

Original Research Article

Incidence of complete agenesis of dorsal wall of sacral canal: study of dry human sacra

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ABSTRACT

Background: The human sacrum is a large, triangular shield-shaped bone formed by the fusion of five separate vertebrae along with the inter-vertebral discs. Gross morphology of sacrum shows a concave ventral surface, a convex dorsal surface and a triangular sacral canal. The sacral canal consists of an anterior wall formed by the fusion of the posterior aspect of the bodies of sacral vertebrae and the dorsal wall is formed by the fused laminae, spines and ossified ligamentum flava. Spina bifida is a developmental defect of sacral vertebrae, where the dorsal wall of sacral canal is partially or completely absent. The present study is an attempt to verify the incidence of complete agenesis of dorsal wall of sacral canal.

Methods: Eighty six dry human sacra were collected from the undergraduate students and department of anatomy of three different medical colleges of Uttar Pradesh for the study of dorsal wall of sacral canal.

Results: Out of eighty six bones studied, two (2.33%) of the bones showed complete absence of the dorsal wall of the sacral canal.

Conclusions: Complete agenesis of dorsal wall of sacral canal may lead to partial or complete failure of caudal epidural anaesthesia. Association between dorsal sacral agenesis and some other congenital malformations have also been reported by few authors. Anatomical knowledge of these variations of dorsal wall of sacral canal is important for anaesthetists, radiologists and spine surgeons.

Keywords: Sacrum, Sacral agenesis, Spina bifida, Caudal epidural anaesthesia

INTRODUCTION

The Sacrum is a large, triangular shield-shaped bony structure, at the base of the spine and at the upper and posterior part of the pelvic cavity. It forms a link between spine and a pair of hip bones, forming postero-superior wall of the pelvic cavity wedged between the two hip bones.¹ The sacrum forms the posterior pelvic wall and strengthens and stabilizes the pelvis. Joined at the very end of the sacrum are two to four tiny, partially fused vertebrae known as the coccyx or "tail bone". Gross morphology of sacrum shows a concave ventral surface, a convex dorsal surface and a sacral canal (vertebral canal of sacrum). The sacral canal consists of an anterior wall

formed by the fusion of the posterior aspects of sacral vertebral bodies and the dorsal wall is formed by the fused laminae, spines and ossified ligamentum flava. A median sacral crest is present along the midline of the dorsal wall of sacral canal, formed due to fusion of spinous processes of upper three or four sacral vertebrae. Lateral to the median sacral crest, intermediate and lateral sacral crest can be demonstrated; formed by the fusion of articular processes and transverse processes of sacral vertebrae respectively. The sacral canal runs throughout the greater part of the bone. Upper part of sacral canal is triangular in form, whereas in the lower part; its posterior wall is incomplete due to non-development of the laminae and the spinous processes. The sacral canal

lodges the sacral nerves, and its walls are perforated by the anterior and posterior sacral foramina through which ventral and dorsal ramus of these nerves pass out.

The opening present at the caudal end of sacral canal is known as sacral hiatus. It is formed due to failure of fusion of laminae of fifth (occasionally fourth) sacral vertebrae. It is located inferior to the fourth (or third) fused sacral spines at the lower end of median sacral crest. The sacral hiatus contains lower sacral and coccygeal nerve roots, filum terminale externum and fibro-fatty tissue. In recent state, the hiatus is covered by superficial posterior sacrococcygeal ligament which is attached to the margin of the hiatus. The deep posterior sacrococcygeal ligament is attached to the floor of sacral hiatus. Sacral hiatus have been utilized for administration of epidural/caudal anaesthesia in obstetrics as well as in orthopaedic practice for treatment and diagnosis.

Anatomical variations of the dorsal wall of sacrum are frequently found. Most of these variations are in relation to the sacral hiatus. However, many authors have reported the agenesis of dorsal wall of sacral canal (spina bifida) due to partial or complete failure of fusion of spinous processes and laminae of sacral vertebrae. Agenesis of dorsal wall of sacrum makes it difficult to locate the sacral hiatus for caudal epidural anaesthesia leading to failure of anaesthesia. Absence of the dorsal wall may be life threatening due to abnormal elongation of sacral hiatus causing puncture of the dural sac during introduction of anaesthetic drug. Another important aspect of agenesis of dorsal wall of sacrum is its association with various anorectal malformations. Anatomical knowledge of these sacral variations is important for interpretations of sacral radiographs.

Spina bifida is one of the most serious developmental defects of vertebrae, due to imperfect fusion or non-union of vertebral arches. It may involve only the vertebral arches, leaving the spinal cord intact; known as spina bifida occulta. A more severe form is spina bifida cystica, which involves vertebral arches and neural tube; exposing the neural tissue. Spina bifida occulta results due to failure of fusion of one or more neural arches of the developing vertebrae during the fourth week of development.² Spina bifida occulta occurs most commonly in sacral region.³ The occurrence of spina bifida occulta in sacral region spreading from S1 to S5 has been termed as sacral spina bifida occulta (SSBO). In most severe form of sacral spina bifida occulta, the dorsal wall of sacral canal is completely open.⁴ The present study is an attempt to verify the incidence of complete agenesis of dorsal wall of sacral canal in dry human sacra.

METHODS

Current study was conducted in the department of anatomy of Mayo institute of medical sciences, Barabanki, Uttar Pradesh. For study purpose, eighty six

dry human sacra were collected from the undergraduate students and department of anatomy of three different medical colleges of Uttar Pradesh. These bones were collected from the department of anatomy of Major SD Singh medical college (Farrukhabad), Krishna Mohan medical college (Mathura) and Mayo institute of medical sciences (Barabanki) over a period of four years from March 2016 to February 2020. A descriptive osteological study was done to observe the features of dorsal wall of sacrum.

Inclusion criteria

Eighty six dry adult sacra of all ages were included, irrespective of their sex. Bones with normal five segments were included in this study. Bones included were free of any signs of fracture.

Exclusion criteria

Sacra having some parts broken or showing some loss of osseous material have been excluded from study. Sacrum with any sign of fracture or showing features of sacralisation or lumbarisation was excluded from the study.

RESULTS

Out of these eighty six sacra, two bones (2.33%) were found with complete absence of dorsal wall of sacral canal (Figure 1 and Figure 2). Ventral wall of sacral canal of these two bones were normal and there were no features of lumbarisation or sacralisation. Photographs of dorsal surface of these two bones were taken using digital camera. Photographs of the dorsal surface of some of the normal sacra were also taken. Data was collected and statistical analysis was done in the form of simple percentage of the bones with complete agenesis of dorsal wall of sacral canal.



Figure 1: Complete agenesis of dorsal wall of sacral canal.

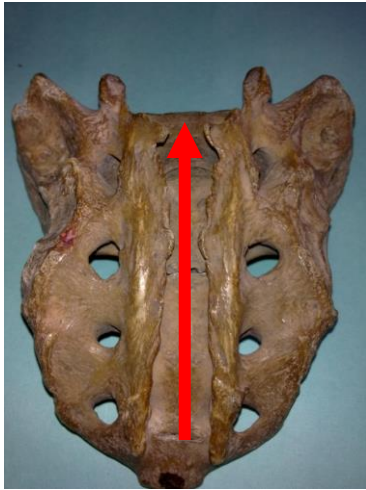


Figure 2: Complete agenesis of dorsal wall of sacral canal

DISCUSSION

Variations in the dorsal wall of sacrum have been reported by many authors ranging from elongated sacral hiatus to complete agenesis of dorsal wall of sacral canal. Incidence of complete agenesis of dorsal wall of sacral canal varies from 1.33% to 4.4% in studies done by various authors (Table 1). Singh classified these variations of dorsal wall of sacrum i.e. sacral spina bifida occulta into five types as; type I with completely open sacral canal, type II below S1 down to S5, type III below S2 down to S5, type IV below S3 down to S5 and type V S1 to S2 open with normal sacral hiatus at the apex of sacrum.⁴ According to this classification complete agenesis of dorsal wall of sacral canal is classified as sacral spina bifida occulta type 1. Singh reported complete agenesis of dorsal wall of sacral canal in 1.4% of sacra in her study.

Table 1: Incidence of complete agenesis of dorsal wall of sacral canal reported by various authors.

Authors	Year of study	No. of dry bones	Incidence of sacral agenesis, N (%)
Singh⁴	2013	140	2 (1.4)
Shinde et al⁵	2018	300	4 (1.33)
Nagendrappa et al⁶	2014	100	3 (3)
Saha et al⁷	2016	125	2 (1.6)
Aragao et al¹³	2019	45	2 (4.4)
Present study	2020	86	2 (2.33)

Shinde et al performed a study of dry sacral bones in maharashtrian population and noted complete dorsal agenesis in 1.3% of bones.⁵ They performed their study with 300 dry sacrum from Maharashtrian population and suggested that caudal anaesthesia can be done under fluoroscopic or ultrasound guidance for a better outcome.

This will avoid partial block or failure of anaesthesia in patients with elongated sacral hiatus or dorsal wall agenesis. Nagendrappa et al reported complete agenesis of dorsal wall of sacrum in 3% of bones, higher than the incidence reported in our study.⁶

In another study done by Saha et al in West Bengal population, 1.6% of sacrum with complete spina bifida is seen.⁷ They mentioned importance of the anatomical knowledge of these variations of sacrum to diagnose low back pain. Banerjee et al, Swathi et al and vanitha et al also reported incidental findings of complete agenesis of dorsal wall of sacral canal during routine osteology classes for undergraduate students.⁸⁻¹⁰

In present study, incidence of complete agenesis of dorsal wall of sacrum was 2.33%, which comes under the range of incidence reported by previous authors. Agenesis of dorsal wall of sacrum occurs due to failure of the fusion of sacral lamina to form median sacral crest. Development of vertebral column occurs from sclerotome portion of the somites. Partial or complete agenesis of dorsal wall of sacrum i.e. spina bifida occulta occurs due to defect in the union of lamina with the spinous process. This defect is more common in sacral region. In present study, both of the bones carry some part of the lamina, but they fail to fuse with the spinous process forming the median sacral crest. Various genetic and environmental factors account for neural tube defects. Mutations of sonic hedgehog, homeobox and VANGL proteins are attributed to these defects. Alteration in signaling of sonic hedgehog gene leads to faulty induction of vertebra formation by the underlying notochord. Homeobox genes patterns the vertebra, their mutation can cause failure of the proper formation of a part of it. Recently mutation of VANGL genes have been identified and associated with familial cases of neural tube defects. VANGL gene regulates the process that lengthens the neural tube and is necessary for normal closure to occur.³ Pax2 gene is required for the formation of neural arch. Mutation in the expression of Pax2 gene may leads to non-development of laminae. Reduced activity of BMP gene had also been reported to be associated with complete agenesis of dorsal wall of sacral canal.⁶

Spina bifida occulta, is usually clinically insignificant, presents as an isolated finding in up to 20% of radiographically examined vertebral columns.² Most people are unaware that they have this vertebral defect because it produces no symptoms unless it is associated with an abnormality of the spinal nerve roots. On the other hand, it may be associated with severe deficits like backache, lower limb and bladder or bowel affections due to injury to sacral nerves by external trauma. These sacral vertebral defects have been seen in children with anorectal malformations.¹¹ About one third of patients with anorectal anomalies have been recognized to have sacral malformation by ultrasonography or magnetic resonance imaging scans.¹²

The detailed study of dorsal wall of sacrum is of great relevance, since this route is frequently utilized for caudal epidural anaesthesia for the diagnosis and treatment of lumbar spine disorders and various other surgeries. The knowledge of sacral anatomy is also important for epidural analgesia. A spinal needle is introduced through sacral hiatus to introduce analgesic and anaesthetic drugs for distribution in epidural space. Anatomical variations of dorsal wall of sacrum make it difficult to localize caudal epidural space. In complete agenesis of dorsal wall of sacral canal, caudal epidural anaesthesia is possible but it carries the risk of life threatening complications like puncture of dural sac.

CONCLUSION

Anatomical variations of dorsal wall of sacrum are fairly common. Knowledge of these variations is useful for anesthesiologists, radiologists and spine surgeons. Complete agenesis of dorsal wall of sacral canal may lead to failure of caudal epidural anaesthesia. Life threatening complications of dural sac puncture may also be associated with caudal epidural anaesthesia in persons with complete agenesis of dorsal wall of sacral canal. Complete spina bifida occulta is an incidental finding, but whenever found; possibility of some anorectal malformations must be kept in mind. Complete dorsal sacral agenesis may be associated with severe deficits like backache, lower limb and bladder or bowel affections due to injury to sacral nerves by external trauma. The present study has been done from dry bones, but clinical implications of these variations have been brought about by clinical cases and associated pathological conditions.

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