International Journal of Anatomy and Research,
Int J Anat Res 2025, Vol 13(4):9381-86. ISSN 2321-4287
DOI: https://dx.doi.org/10.16965/ijar.2025.252

Original Research Article

A Radiological Study for Assessing the Prevalence of Dorsal Wall Agenesis of the Sacral Canal with Concomitant Developmental Anomalies in Other Organs

Dibendu Ghosh *[1], Anandi S [2], Ashok Narayan S H [3], Debasis Bandyopadhyay [4], Gaurav Daniel [5], Saurav Dhand [6].

[*1] Assistant Professor, Dept of Anatomy, Armed Forces Medical College, Pune, Maharashtra, India.
ORCiD: 0009-0008-9605-8915
[2] Assistant Professor, Dept of Anatomy, Armed Forces Medical College, Pune, Maharashtra, India.
ORCiD: 0009-0000-0495-6526
[3] Assistant Professor, Dept of Radiology, 151 Base Hospital, Guwahati, Assam, India. **ORCiD:** 0000-0001-8748-6610
[4] Professor and Head, Dept of Anatomy, Armed Forces Medical College, Pune, Maharashtra, India.
ORCiD: 0009-0009-4269-1851
[5] Junior Resident, Dept of Anatomy, Armed Forces Medical College, Pune, Maharashtra, India.
ORCiD: 0009-0001-3762-7320
[6] Junior Resident, Dept of Anatomy, Armed Forces Medical College, Pune, Maharashtra, India.
ORCiD: 0009-0002-8755-3136

ABSTRACT

Background: The sacral canal is a component of the vertebral canal located within the sacrum. Aberrations in the embryogenesis of the sacrum can result in multiple vertebral anomalies. Complete non-fusion of the sacral spinous process, leading to an open dorsal wall of the sacral canal, can occur independently or be associated with other developmental anomalies. Our study aimed to ascertain the prevalence of open sacral canals within the western Maharashtrian population, as well as to demarcate the spectrum of concomitant embryological anomalies observed in individuals exhibiting this morphological variation.

Methodology: This retrospective study analysed 200 samples, including 106 males and 94 females, using computed tomographic (CT) sacral images collected over a 36-month period. The study assessed the prevalence of an open sacral canal. Simultaneously, individuals with positive findings on CT images were also corroborated for the presence of additional developmental anomalies documented in the respective CT images.

Results: This study showed the prevalence of an open sacral canal in 3 out of 200 CT images. Individuals with positive findings on the CT also exhibited additional abnormalities. A 48-year-old female had a right-sided hypoplastic kidney and type IV lumbosacral transitional vertebra (LSTV) according to Castellvi's classification. An 88-year-old male presented with an ectopic kidney (pelvic kidney) and renal calculi. A 26-year-old male showed spina bifida at the 5th lumbar vertebra, an extrarenal pelvis (right), and pelvic ureteric junction obstruction with hydronephrosis (left).

Conclusions: The present study revealed a prevalence of 1.5% for the complete absence of the dorsal wall of the sacral canal. Furthermore, it revealed the presence of additional developmental anomalies in adjacent vertebrae and kidneys. It is essential to confirm a prior diagnosis of complete absence of the dorsal wall of the sacral canal during the pre-anaesthesia check, as this condition absolutely contraindicates the use of caudal epidural anaesthesia. All sacral vertebral anomalies require a comprehensive evaluation to rule out other developmental anomalies, particularly renal anomalies.

KEY WORDS: Open Sacral Canal, Lumbosacral Transitional Vertebra, Renal Anomaly.

Corresponding Author: Dr. Dibendu Ghosh, Assistant Professor, Department of Anatomy, Gate no. 4, Armed Forces Medical College, Near Race Course, Pune-Solapur highway road, Pune, Maharashtra, 411040, India. **E-Mail:** dib_dev2005@yahoo.com

Access this Article online	Journal Information
Quick Response code	**International Journal of Anatomy and Research**
	ISSN (E) 2321-4287 | ISSN (P) 2321-8967
	https://www.ijmhr.org/ijar.htm
	DOI-Prefix: https://dx.doi.org/10.16965/ijar
DOI: 10.16965/ijar.2025.252	**Article Information**
	Received: 30 Aug 2025 — Accepted: 15 Nov 2025
	Peer Review: 03 Sep 2025 — Published (O): 05 Dec 2025
	Revised: 15 Sep 2025 — Published (P): 05 Dec 2025

BACKGROUND

Embryogenesis of the sacrum occurs from the sclerotome and passes through three phases: pre-cartilaginous phase, chondrification/cartilaginous phase, and ossification phase. During the cartilaginous phase, the chondrification center appears during the 6th week [1]. During the ossification phase, each vertebra develops from four primary centers and five secondary centers. Deviation/aberration in the embryogenesis of the sacral sclerotome can result in various sacral anomalies. The present study focuses on identifying the prevalence of complete absence of the dorsal wall of the sacral canal and other associated developmental anomalies.

The mechanisms of various sacral anomalies are as follows:

Spina Bifida: Normally, the centrum has two primary centers, which eventually fuse to form a single primary center for the centrum. Each neural arch develops from one primary center. Failure of embryonic fusion of the two halves of the neural arches results in spina bifida

Hemi Vertebra: Each vertebra develops from two chondrification centers. The non-appearance of one of these centers leads to a Hemivertebra.

Lumbarisation of the first sacral vertebra: Fusion of the first sacral vertebra with the fifth lumbar vertebra. The first sacral vertebra remains separate from the rest of the sacrum

Spondylolisthesis: Displacement of the vertebral body caused by failure in the formation of articular facets.

METHODS

The present study is a retrospective study conducted on 200 samples (106 males and 94 females) computed tomographic (CT) sacral images in the Department of Anatomy/ Radiology, Medical College in western Maharashtra between February 2023 to February 2025. Ethical approval for the study was obtained from the institutional ethical committee.

Inclusion and Exclusion Criteria: The computed tomographic images of the pelvic region of both males and females, which accurately displayed the dorsal surface of the sacrum, were included in the study. CT images with incomplete sacral exposure were excluded from the analysis.

Data Analysis: IBM Statistical Package for the Social Sciences (SPSS), version 23, was used for the current study. With a confidence level of 95% and a P value of < 0.05, it was considered statistically significant.

Sample size: The sample size was calculated using the prevalence formula. With Z = 1.96 (95% confidence interval), p = 0.193 (1.93%), and d = 0.05 (5%), the required sample size is 29, based on the study by Evangelos N et al. [2]. The current study was carried out on 200 samples (200 CT images were studied).

Methodology: 200 CT images of the sacrum were analysed to determine the prevalence of complete absence of the dorsal wall of the sacral canal and other associated developmental anomalies using a 16-row detector CT scanner (Somatom Emotion, Siemens, Germany).

RESULTS

The present study showed that the prevalence of an open sacral canal/absent dorsal wall of the sacral canal was 3 in 200 CT images. Individuals with an absent dorsal wall of the sacral canal on the CT also exhibited additional findings.

1. A 48-year-old female had a hypoplastic right kidney and a type IV lumbosacral transitional vertebra (LSTV) according to Castellvi's classification. [Figure: 1-3]

2. An 88-year-old male presented with abdominal pain. Oblique coronal reformatted CECT of the abdomen showed renal calculi and an ectopic kidney (pelvic kidney). [Figure 4 and 5]

3. A 26-year-old male exhibited spina bifida at the 5th lumbar vertebra, an extrarenal pelvis (right) and pelvic ureteric junction obstruction with hydronephrosis (left). [Figure 6 and 7]

DISCUSSION

The sacrum is an irregular bone, is formed by the fusion of five sacral vertebrae. The foramina and the laminae of all sacral vertebrae undergo fusion during the development of the sacrum, collectively forming the sacral canal. This sacral canal serves as a passage for the cauda equina, sacral nerve roots, and filum terminale [3].

Case 1: (48-year-old Female)

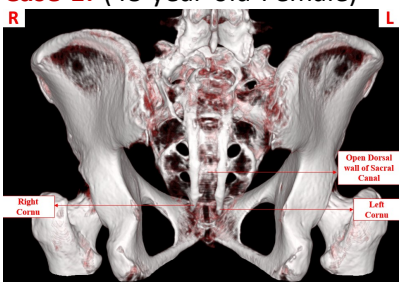

Fig 1: VRT Image showing the Unfused dorsal wall of the sacral canal.

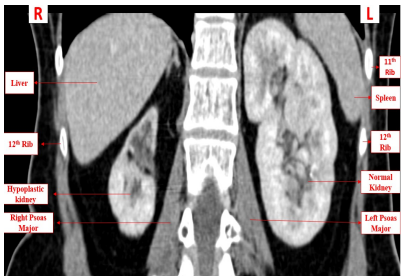

Fig 2: Coronal Reformatted CECT Image Showing Hypoplastic Kidney (Right) With Compensatory Hypertrophy of Left Kidney.

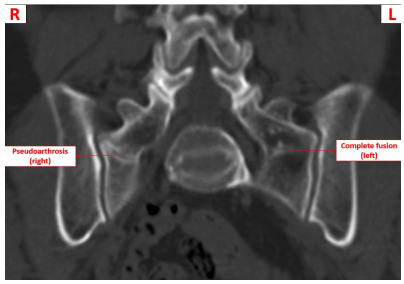

Fig 3: Coronal Reformatted image of LS Spine Bone Window Showing Type IV LSTV

Case 2: (88-year-old Male)

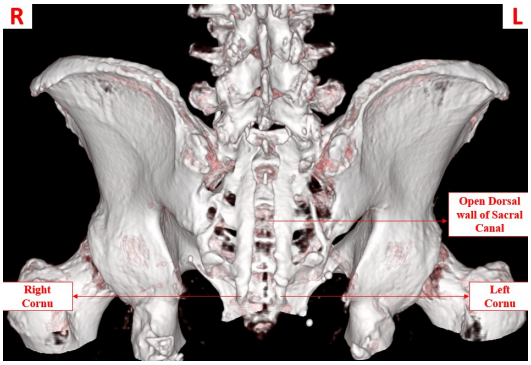

Fig 4: VRT Image showing Unfused dorsal wall of sacral canal.

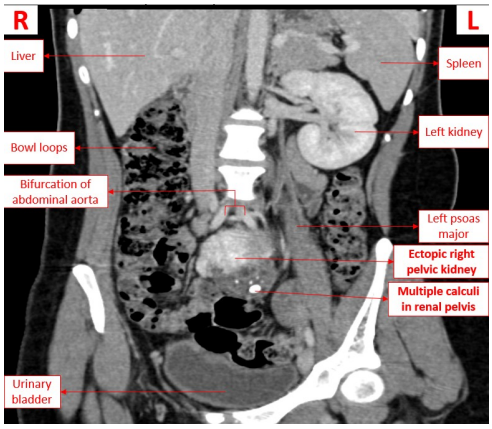

Fig 5: Oblique Coronal Reformatted CECT Abdomen Showing Ectopic Right Kidney (Pelvic Kidney) associated with multiple non-obstructive calculi in the right renal pelvis.

Case 3: (26-year-old Male)

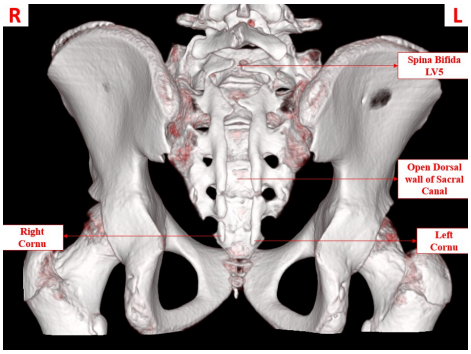

Fig 6: VRT Image showing Unfused dorsal wall of sacral canal.

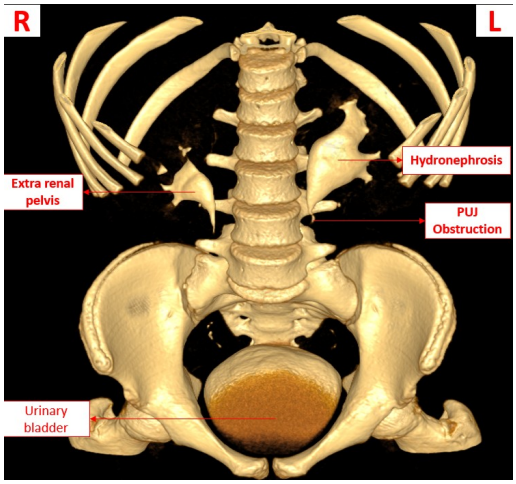

Fig 7: VRT image of CT urography showing -Extrarenal pelvis (right) -PUJ Obstruction with Hydronephrosis (Left)

(R – Right, L - Left)

Failure of embryonic fusion of the two halves of the neural arches results in spina bifida. Non-fusion of all neural arches from S1 to S5 leads to an open dorsal wall of the sacral canal. The present study revealed a prevalence of 1.5% (3 in 200 CT sacral images) for an unfused dorsal wall of the sacral canal, as determined by CT scans; a comparison table is presented in **Table 1**. Additionally, all three individuals with unfused dorsal walls of the sacral canal on CT images also had other associated anomalies.

Table 1: Prevalence of absent dorsal wall of the sacral canal in various studies.

Author	Sample Size	Prevalence %
Kumar et al. 1992 [4]	202	1.49
Nagar SK et al. 2004 [5]	263	1.5
Senoglou et al. 2005 [6]	96	2.08
Patel et al. 2011 [7]	150	2
Kiran et al. 2011 [8]	50	2
Singh R et al. 2013 [9]	140	1.4
Saha D et al. 2016 [10]	125	1.6
Punja et al. 2021 [11]	50	2
Abera et al. 2021 [12]	61	1.63
Evangelos N et al 2024 [2]	155	1.93
Present study	**200**	**1.5**

Case 1: A 48-year-old female additionally showed a right-sided hypoplastic kidney and Type IV LSTV

Renal hypoplasia is classified into three types: simple, oligo-meganephronic and segmental hypoplasia [13]. Simple hypoplasia is defined as a 50% reduction in the weight of the kidney, which more often results in hypertension. Oligo-meganephronic hypoplasia is characterized by fewer but enlarged nephrons. Segmental hypoplasia is characterized by hypoplastic blood vessels and widely spaced collecting ducts [14].

The lumbosacral transitional vertebra (LSTV) includes lumbarization of the sacral vertebra and sacralization of a lumbar vertebra, with prevalence ranging from 4% -30% [15]. According to Castellvi's Classification [16], lumbosacral transitional vertebrae (LSTV) are classified into four types: -

Type I: Enlarged and dysplastic transverse process (at least 19 mm)

Type II: Pseudo articulation of the transverse process and sacrum with incomplete lumbarization/ sacralization; enlargement of the transverse process with pseudoarthrosis

Type II A: Unilateral

Type II B: Bilateral

Type III: Transverse process fuses with the sacrum and there is complete lumbarization/ sacralization, enlarged transverse process with complete fusion

Type III A: Unilateral

Type III B: Bilateral

Type IV Involves a unilateral type II transition with a type III on the contralateral side.

This individual, in addition to the non-fused dorsal wall sacral canal, showed simple renal hypoplasia and type LSTV IV (Type II A on the right and type III A on the left side)

Case 2: An 88-year-old male presented with an ectopic kidney and calculi. The kidney and ureter develop from the metanephric blastema and the ureteric bud. During its initial stages of embryogenesis, the kidney is located in the sacral region and gradually ascends to its definitive adult position in the lumbar region. Failure of the ascent of the kidney to its definitive position results in an ectopic kidney. The ectopic kidney can be located within the pelvis or as high as the thoracic region, and it continues to receive blood supply from its transitory blood vessels [17]. An ectopic kidney may be asymptomatic or may present with recurrent urinary tract infections or renal calculi.

This individual, identified with the absent dorsal wall sacral canal, also exhibited the presence of an ectopic kidney (pelvic kidney) with calculi in the renal pelvis.

Case 3: A 26-year-old male displayed spina bifida at the 5th lumbar vertebra, an extrarenal pelvis (right), and pelvic ureteric junction obstruction with hydronephrosis (left).

Non-fusion of the neural arches of the 5th lumbar vertebra causes spina bifida at LV 5. Spina bifida is generally classified into spina bifida occulta and spina bifida cystica. In spina bifida occulta, there is no protrusion of the meninges or spinal cord; however, in spina bifida cystica, there is a protrusion of the meninges only, leading to meningocele, or a protrusion of both the meninges and spinal cord, resulting in meningomyelocele.

Extrarenal pelvis is a pelvis predominantly outside the renal sinus, and it is larger and more distensible than an intrarenal pelvis; its incidence rate is approximately 10% [18].

Pelviureteric junction (PUJ) obstruction is a common urological condition with an unknown incidence among adults [19]. The cause of PUJ obstruction can be intrinsic, such as stenosis, or extrinsic, caused by crossing accessory vessels [20]. PUJO can lead to congenital hydronephrosis or may remain asymptomatic and be detected incidentally during adulthood [21].

Considering that the spinal cord terminates at the level of the L2 vertebra, the complete absence of the dorsal wall of the sacral canal does not contribute to medical conditions. However, it plays a significant role in caudal epidural anaesthesia, urological surgeries, and other related procedures.

The dorsal surface of the sacrum provides attachment for multiple muscles, such as multifidus and erector spinae; in the completely absent dorsal wall of the sacral canal, the area for muscular attachment is drastically reduced, which causes persistent low back ache [9].

Caudal epidural anaesthesia (CEA) is frequently used in paediatric and gynaecological surgeries. The procedure for CEA involves positioning the patient in a lateral decubitus position, then palpating the apex of the sacral hiatus and the lower ends of the sacral cornua, which define the lateral boundaries of the sacral hiatus, followed by a caudal puncture [22]. The absence of a dorsal wall in the sacral canal makes administering CEA more challenging.

A study by Galloway et al. [23] found a higher number of sacral spina bifida occulta cases in a small group of adults with lower urinary tract problems, such as detrusor hyperreflexia during filling, low bladder compliance and impaired bladder sensation.

Limitation: The present study was conducted on CT images of population which were a subset of the western Maharashtra population. So, the current study results cannot be generalised to the entire population.

CONCLUSION

The current study reported a 1.5% prevalence of complete absence of the dorsal wall of the sacral canal. It also revealed the presence of other developmental anomalies in the adjacent vertebrae and kidneys of individuals with an absent dorsal wall of the sacral canal. Therefore, it is crucial that all sacral vertebral anomalies undergo thorough assessment to identify additional developmental issues, particularly renal anomalies.

ABBREVIATIONS:

CT- Computed Tomographic
LSTV- Lumbosacral Transitional Vertebra
PUJ- Pelviureteric Junction
PUJO- Pelviureteric Junction Obstruction
CEA- Caudal Epidural Anaesthesia

Source(s) of support: No funding from any source.

Competing Interest: Nil

Author Contribution: All authors have contributed equally to the conception, data analysis, and writing of the current study and have approved the final version of the manuscript.

REFERENCES

[1]. Moore KL and Persaud TVN. The developing human. Clinically oriented embryology (11th ed). Philadelphia: WB Saunders 2018; 315-332.
[2]. Evangelos N, Gregory T, Valeria K, et al. Complete Dorsal Wall Agenesis of the Sacral Canal in a Greek Population: An Osteological Study. Folia Medica 2024; 66(3):386-394 https://doi.org/10.3897/folmed.66.e118790 PMid:39365624
[3]. Standring S, Gray's Anatomy: The anatomical basis of clinical practice. 42nd ed. London. Churchill Livingstone/ Elsevier 2021;1259-1292
[4]. Kumar V, Pandey SN, Bajpai PN, et al. Morphometrical study of sacral hiatus. J Anat Soc India 1992; 41(1):7-13.
[5]. Nagar SK. A study of sacral hiatus in dry human sacra. J Anat Soc India 2004; 53(2):18-21.
[6]. Senoglu N, Senoglu M, Oksuz H, et al. Landmarks of the sacral hiatus for caudal epidural block: an anatomical study. BJA 2005; 95(5):692-5. https://doi.org/10.1093/bja/aei236 PMid:16155035
[7]. Patel ZK, Thummar B, Rathod SP, et al. Multi-centric morphometric study of dry human sacrum of Indian population in Gujarat region. NJIRM 2011; 2:31-5.
[8]. Kiran VP, Bhusareddi PS, Harsh MP, et al. Agenesis of dorsal wall of sacral canal. Anatomica Karnataka 2011; 5(1):69-71.
[9]. Singh R. Classification, causes and clinical implications of sacral spina bifida occulta in Indians. Basic Sci Med 2013; 2(1):14-20. https://doi.org/10.1096/fasebj.27.1_supplement.746.15
[10]. Saha D, Bhadra RC. Morphometric study of complete agenesis of dor¬sal wall in dry human sacrum in West Bengal population. Indian J Basic Appl Med Res 2016; 6(1):226-30.
[11]. Punja R, Sumalatha S, Afrah F, et al. Clinically relevant morphometry of sacral hiatus and morphology of sacrum. Turk Neurosurg 2021; 33(3). https://doi.org/10.5137/1019-5149.JTN.35322-21.4 PMid:37222010
[12]. Abera Z, Girma A, Bekele A, et al. Assessment of morphological and morphometrical variations of sacral hiatus in dry human sacrum in Ethiopia. Local and Regional Anesthesia 2021; 14:25-32. https://doi.org/10.2147/LRA.S277556 PMid:33658843 PMCid:PMC7917331
[13]. Bonsib, S.M. Renal Hypoplasia, From Grossly Insufficient to Not Quite Enough: Consideration for Expanded Concepts Based Upon the Author's Perspective With Historical Review. Adv. Anat. Pathol 2020; 27, 311 https://doi.org/10.1097/PAP.0000000000000269 PMid:32520748 PMCid:PMC7458098
[14]. Shindo S.; Bernstein J, Arant B.S. Evolution of renal segmental atrophy (Ask-Upmark kidney) in children with vesicoureteric reflux: Radiographic and morphologic studies. J. Pediatr. 1983; 102:847-854.

https://doi.org/10.1016/S0022-3476(83)80010-9 PMid:6854447

[15]. Bron JL, van Royen BJ, Wuisman PI. The clinical significance of lumbosacral transitional anomalies. Acta Orthop Belg 2007; 73:687-95

[16]. Castellvi AE, Goldstein LA, Chan DP. Lumbosacral transitional vertebrae and their relationship with lumbar extradural defects. Spine 1984; 9:493-95 https://doi.org/10.1097/00007632-198407000-00014 PMid:6495013

[17]. Collura G, De Dominicis M, Patricolo M, Caione P. Hydronephrosis due to malrotation in a pelvic ectopic kidney with vascular anomalies. Urol Int 2004;72(4):349-351. https://doi.org/10.1159/000077692 PMid:15153737

[18]. Brant, W. E., and C. A. Helms. 2007. Fundamentals of diagnostic radiology. Lippincott Williams & Wilkins, Philadelphia, PA, USA. 19106 ISBN: 10: 0-7817-6135-2

[19]. Pickersgill NA, Wright AJ, Figenshau RS. Ureteropelvic junction obstruction caused by metastatic cholangiocarcinoma. Int Braz J Urol 2019; 45(6):1266-1269. https://doi.org/10.1590/s1677-5538.ibju.2019.0053 PMid:31808416 PMCid:PMC6909870

[20]. Anderson KR, Weiss RM. Physiology and evaluation of ureteropelvic junction obstruction. J Endourol 1996;10(2):87-91. https://doi.org/10.1089/end.1996.10.87 PMid:8728672

[21]. Williams B, Tareen B, Resnick MI. Pathophysiology and treatment of ureteropelvic junction obstruction. Curr Urol Rep 2007; 8(2):111-117. https://doi.org/10.1007/s11934-007-0059-8 PMid:17303015

[22]. Bagheri H, Govsa F. Anatomy of the sacral hiatus and its clinical rel¬evance in caudal epidural block. Surg Radiol Anat 2017; 39:943-51. doi: 10.1007/s00276-017-1823-1 https://doi.org/10.1007/s00276-017-1823-1 PMid:28247084

[23]. Galloway NT, Tainsh J. Minor defects of the sacrum and neurogenic bladder dysfunction. Br J Urol 1985; 57(2):154-5. https://doi.org/10.1111/j.1464-410X.1985.tb06410.x PMid:3986449

How to cite this article:

Dibendu Ghosh, Anandi S, Ashok Narayan S H, Debasis Bandyopadhyay, Gaurav Daniel, Saurav Dhand. A Radiological Study for Assessing the Prevalence of Dorsal Wall Agenesis of the Sacral Canal with Concomitant Developmental Anomalies in Other Organs. Int J Anat Res 2025;13(4):9381-9386. **DOI:** 10.16965/ijar.2025.252