Original Article

Prevalence of occult spina bifida in isthmic versus degenerative spondylolisthesis: retrospective radiographic review of consecutive surgical patients

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Background: Spondylolisthesis is defined as the anterior or posterior translation of one vertebral body over another. Spina bifida occulta (SBO) is a developmental anomaly characterized by the incomplete fusion of the laminae of one or more vertebral arches along the midline. Currently, there is no documented prevalence of SBO in patients with degenerative spondylolisthesis (DS) undergoing spinal surgery. This study aims to estimate the prevalence of SBO in patients with DS undergoing spine surgery and compare it with that in patients with isthmic spondylolisthesis (IS) undergoing surgery.

Methods: Our study is a cross-sectional retrospective review of consecutive patient records from two major tertiary hospitals in Sydney, Australia, covering the period from January 1st, 2015 to December 31st, 2023. Patients diagnosed with spondylolisthesis at spinal levels L4/L5 or L5/S1 were identified and screened for the presence of SBO.

Results: Among the patients who underwent spinal surgery, 23.4% were found to have spondylolisthesis due to either degenerative changes or isthmic pars defects at L4/L5 or L5/S1. Within the DS group, the prevalence of SBO was 11.9% (all at the S1 level), while 24.7% of the IS group exhibited SBO. The male-to-female ratio for patients with IS and SBO was 3.6:1, compared to 0.66:1 for those with DS and SBO.

Conclusions: SBO is a frequently overlooked anatomical variation in adult spine surgery, particularly in cases of degenerative and IS. With a prevalence of 11.9% in DS, it is crucial for spine surgeons to be vigilant, especially during open posterior lumbar spine fusion surgeries, to prevent unintended durotomy and neurological damage. Awareness of the absence of the S1 spinous process is essential for effective surgical planning, particularly when using navigated spinous process clamps for pedicle screw placement.

Keywords: Spina bifida occulta (SBO); degenerative spondylolisthesis (DS); isthmic spondylolisthesis (IS)

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Introduction

Background

The term spondylolisthesis originates from the Greek words "spondylos", meaning vertebra, and "olisthánein" meaning "to slip" (1). It broadly refers to the displacement of one vertebral body over another. In 1976, Wiltse *et al.* (2) classified spondylolisthesis into five categories: dysplastic, isthmic, degenerative, traumatic, and pathological. Epidemiological data on spondylolisthesis varies widely, with reported prevalence ranging from 2.7% to 28% (3,4), influenced by factors such as age, sex, and whether the population is symptomatic or asymptomatic. Spina bifida occulta (SBO) is the most benign form of spina bifida, involves the failure of the laminae to fuse. The prevalence of SBO in adults can be as high as 12.4% (5). While a correlation between SBO and spondylolysis is recognized with prevalence ranging from 22–70% (6), the prevalence of SBO in patients with degenerative spondylolisthesis (DS) undergoing surgery remains unreported. The most common levels of spondylolisthesis are L4/L5 and L5/S1 (4) and whence we elected to only include those levels in our study.

Rationale and knowledge gap

Recognizing SBO during surgical procedures is crucial to mitigate the risk of unintended durotomy and injury to neural elements due to unrecognized bony defects. With the advent of navigated instrumentation and spinal process clamps, awareness of the absence of the spinous process is vital for effective surgical planning. There is no reported prevalence of SBO in a surgical cohort with DS.

Objective

This study aims to quantify the prevalence of SBO in a cohort of surgical patients with either DS or isthmic spondylolisthesis (IS). Most existing studies on spondylolisthesis prevalence focus on asymptomatic populations, neglecting symptomatic surgical cohorts. Our research seeks to raise awareness of SBO and quantify its prevalence among patients treated for symptomatic lower back pathology, categorizing them based on degenerative versus IS and the presence or absence of SBO. We present this article in accordance with the STROBE reporting checklist (available at https://jss.amegroups.com/article/view/10.21037/jss-24-151/rc).

Highlight box

Key findings

- Prevalence of spina bifida occulta with spondylolisthesis is 14.9%.
- Prevalence of spina bifida occulta with degenerative spondylolisthesis 11.9%.
- Prevalence of spina bifida occulta with isthmic spondylolisthesis is 24.7%.

What is known and what is new?

- Prevalence of spina bifida occulta in the general population ranges 7.4–12.4%.
- Prevalence of spina bifida occulta in a surgical cohort focused on the L4–S1 levels is 14.9%.

What is the implication, and what should change now?

- Increased awareness of this occult condition to help plan safe surgery on the lumbar spine.
- Careful examination of pre-operative imaging for patients planned for surgery on the lower lumbar spine screening for spina bifida occulta.

Methods

We performed a cross-sectional retrospective review of patient records from two tertiary hospitals in Sydney (Nepean Public Hospital and Westmead Public Hospital), covering surgeries conducted between January 1st, 2015 and December 31st, 2023. Surgeries were performed by both neurosurgeons and orthopaedic spine surgeons. Inclusion criteria included patients aged over 18 years who underwent surgery at spinal levels L4–S1, with imaging available for review. Exclusion criteria encompassed surgeries at levels other than L4–S1, surgeries conducted prior to the study period, unavailability of imaging, and spondylolisthesis due to causes other than degenerative or isthmic factors, spondylolisthesis at level other than L4–S1 (*Table 1*). Patients' electronic medical records were accessed, and baseline demographic data (age, sex) were collected. Imaging [X-rays, computed tomography (CT), magnetic resonance imaging (MRI)] was reviewed for the presence of spondylolisthesis, its level, aetiology (based on Wiltse classification), grade (according to Meyerding grading), and presence of SBO and its level. Other pathologies like spinal lipoma, limited dorsal myeloschisis and dermal sinus were screened for. Most patients' images were available on the hospitals Picture Archiving and Communication System (PACS); however, some patients had their images done at private radiology providers outside the hospital PACS.

Table 1 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Surgery performed between January 1st, 2015 and December 31st, 2023	Any patient who had surgery prior to January 1st, 2015
Spondylolisthesis due to isthmic spondylolysis or degenerative spondylolisthesis	Spondylolisthesis from other causes: traumatic, dysplastic, tumour, post operative, infection
Images available to review	Images unavailable for assessment

For those patients the individual radiology provider was contacted for access to patients scans. The authors (A.A.W., Y.L.) reviewed the images, consulting reporting radiologists in cases of disagreement. CT scan for some patients was not available, and data collection was reliant on MRI and X-rays. Patients who had no images available for review were excluded.

Sampling bias was reduced by taking all effort to include all patients who fulfilled inclusion criteria in both hospital sites and including patients operated on by both neurosurgeons and orthopaedic spine surgeons. Patients with no scans available were excluded.

Power calculation was conducted to determine the sample size required to detect a significant difference of SBO prevalence between DS and IS. The analysis aimed for a power of 0.8 with an alpha level set at 0.05, indicating a 5% risk of type 1 error. Based on expected prevalence of 12% in DS and 30% in IS, the required sample sizes were calculated to be 173 in DS and 58 in IS, resulting in a total sample size of 231 participants. The study was conducted in accordance with the Declaration of Helsinki and its subsequent amendments. Local institutional ethical approval was obtained from Research Ethics and Governance for the Nepean and Blue Mountains Local Health District (No. 2024/ETH02073). Both participating hospitals were informed and agreed on the study. Because of the retrospective nature of the study, the requirement for informed consent was waived.

Statistical analysis

Statistical analysis was performed using Microsoft Excel and IBM SPSS Statistics version 25, reporting median age of patients, prevalence of DS and IS, presence or absence of SBO, spinal level of SBO. Chi-squared test and Fisher's Exact probability test were used for categorical variables and *T*-test for continuous variable.

Results

A total of 2,007 patient records were reviewed, with 351 excluded based on the exclusion criteria. Imaging for 1,656 patients was analysed, of which 20 lacked available images; 388 patients were diagnosed with spondylolisthesis, yielding a prevalence of 23.4% among all surgical patients (*Figure 1*). Of those patients we reviewed CT lumbar spine in 343 patients, and the rest (n=45) we reviewed MRI Lumbar spine along with lumbar spine X-rays. No cases with spinal lipoma, limited dorsal myeloschisis and dermal sinus were observed. Mean age in DS group was 69 (range, 41–91) years, and in IS group was 54 (range, 23–83) years (P<0.05) (*Table 2*). In the DS group, the prevalence of SBO was 11.9%, while in the IS group, it was 24.7% (P value =0.002). Patients with DS and SBO were more likely to present with grade 2 spondylolisthesis compared to those without SBO [risk ratio (RR) 3.09, P value =0.04]. The male-to-female ratio for IS patients with SBO was 3.6:1, compared to 0.66:1 for DS patients with SBO (P value =0.004) (*Table 3*). All patients with DS and SBO had their defect level at S1. Whereas in the IS and SBO group (n=23), 3 patients had their defect at L5, 16 at S1, 2 at L5 and S1, 2 had S1–S4 bifid spine (*Table 4*).

Discussion

Our findings indicate that the prevalence of SBO in DS surgical patients is 11.9%, comparable to the 12.4% prevalence reported by Eubanks in the general population. Conversely, the 24.7% prevalence of SBO in IS surgical patients contrasts with the 41.2% reported in paediatric populations by Urrutia *et al.* (7), potentially reflecting differences in spinal maturity (8). Additionally, patients with DS and SBO exhibited a higher grade of spondylolisthesis, suggesting a possible biomechanical weakness, although this was argued by Sairyo *et al.* (9). A notable association between male gender and SBO in

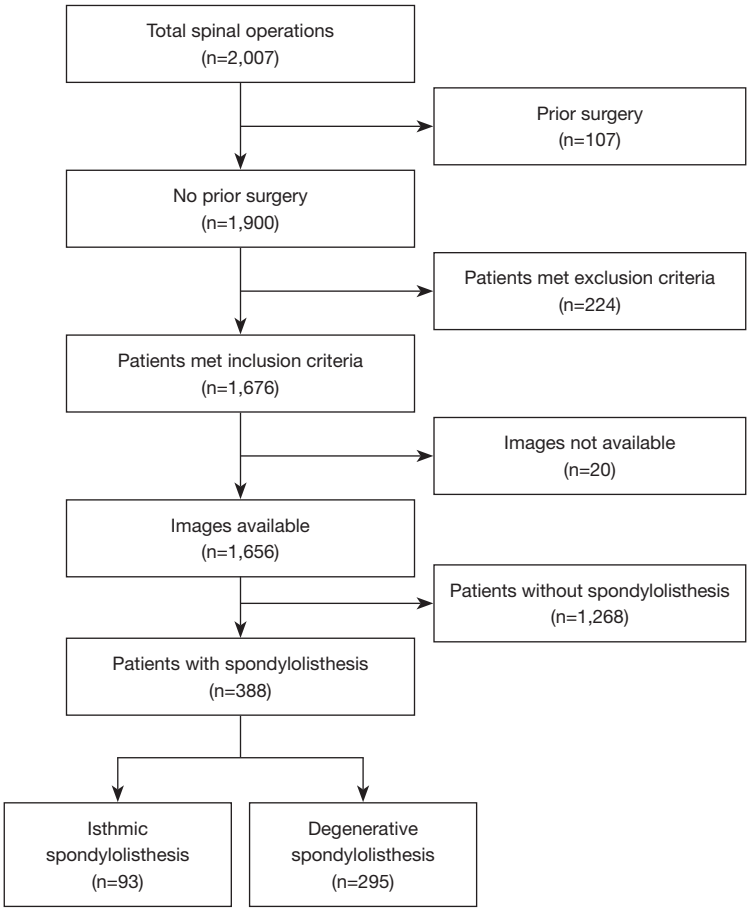

Figure 1 Flowchart of included and excluded patients.

Table 2 Distribution of patients by age and gender

Variables	Age in years, mean [range]	Gender, M:F (ratio)
DS without SBO (n=260)	63 [41–91]	72:188 (0.38)
DS with SBO (n=35)	70 [53–89]	14:21 (0.66)
DS subtotal (n=295)	69 [41–91]	86:209 (0.41)
IS without SBO (n=70)	48 [29–83]	32:38 (0.84)
IS with SBO (n=23)	56 [23–77]	18:5 (3.6)
IS subtotal (n=93)	54 [23–83]	50:43 (1.16)
Spondylolisthesis total (n=388)	65.7 [23–91]	136:252 (0.54)

DS, degenerative spondylolisthesis; F, female; IS, isthmic spondylolisthesis; M, male; SBO, spina bifida occulta.

Table 3 Distribution of patients by type of spondylolisthesis, presence or absence of spina bifida occulta and Meyerding grade of spondylolisthesis

Type of spondylolisthesis	Grade of spondylolisthesis			Fisher's exact test
	1	2	3	
DS no SBO	248	12	0	
DS SBO	30	5	0	0.038
IS no SBO	42	27	1	
IS SBO	17	5	1	0.179

DS, degenerative spondylolisthesis; IS, isthmic spondylolisthesis; SBO, spina bifida occulta.

Table 4 Level of spina bifida occulta in the isthmic spondylolisthesis group

Level of spina bifida occulta in isthmic spondylolisthesis	Number
L5	3
S1	16
L5, S1	2
S1–S4	2
Total	23

IS was also observed, consistent with previous paediatric studies (10).

Limitations of our study include its retrospective nature and the restricted population from two public hospitals in Western Sydney, as well as incomplete access to some imaging studies. Forty-five patients with spondylolisthesis had MRI lumbar spine but no CT lumbar spine available for review. This study is limited to spinal levels L4–S1. However, it included patients listed for surgery over a long-time span (2015 to 2023), from two different tertiary public hospitals, treated under the care of both neurosurgeons and orthopaedic spine surgeons. This makes this research more generalizable in public hospital setting treating lower lumbar spine pathology. This research is the first to specifically examine a surgical cohort regarding the prevalence of SBO, making it particularly relevant for adult spine surgeons.

To mitigate biases inherent in retrospective studies, future research should establish a prospective database for patient data collection and create a national database for centralized data collection from all public and private centres. Further investigations should also assess the risk of unintended durotomy associated with unrecognized SBO, emphasizing the importance of awareness regarding this rare but preventable complication.

Conclusions

SBO is an often-overlooked anatomical variation in adult spine surgery, particularly in cases of degenerative and IS. With a prevalence of 11.9% in DS at the lower lumbar spine, it is sufficiently common that spine surgeons should routinely consider it, especially when planning open posterior lumbar spine fusion surgeries to avoid unintended durotomy and neurological damage. Awareness of the absence of the S1 spinous process is crucial for effective surgical planning, particularly when utilizing navigated spinous process clamps for pedicle screw placement (*Figure 2*).

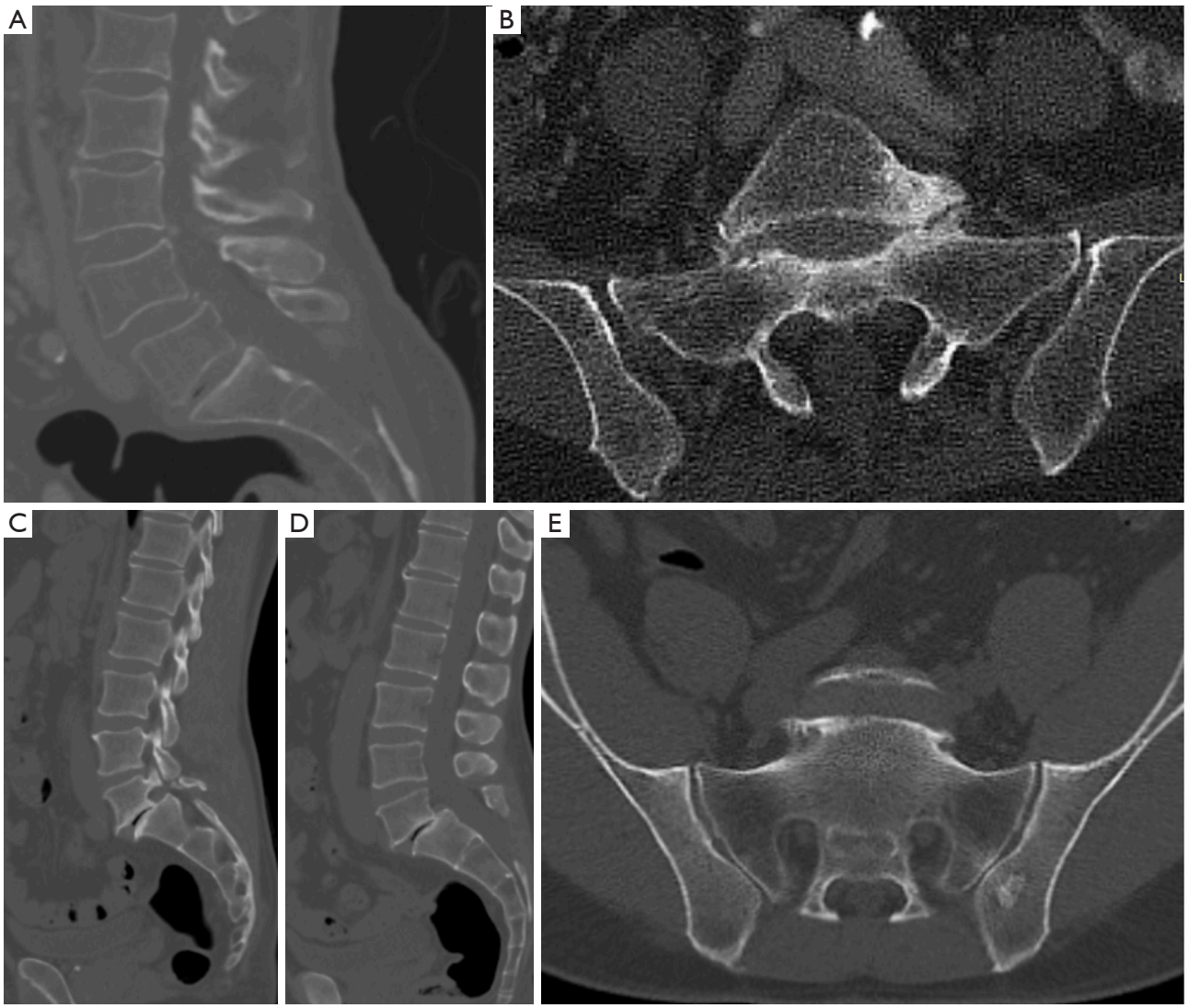

Figure 2 CT examples of spina bifida occulta involving the sacral spine. (A,B) Sagittal and axial cuts in the lumbosacral spine showing DS at L4/L5 with associated SBO at S1 in an 85-year-old female with neurogenic claudication who underwent simple decompression. (C-E) Sagittal and axial cuts CT in the lumbosacral spine in a 55-year-old with bilateral L5 radiculopathy from L5/S1 IS and associated SBO, this patient underwent L5/S1 posterolateral interbody fusion. CT, computed tomography; DS, degenerative spondylolisthesis; IS, isthmic spondylolisthesis; SBO, spina bifida occulta.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jss.amegroups.com/article/view/10.21037/jss-24-151/rc

Data Sharing Statement: Available at https://jss.amegroups.

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Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at https://jss.amegroups.com/article/view/10.21037/jss-24-151/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki and its subsequent amendments. Local institutional ethical approval was obtained from Research Ethics and Governance for the Nepean and Blue Mountains Local Health District (No. 2024/ETH02073). Both participating hospitals were informed and agreed on the study. Because of the retrospective nature of the study, the requirement for informed consent was waived.

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