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## Clinical Case Studies

## Reduction of adolescent grade IV L5–S1 spondylolisthesis with anterior joystick manipulation during a combined anterior and posterior surgical approach: A case report



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## ABSTRACT

**Background:** High-grade isthmic spondylolisthesis poses a clinical challenge in the pediatric and adolescent population. Current surgical management using posterior-based approaches may lead to incomplete reduction and restoration of listhesis, disc height, and lordosis. Combined anterior and posterior approach addresses these issues but has been infrequently reported, mainly in the treatment of low-grade isthmic spondylolisthesis. Neither offers good disc space visualization and control of spinal alignment during reduction.

**Case Description:** A healthy 17-year-old female presented with 9 months of progressively worsening lower back pain radiating down the left lower extremity and 3 inches of height loss. Diagnosis of grade IV L5–S1 spondylolisthesis was made using plain radiographs, CT, and MRI. Management with combined anterior and posterior fusion, involving the manual manipulation of segments using an anterior pedicle screw joystick, was pursued.

**Outcome:** Satisfactory alignment, solid arthrodesis, no complications, and improved patient reported outcomes.

**Conclusions:** Combined anterior and posterior fusion with anterior joystick manipulation allowed for full reduction of grade IV spondylolisthesis and restoration of disc/foraminal height and L5–S1 segmental lordosis without neurological complication. Although less commonly performed in children and adolescents, this surgical approach can assist in restoring optimal alignment in isthmic spondylolisthesis.

## Background

Isthmic spondylolisthesis with anterior displacement of the vertebrae resulting from pars interarticularis defects may lead to lower back pain, most commonly at L5–S1 [1,2]. In pediatric patients, this condition is commonly associated with hyperextension activities [2,3]. Although often asymptomatic, continued disc slippage predominantly during rapid bone growth periods can lead to nerve root compression and radiculopa-

thy [4]. The Meyerding system classifies spondylolisthesis from grade I (no displacement) to grade V (complete displacement) [5,6]. High-grade (III–IV) spondylolisthesis can be surgically managed with posterior fusion and, less commonly, with combined anterior and posterior fusion [7]. However, few cases of high-grade spondylolisthesis successfully managed with the combined approach have been reported in the pediatric population. Additionally, neither approach offers good disc space visualization and control of spinal alignment during listhesis reduction.

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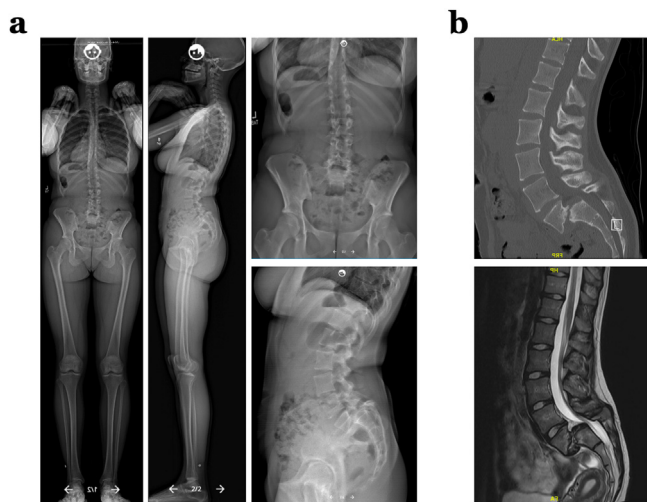
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**Fig. 1.** (A) Plain radiographs, anteroposterior (far left and top right) and lateral neutral (middle left and bottom right) views, at preoperative baseline showing Meyerding grade IV L5-S1 spondylolisthesis with chronic bilateral pars interarticularis defects; (B) Computed tomography (top) and magnetic resonance imaging (bottom) showing severe bilateral L5-S1 foraminal stenosis and reactive endplate sclerosis with cystic degenerative change of inferior L5 and superior S1.

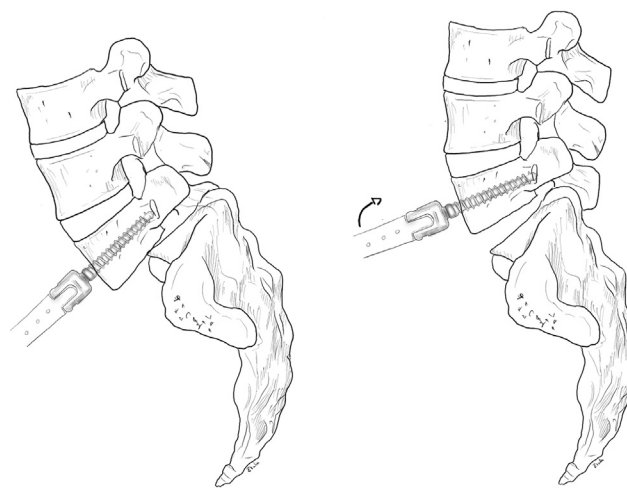
Here, we describe a case of an adolescent with high-grade spondylolisthesis who underwent combined anterior and posterior fusion with manual manipulation of listhesis using an anterior pedicle screw joystick, with good postoperative clinical and radiographic outcomes.

**Case presentation**

A 17-year-old female presented with 9 months of progressive lower back pain radiating down the left lower extremity and 3-inch height loss. Initially, the pain was only present during strenuous activities but worsened prompting her visit. Physical examination revealed lumbar spine tenderness, significant step-off over L5-S1, and no neurologic deficits. Full body radiographs revealed mild scoliosis and severe grade IV anterolisthesis of L5 on S1 with chronic bilateral pars interarticularis defects (Fig. 1A). CT and MRI further revealed severe bilateral L5-S1 foraminal stenosis and endplate degenerative changes (Fig. 1B) with grade IV L5-S1 spondylolisthesis.

Patient underwent an L5-S1 anterior lumbar interbody fusion (ALIF) with L5-pelvis posterior decompression and fusion (PLIF). With the patient supine, a Pfannenstiel incision and retroperitoneal exposure of the L5-S1 disc was performed. Following radiographic verification, all endplate cartilage and intervertebral disc material were removed with pituitary rongeurs and curettes. A 6.5-mm pedicle screw was inserted in the anterior aspect of the L5 vertebral body. The threaded screwdriver was left attached to this pedicle screw, thereby effectively acting as a joystick and providing leverage while manipulating the L5 vertebral body. The disc space was then gently mobilized with a Cobb elevator and manipulated with this joystick. Reduction of the listhesis was achieved using sequential interbody trials and a paddle distractor. The anterior pedicle screw joystick, in this process, provided additional disc space distraction and control of the L5 body during insertion of trials, thereby decreasing the likelihood of endplate violation during disc space manipulation and assisting with angular control during restoration of appropriate lordosis at this segment (Fig. 2). A 20°, 15 mm height titanium cage was implanted to restore appropriate disc and foraminal height. Two downgoing screws were used to lock the cage onto S1; the cage was not secured to the L5 body pending further reduction through a posterior approach.

Next, posterior approach was performed and L5 and S1 pedicle screws were placed, with care taken to preserve the L4-5 facet cap-



**Fig. 2.** Illustration of the joystick technique showing reduction of the segmental sagittal malalignment.

**Table 1**

Preoperative and postoperative spinopelvic parameters showing significant improvements following full reduction of the listhesis.

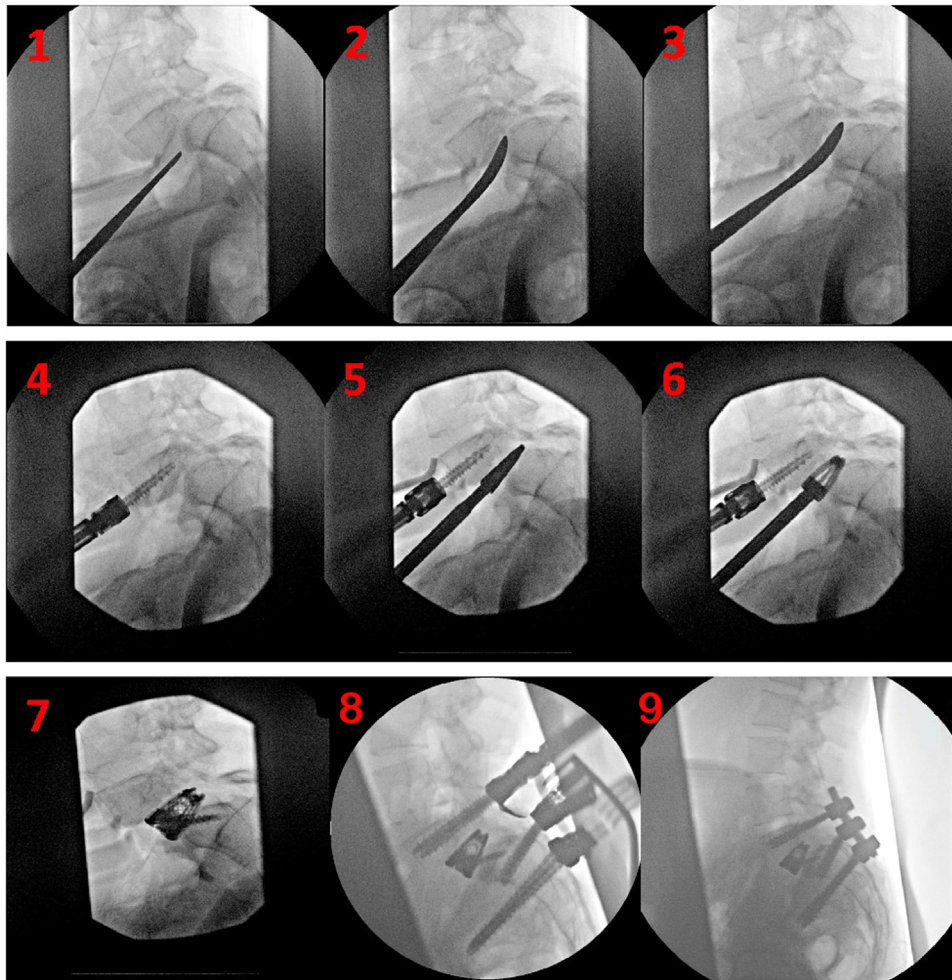
Spinopelvic parameters	Preop	Postop
Pelvic tilt (PT, °)	35	29
Pelvic incidence (PI, °)	87	86
Sacral slope (SS, °)	52	58
Lumbar lordosis (LL, °)	-61	-76
L1-L4 lordosis (°)	-51	-38
L4-S1 lordosis (°)	-17	-53
PI-LL (°)	26	10
Thoracic kyphosis T4T12 (TK, °)	27	33
T1 pelvic angle (TPA, °)	23	22
Sagittal vertical axis (SVA, mm)	-19	4
Spondy distance (mm)	23	4
Spondy slip angle (°)	17	-28
Spondy grade	Grade IV	Grade I

sules. Bilateral S2-alar-iliac screws were then placed (Fig. 3). Reduction screws were used to fully reduce the listhesis. At this time, a 76% reduction in MEP signal of the left tibialis anterior was noted (Fig. 4A). Reduction screws were, subsequently released and a grade II osteotomy was performed with a Kerrison punch to decompress the L5 nerve roots bilaterally. Reduction was then re-performed and MEP, SSEP, and EMG signals were confirmed with return of baseline tibialis anterior signal (Fig. 4B). Compression was performed to prevent cage migration and enhance lordosis. Radiographs demonstrated safe and stable implant positioning.

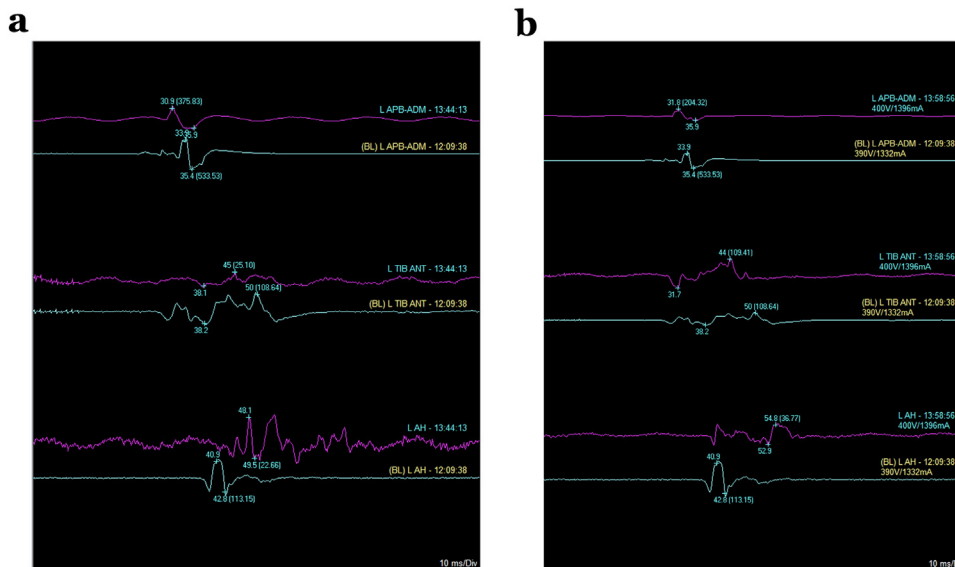
Postoperative recovery was uneventful, with complete resolution of pain, 3-inch height gain, and no neurological complications. Full body radiographs at 1-year follow-up demonstrated maintained alignment and solid fusion (Fig. 5). Sagittal alignment improved with L4-S1 lordosis increasing from 17° preop to 53° postop, PI-LL mismatch from 26° to 10°, lordosis distribution index from 28% to 70%, and pelvic tilt from 35° to 29°; reciprocal improvement of thoracic kyphosis from 27° to 33° was also achieved. Ultimately, near full correction of spondylolisthesis was noted (slip angle=17° of kyphosis to 28° of lordosis, slip distance=23 mm grade IV preop vs 4 mm grade I postop; Table 1).

**Discussion**

Optimal surgical management of high-grade isthmic spondylolisthesis among adolescents remains controversial. Posterior fusion, the most commonly utilized method, offers acceptable outcomes in many cases, but frequently results in incomplete reduction and restoration of listhesis, disc height, and segmental lordosis [7,8].



**Fig. 3.** Intraoperative fluoroscopy showing (1) Straight Cobb elevator unable to achieve disc space access, (2) Curved Cobb elevator accessing disc space, (3) Mobilization of the disc, (4) Joystick placement into L5 body with pedicle screw and fixed driver, (5) Bullet distractor to further mobilize disc, (6) Trial replacement, (7) Final ALIF cage placement, (8) Initial reduction attempt leading to loss of left tibialis anterior MEP, (9) Final lateral radiograph.



**Fig. 4.** Intraoperative motor evoked potential (MEP) tracings showing preservation of function of the left abductor pollicis brevis (LAPB), left tibialis anterior (LTIB), and left abductor hallucis (LAH). Baseline tracings (blue) were set prior to the incision of the posterior portion. (A) Alert tracings (pink) after initial listhesis reduction showing a 76% decrease in LTIB MEP amplitude from baseline; (B) resolution tracings (pink) after final listhesis reduction showing recovery of LTIB MEP amplitude to baseline.

A combined surgical approach utilizing ALIF can be a preferred alternative, as it allows for optimal restoration of disc height and lordosis. ALIF has previously been shown to offer greater segmental lordosis and improved patient outcomes compared to PLIF in the treatment of isthmic spondylolisthesis [9]. With a combined approach, a larger global lumbar lordosis is achieved which reduces spinopelvic mismatch and the associated risk for adjacent segment disease seen when  $PI-LL > 10^\circ$  [10]. The apex of lumbar lordosis is also optimally redistributed to the

caudal spinal segments, with the largest contribution occurring at L4–S1 where most of global lordosis normally stems [11–13]. Finally, there is also an associated reduction pelvic tilt, which can compensate for spinal malalignment and correlates with worse functional outcomes [14,15].

Optimal control of the vertebral bodies during the reduction of listhesis can be achieved with the described anterior pedicle joystick approach. A similar surgical technique utilizing Caspar pins has previously been illustrated in anterior cervical fusion, offering good angular con-



**Fig. 5.** Plain radiographs, anteroposterior (far left and top right) and lateral neutral (middle left and bottom right) views, at postoperative 2-month follow-up showing L5–S1 anterolisthesis with interval posterior transpedicular spinal fusion and interbody spacer without evidence of hardware complication.

trol of screws and efficient restoration of spinal alignment [16,17]. Nevertheless, one must consider the possible complications resulting from this technique such as the improper pin insertion compromising adjacent vertebral endplates and neurovascular structures [18]. If the screw plows anterior vessel injury may occur and direct repair is necessary. Another rare but potential complication is a fracture through the remnant hole from the joystick screw [19]. Careful force-control of the joystick is needed to prevent screw cut-out from the vertebral body. Monitoring of the screw-bone interface is needed to assess for early joystick failure. If the screw begins to cut-out, abandonment of that technique should be considered. Our study serves as a proof-of-concept that this technique can be translated to the management of high-grade lumbar spondylolisthesis, as it allows for good disc space visualization and enhanced manipulation of spinal segments during listhesis reduction.

Although less commonly performed in children and adolescents, our report shows that combined anterior and posterior fusion with anterior joystick manipulation can assist in restoring optimal spinopelvic alignment without complication.

#### Patient informed consent

Complete written informed consent was obtained from the patient for the publication of this study and accompanying images.

#### Summary Statement

High-grade isthmic spondylolisthesis in children and adolescents can be successfully managed with anterior joystick manipulation during a combined anterior and posterior surgical approach, resulting in optimal spinal alignment and good restoration of disc/foraminal height and segmental lordosis.

#### Declarations of competing interest

One or more of the authors declare financial or professional relationships on ICMJE-NASSJ disclosure forms.

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