A Study on the Variations of Sacrum And Its Clinical Significance

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Abstract

Background: The sacrum is a large, triangular bone formed by five fused sacral vertebrae situated in the lower part of the vertebral column and at the upper and back part of the pelvic cavity, where it is inserted like a wedge between the two hip bones. Its base articulates with the last lumbar vertebra, and its apex with the coccyx. Numerous anatomical variations of the sacrum have been reported including complete bilateral sacralization of the fifth lumbar vertebra or complete bilateral sacralization of first coccygeal vertebra in different races. Knowledge of the posterior pelvic anatomy, its variations, and related imaging is important for diagnostic and therapeutic purposes in low back pain, spinal surgery and for interventional procedures like spinal anaesthesia and lumbar puncture.

Purpose of the study: The present study was designed to determine the variations of sacrum in the dry bones available in the Departments of Anatomy of VMKVMC and VMHMC.

Result: Examination of 155 sacrum showed-

1. Sacralization Of Lumbar Vertebra-Sacralization of lumbar vertebra-23.22%; Non-union of transverse process of L5 with S1- Unilateral(3.22%), Bilateral(1.93%); Non-union of body of L5 with S1-7.74%; Foramen/Cleft at the lamina of sacralized lumbar vertebra- Foramen(3.87%), Cleft(5.16%)
2. Variations Of Sacral Hiatus- Inverted U-shaped(39.35%); Inverted V-shaped(16.77%); Dumbbell shaped(7.091%); Hiatus resembling foramen(0.64%); Irregular(24.51%); Absent(5.80%)
3. Variations In The Number Of Sacral Foramina-3(1.93%);4(55.48%);5(31.61%)
4. Lumbarization Of Sacral Vertebrae-3(1.93%)
5. Sacralization Of Coccygeal Vertebrae-33(21.29%)
6. Spina Bifida-8(5.16%)

Conclusion: Knowledge of variations of sacrum is important for spinal surgeons in giving epidural anaesthesia and lumbar puncture and to clinical anatomists, forensic experts and morphologists for determination of age, sex and stature. It is also important during reporting of CT and MRI and for the differential diagnosis of low backache.

Keywords: Congenital anomaly, vertebra, sacrum

I. Background

Lumbosacral region is a region where there are many puzzling stresses and strains, that it renders the question more than ordinary interest¹. It is expected that any sort of compromise in skeletal features by any pathology, either congenital or acquired will affect the stability of the spine and its biomechanics. Developmental defects occurring at the lumbosacral border results in sacralization of fifth lumbar vertebra or lumbarization of first sacral vertebra²-⁴ and developmental defects occurring at the sacro-coccygeal border result in sacralization of first coccygeal vertebra. Many other intermediate variations have also been reported. The prevalence rate of lumbarization of first sacral vertebra is 3.4% to 7.2%⁵ and sacralization of fifth lumbar vertebra varies from 1.7% to 14%⁵,⁶ and sacralization of first coccygeal vertebra varies from 7.8% to 37% in different populations⁶.

The opening present at the caudal end of sacral canal is known as sacral hiatus. It is formed due to the failure of fusion of laminae of the fifth (occasionally 4th) sacral vertebra. Sacral hiatus is utilized for administration of epidural anaesthesia in obstetrics as well as in orthopaedic practice for transpedicular and lateral mass screw placement⁷,⁸. The variation in the development of the sacral hiatus can cause decrease area for the attachment of extensor muscle at back causing painful conditions⁹. Sacral hiatus with guide wire assistance is an accessible conduit for uncomplicated entry into the subarachnoid and basal cisternal space without damaging the surrounding structures. Lumbosacral transitional vertebrae (LSTV) are congenital...
anomalies of the lumbosacral region which include lumbarization and sacralization. This condition occurs due to defect in the segmentation of the lumbo-sacral spine during development. 

The sacrum may contain six vertebrae, by development of an additional sacral element or by incorporation of the fifth lumbar or first coccygeal vertebrae. Inclusion of the fifth lumbar vertebra (sacralization) is usually incomplete and limited to one side. In most minor degree of the abnormality a fifth lumbar transverse process is large and articulates, sometimes by a synovial joint, with the sacrum at the posterolateral angle of its base. Reduction of sacral constituents is less common but lumbarization of the first sacral vertebra does occur: it remains partially or completely separate. The bodies of the first two sacral vertebrae may remain unfused when the lateral masses are fused. The dorsal wall of the sacral canal may be variably deficient, due to imperfect development of laminae and spines. Orientation of the superior sacral articular facets displays wide variation, as does the sagittal curvature of the sacrum. Asymmetry of the superior facets alter the relation between the planes of the two lumbosacral facet joints.

The aim of the study is to determine the variations of sacrum in the dry bones.

**Objectives:**
1. Sacralization of lumbar vertebrae
   a) Complete or incomplete
   b) Non-union of transverse process of L5 with S1
   c) Non-union of body of L5 with S1
   d) Non-union of lamina of L5 with S1
   e) Foramen/Cleft at the lamina of sacralized lumbar vertebra
2. Sacralization of coccygeal vertebrae
3. Lumbarization of S1 vertebra
4. Spina bifida
5. Variations in shapes of sacral hiatus
6. Number of sacral foramina

**II. Materials**

The study was carried out in 180 sacral vertebrae available in the Department of Anatomy in both Vinayaka Mission’s Kirupananda Vairity Medical College and Vinayaka Mission’s Homeopathy College, Salem, Tamil Nadu for a period of 2 months. A 12.5 megapixel camera was used to take the photographs and was documented in the computer. Sacrum with gross deformity was excluded from the study. The study was carried out after getting ethical clearance from the institution. The number of sacrum with variations in the present study is compared with the findings of other authors and is analyzed statistically for its relevance.

**III. Results And Observations**

**Examination of 155 dry Sacrum showed**

**Table-1: Sacralization Of Lumbar Vertebra**

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Variations</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Sacralization Of Lumbar Vertebra</td>
<td>36</td>
<td>23.22%</td>
</tr>
<tr>
<td>2.</td>
<td>Non-Union Of Transverse Process Of L5 With S1</td>
<td>Unilateral-5( Right) Unilateral-3 Bilateral-3</td>
<td>3.22%</td>
</tr>
<tr>
<td>3.</td>
<td>Non-Union Of Body Of L5 With S1</td>
<td>12</td>
<td>7.74%</td>
</tr>
<tr>
<td>4.</td>
<td>Non-Union Of Lamina Of L5 With S1</td>
<td>14</td>
<td>9.03%</td>
</tr>
<tr>
<td>5.</td>
<td>Foramen/Cleft At The Lamina Of Sacralized Lumbar Vertebra</td>
<td>Foramen-6 Cleft-8</td>
<td>3.87%</td>
</tr>
</tbody>
</table>

**Table-2: Variations Of Sacral Hiatus**

<table>
<thead>
<tr>
<th>Sl no</th>
<th>Shapes Of Sacral Hiatus</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Inverted U- shaped</td>
<td>39.35%</td>
</tr>
<tr>
<td>2.</td>
<td>Inverted V- shaped</td>
<td>16.77%</td>
</tr>
<tr>
<td>3.</td>
<td>Dumbbell shaped</td>
<td>5.09%</td>
</tr>
<tr>
<td>4.</td>
<td>Hiatus resembling foramen</td>
<td>0.64%</td>
</tr>
<tr>
<td>5.</td>
<td>Irregular</td>
<td>24.51%</td>
</tr>
<tr>
<td>6.</td>
<td>Absent</td>
<td>5.80%</td>
</tr>
</tbody>
</table>
Table-3: Variations In The Number Of Sacral Foramina

<table>
<thead>
<tr>
<th>Sl no</th>
<th>Number Of Sacral Foramina</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>3</td>
<td>1.93%</td>
</tr>
<tr>
<td>2.</td>
<td>4</td>
<td>55.48%</td>
</tr>
<tr>
<td>3.</td>
<td>5</td>
<td>31.61%</td>
</tr>
</tbody>
</table>

IV. Lumbarization Of Sacral Vertebrae-3(1.93%)
V. Sacralization Of Coccygeal Vertebrae-33(21.29%)
VI. Spina Bifida- 8(5.16%)

IV. Discussion

The prevalence of the lumbarization of first sacral vertebra varies from 4.2% to 9.2% in different populations by origin. The importance of the sacrum in the identification of an individual is well known. The sacrum is implicated in the determination of gender, age and stature. It has been studied extensively, probably because of its contribution to the pelvic girdle and the functional differences in the region between the sexes. Failure to recognize and to number lumbosacral transitional vertebra during spinal surgery may have serious consequences. Incorrect numbering can theoretically lead to problems with the administration of epidural or intradural anaesthetics in patients with LSTV.

Table-4: Comparison Of The Prevalence Of Lumbarization And Sacralization Of Sacral Vertebra Of Different Authors With The Present Study

<table>
<thead>
<tr>
<th>Prevalence rate</th>
<th>Present study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumbarization of first sacral vertebrae- 3.4-7.2%</td>
<td>1.93%</td>
</tr>
<tr>
<td>Sacralization of fifth lumbar vertebra varies -1.7% to 14%</td>
<td>23.22%</td>
</tr>
<tr>
<td>Sacralization of first coccygeal vertebra varies -7.8% to 37%</td>
<td>21.29%</td>
</tr>
</tbody>
</table>

The present study correlates with the study given by Sharma VA et al in 2011 of sacralization of first coccygeal vertebrae and falls within the range of 7.8%–37%. In the present study the prevalence rate of sacralization of fifth lumbar vertebra is 23.22% and is slightly higher as compared to Bron et al 2007.

Table-5: Shapes Of Sacral Hiatus

<table>
<thead>
<tr>
<th>Author</th>
<th>Sacral hiatus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinodkumar et al (1992)</td>
<td>Inverted V-78.23%, Inverted U-78.23%, Dumbbell shaped-7.43%</td>
</tr>
<tr>
<td>Aggarwal et al</td>
<td>Inverted U-40.35%</td>
</tr>
<tr>
<td>Kumar et al (2009)</td>
<td>Absent hiatus-0.99%</td>
</tr>
<tr>
<td>Nagar et al</td>
<td>Inverted U-41.51%</td>
</tr>
<tr>
<td>Njihia et al (2011)</td>
<td>Inverted V-32.1%</td>
</tr>
<tr>
<td>Present study</td>
<td>Inverted U-39.35%, Inverted V-16.77%, Dumbbell shaped-7.091%, Hiatus resembling foramen-0.64%, Irregular-24.51%, Absent-5.80%</td>
</tr>
</tbody>
</table>

Clinically, the study on the variations of sacral hiatus can help to identify the caudal epidural space in giving caudal epidural block by palpating the sacral cornu. So knowing the anatomical relations of the sacral hiatus will facilitate procedures like fluoroscopy.

The present study on the variations of the shapes of sacral hiatus correlates with the study given by Aggarwal et al. on inverted U-shaped(40.35%) sacral hiatus and Vinod Kumar et al on dumbbell shaped(7.43%) sacral hiatus.

V. Conclusion

Knowledge of variations of sacrum is important for spinal surgeons in giving epidural anaesthesia and lumbar puncture and to clinical anatomists, forensic experts and morphologists for determination of age, sex and stature. It is also important during reporting of CT and MRI and for the differential diagnosis of low backache. The present study on the variations of sacrum is of morphological significant and can help in dealing with clinical cases related to lumbosacral and sacro-coccygeal region and is useful for diagnostic and therapeutic purposes.
List Of Abbreviations-
LSTV- Lumbosacral transitional vertebrae
CT- Computerized Tomography
MRI- Magnetic Resonance Imaging

Competing Interest- The author(s) declare that they have no competing interests.

Author’s Contribution-
1. Dr. Diana Laishram- Data collection, conception and design, given final approval of the version to be published.
2. Dr. Aniruddha Ghosh- Analysis and interpretation of data.
3. Dr. Deepti Shastri- Involved in drafting the manuscript and revising it critically for important intellectual content.

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References

Figures-
Fig-1 Complete sacralization of lumbar vertebrae
Fig-2 Incomplete sacralization with non-union of transverse process of L5 with S1
A Study On The Variations Of Sacrum And Its Clinical Significance

Fig-3 Incomplete sacralization with non-union of transverse process, spine, laminae & articular facet of L5 with S1

Fig-4 Sacralization with non-union of body of L5

Fig-5 Sacralization with non-union of lamina & spine of L5

Fig-6 Foramen/Cleft at the lamina of sacralized lumbar

Fig-7 Lumbarization of sacral vertebrae

Fig-8 Sacralization of coccygeal vertebrae
Fig-9 Spina bifida

Fig-10 Inverted U-Shaped Sacral Hiatus

Fig-11 Inverted V-Shaped Sacral Hiatus

Fig-12 Dumbbell shaped Sacral Hiatus

Fig-12 Sacral Hiatus resembling foramen

Fig-13 Irregular Shaped Sacral hiatus
A Study On The Variations Of Sacrum And Its Clinical Significance

Fig-13 Sacral Hiatus Absent

Fig-14 3 Sacral Foramina

Fig-15 4 Sacral Foramina

Fig-16 5 Sacral Foramina