from 330.0 to 460.0 with a mean value of 396.03±37.13 and from 162.0 to 283.0 with a mean of 224.74±36.14 respectively.

Table 5. Alar Length, Indentation, and Width

	Alar Length	Alar Length	Alar Width
Minimum	31.0	4.0	25.0
Maximum	39.0	6.0	36.0
Mean	35.60±2.37	4.99±0.80	30.39±3.41
Median	36	5	30
IQR	36	5	30

Alar length ranged from 31.0 to 39.0 with a mean value of 35.60±2.37. Alar Indentation ranged from 4.0 to 6.0 with a mean value of 4.99±0.80. Alar width ranged from 25.0 to 36.0 with a mean value of 30.39±3.41

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.

In the present study, average area of S1 vestibule was 396.03±37.13 mm2 and S2 vestibule was 224.74±36.14 mm2. The results were in concordance with Dong et al. who measured the anatomic parameters of the sacral 1 vestibule in Chinese adults[6]. They observed that area of S1 vestibule was 400.23±85.11 mm2. Carlson et al observed that the average area of the vestibule was 330 mm2 to 630 mm2 (534 mm2) in males and 450 mm2 in females in US population[7]. Kaiser et al. studied CT scans and virtual outlet views of uninjured pelves in 104 patients. They observed that area of S1 vestibule was 417.4 ± 81.1 mm2 and S2 vestibule was 213.3 ± 87.9 mm2.[8]

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.[8]

We observed that coronal angulation of S1 and S2 vestibule was 22.04°±6.59° and 5.06°±2.77° respectively. Kaiser et al. measurements showed that coronal angulation of S1 and S2 vestibule was 22.6°±11.1° and 5.2°± 4.9°. Our results are in concordance with Kaiser et al[8].

Our study observed that axial angulation of S1 and S2 vestibule was 11.01°±3.74° and 3.51°±2.88° respectively. Kaiser et al. showed that coronal angulation of S1 and S2 vestibule was 11°±10.5° and 3.4°±4.6°**7**. Our results are in concordance with Kaiser et al[8].

In our study, we observed that average alar length, alar Indentation, and alar width was 40.31±18.78 mm, 6.54±3.48 mm, and 29.69±25.59 mm. Kim et al. evaluated upper sacral morphology and anatomy of safe zone related to iliosacral screw fixation in Korean population[9]. They observed that average alar length and indentation was 36.6±4.5 and 5.1±1.6 respectively.

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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