



Anterior approach for a stab wound with penetrating rebar injury causing incomplete cauda equina syndrome in lumbosacral spine lesion: a case report and literature review

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Abstract

Purpose To report a unique case of incomplete CES following a rebar penetrating injury in perineal region with retro-pulsed fragment, which was treated with anterior approach and discuss suitable surgical approach.

Methods Incomplete cauda equina syndrome caused by non-missile penetrating injury is extremely rare. A 26-year-old male patient presented incomplete cauda equina syndrome due to a penetrating rebar wound from his perineal region to the lumbosacral spine. Computed tomography demonstrated a bony fragment broken from S1 body compressing into the spinal canal.

Results By anterior approach, we performed partial corpectomy of L5, decompression by retrieving the bony fragment and L5-S1 interbody fusion. The patient had a significant recovery, and no clinical complication was found after over 2-year follow-up.

Conclusion It is challenging to determine the optimal strategy of surgical treatment for penetrating spinal injuries with retained foreign bodies, here we suggest an anterior approach situation that has the advantage of being able to effectively perform decompression and prevent iatrogenic damages of thecal sac and nerve rootlets.

Keywords Penetrating injury · Lumbosacral spine trauma · Stab wound · Incomplete cauda equina syndrome · Anterior approach

Abbreviations

CES	Cauda equina syndrome
CSF	Cerebrospinal fluid
CT	Computed tomography
MRI	Magnetic resonance imaging

Introduction

The cauda equina syndrome (CES) manifests as a triad of symptoms including saddle anesthesia, urine and/or bowel dysfunction, and motor paralysis combined with back discomfort. The CES is distinguished as complete or incomplete syndrome according to the severity of urination and symptoms. The complete CES presents loss of bladder control, which is not only difficult to micturate but also urinary leaking because of loss of detrusor function. Incomplete CES is characterized by reduced urinary sensation, lack of the urge to urinate, a weak urine stream, and a need to strain of urination [1–3].

Herniation of the central lumbar disc is the most common cause of CES and less common causes were postoperative

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hematoma, neoplasm, trauma, complication after chemonucleolysis, and penetrating injuries have also been identified [1, 3].

Penetrating injuries are less commonly reported as the cause of the CES. The gunshot or stab wound is the main type of penetrating spinal injury. Spinal gunshot injuries are more frequently reported and have a higher prevalence of neurologic impairment. On the other hand, neurologic damage following the stab wound has been reported extremely rare in the clinical circumstance, but the prognosis of surgical approach was reported with better neurologic recovery [4, 5].

CES requires urgent surgical decompression, and central lumbar disc herniation, which is the most common cause of CES, is most sufficiently decompressed with posterior laminectomy. However, if the structure, located in front of the dura mater, is solid and large, isolated posterior decompression does not allow for complete neurologic recovery and the operator should consider additional iatrogenic dural tear and complication because of dural compression [2, 6].

Especially, if traumatic spinal injuries with retro-pulsed fragments and incomplete neurologic deficits have been decompressed with posterior laminectomy only, unrelieved tension on nerve root progress neurologic deficit by bow-string effect of tethered spinal cord [7, 9, 10].

However, there was no definitive study between anterior and posterior surgery, whether one approach is over the other or not and sometimes combined surgery should be considered. Optimal treatment strategy should consider the patient's circumstance including injury mechanism, stability of posterior osteoligamentous structure.

So, here we report a unique case of incomplete CES following a rebar penetrating injury in perineal region with retro-pulsed fragment, which was treated with anterior approach and discuss suitable surgical approach for the bony fragment with literature review.

Case report

A 26-year-old male patient presented to our hospital after falling from a height of one meter to a rebar which vertically penetrated his perineal region (Fig. 1). The emergency rescue team had found him fall down on the steel ground bar, and they could not remove the rebar, which had been too firmly fixed on the ground. The rescue team had found there was no fluid leakage and active bloody discharge, so they decided to rescue him by standing up from the rebar and took him to our emergency department as soon as possible.

On neurologic examination, voluntary anal contracture was absent and deep anal sense was markedly decreased. Voluntary urination function was also lost. Other motor and sensory functions were preserved as normal. This



Fig. 1 Penetrating stab wound due to a rebar crossing the perineal region

patient had no significant accompanying injury such as abdominal or urethral lesion, according to relevant specialists' assessment at that time.

Computed tomography (CT) showed that the rebar penetrated the posterior margin of S1 body, broke a cylindrical bony fragment ($20 \times 15 \times 13$ mm sized) and this foreign body anteriorly compressed the thecal sac at the level of the fifth lumbar vertebral body on magnetic resonance imaging (MRI) (Fig. 2).

Finally, we diagnosed the patient as incomplete CES and performed decompression surgery within 8 h after the patient had got an injury. The surgery had taken 3 h 40 min including autogenous fibular strut bone harvest surgery, and there was 1.902L of estimated blood loss.

We performed anterior approach (trans-abdominal approach) with microscopic magnification and partial corpectomy of L5 for retrieval window ($21 \times 16 \times 14$ mm) of the bony fragment of S1 ($20 \times 15 \times 13$ mm) and autogenous fibular strut bone graft (Fig. 3).

The rebar penetrated the posterior longitudinal ligament and outer layer of ligamentum flavum between the interlaminar space of L5 and S1 to the right side of the spinous process and tip of the L4 spinous process. Bony fragment of tip of the L4 spinous process was translated to L3 spinous process level. However, we found there was almost no damage to the dura or the cerebrospinal fluid (CSF) leakage. After the decompression, we performed interbody fusion between L5 and S1 using autogenous fibular strut bone graft with a fragmentary screw and bone

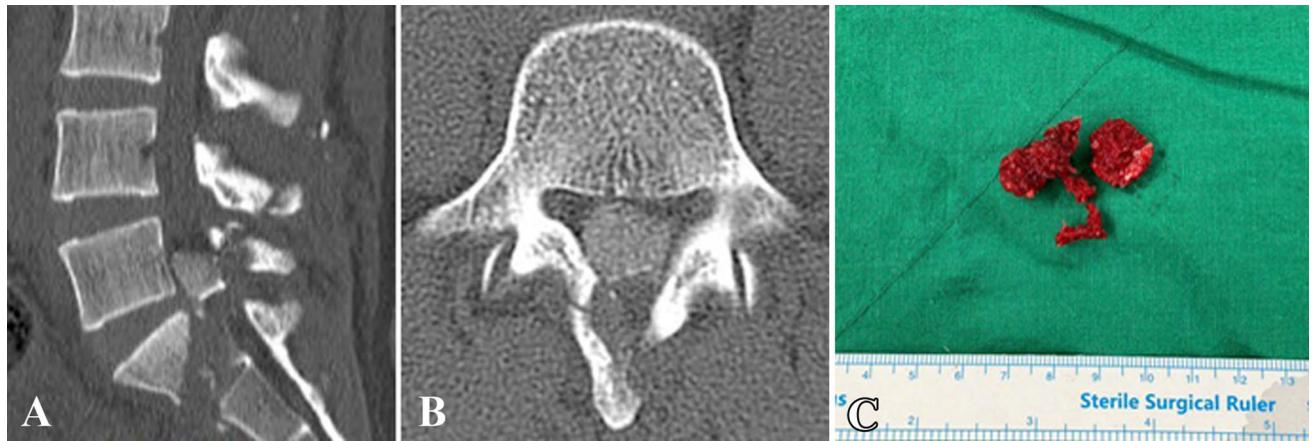
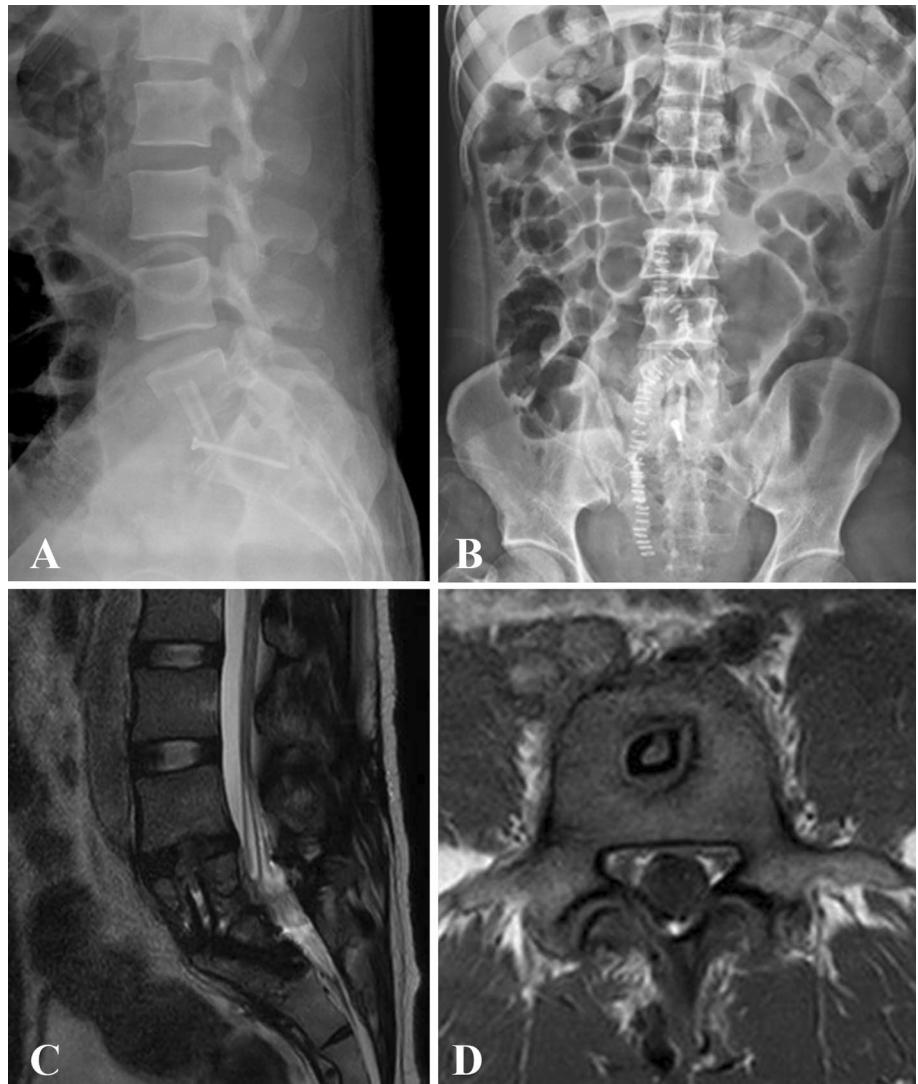


Fig. 2 Computed tomography demonstrated the bony fragment compresses the thecal sac into the spinal canal: **A** Bony fragment of S1 dislocated into the spinal canal in the sagittal image; **B** bony fragment

compressed the thecal sac in the axial image; **C** 20×15x13 mm sized bony fragment was removed

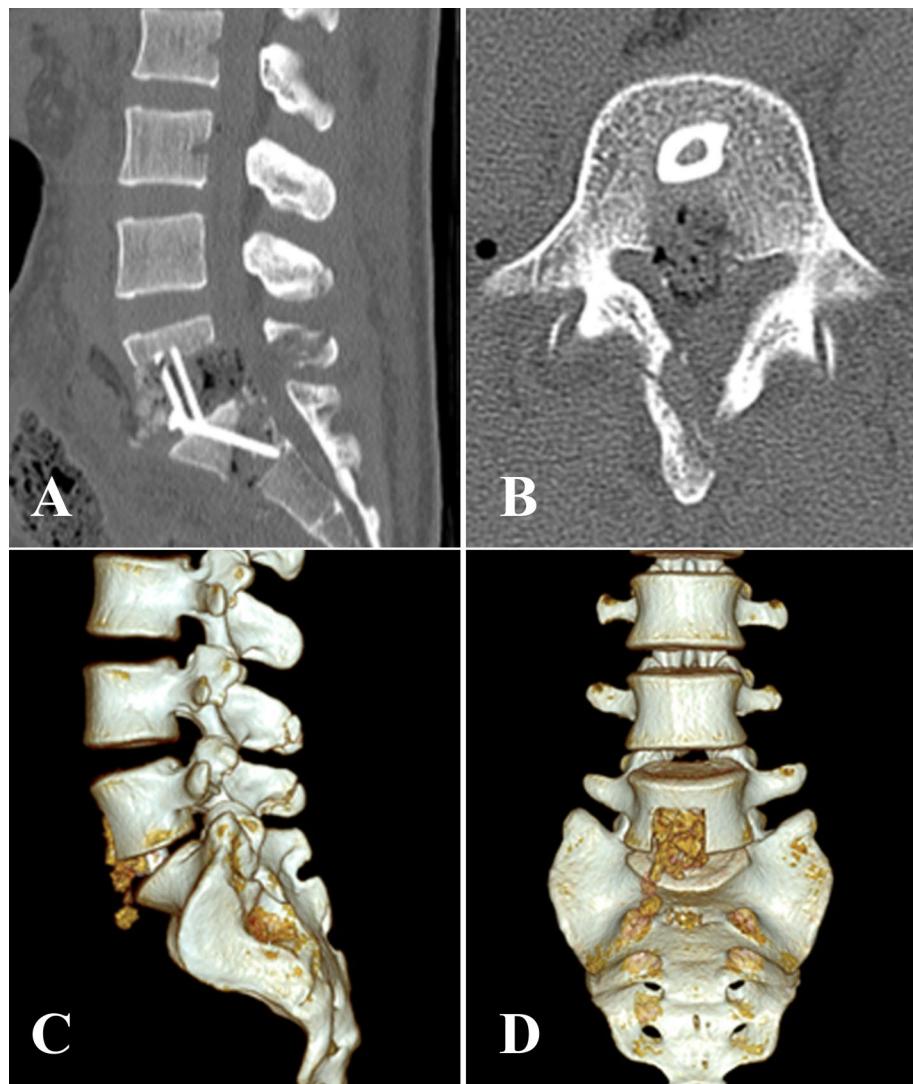
Fig. 3 L5 corpectomy and autogenous fibular strut bone graft were performed with anterior approach: **A** Fibular strut bone graft maintained lumbosacral angle in sagittal image; **B** anteroposterior alignment was maintained with fibular strut bone graft in AP image; **C** spinal canal decompressed and lumbosacral angle maintained in the sagittal T2-weighted MRI image; **D** spinal canal completely decompressed without bony fragment in the axial T2-weighted magnetic resonance imaging



graft using retrieved bony fragment on the bone defect site of L5 partial corpectomy (Fig. 4).

The voluntary anal contraction markedly improved immediate postoperatively and voluntary urination was possible at 4 weeks after the surgery. We did recommend absolute bed rest for 2 weeks and prescribe a low back brace for 6 weeks. The patient had started a walk with a manual wheelchair after absolute bed rest and had a walk by himself after 3 days of manual wheelchair without subsidence of autogenous fibular bone graft. We did check immediate postoperative CT and follow-up simple X-ray that showed little subsidence of autogenous fibular strut bone graft. We took an MRI for confirmation of expansion and decompression of cauda equina; however, we did not take a following up CT for checking bony healing and fusion. We kept following up the patient for over 2 years and identified no clinical complication. The regular X-ray showed a little subsidence of autogenous fibular strut bone graft, but the stability and lumbar lordosis were still well aligned (Fig. 5).

Fig. 4 **A** Sagittal and **B** axial view on preoperative computed tomography; **C** three-dimensional sagittal and **D** axial view on computed tomography after operation

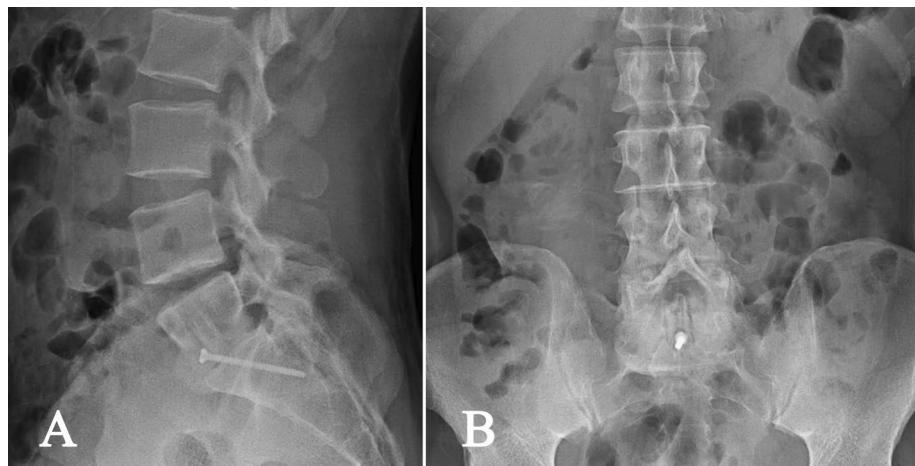


Discussion

The most frequent causes of spinal injuries include falls, motor vehicle accidents, and sports-related mishaps. Compared to those brought on by physical trauma, penetrating spinal injuries are rather uncommon [5], the most typical causes are bullets and knives. However, spinal injuries by penetrating rebar are extremely rare and only one case reported in the literature review. Zhou, Z. S. reported a similar case through the same mechanism, and the case was performed with a posterior approach. On the other hand, we report a unique case of CES following a rebar penetrating injury in the perineal region with a retro-pulsed fragment, which was decompressed with anterior approach [10].

CES is a complex neurologic disorder and is managed as a surgical emergency. Traumatic cauda equina injuries are the most frequent cause of abrupt and acute neurologic

Fig. 5 A Lateral and **B** anteroposterior view of 2-year follow-up X-ray showed little subsidence of autogenous fibular strut bone graft, but the stability and lumbar lordosis were still well aligned



deterioration. Assessment should be made to identify lower extremity sensitivity and motor impairments during the initial emergency evaluation [5].

On radiographic evaluation, regularly anterior/posterior and lateral radiographs of the spine should be taken and evaluated immediately. In these emergency situations, CT is the ideal investigative modality and if the composition of the grab is uncertain, especially when it is close to important structures, or when the patient has a neurologic deficit without the detection of the compression in the canal or a trajectory across the canal, the role of magnetic resonance imaging (MRI) is helpful [5, 11].

Immediate radiologic evaluation gives an insight for the cause of CES including fractured bony anatomy, foreign material, and tissue material like disc herniation, which should be clearly defined and allows for more objective judgements about stability and three-dimensional location between canal and cauda equina before surgical decision.

After the evaluation and diagnosis were completed as CES, the emergency surgical decompression was recommended, especially diagnosed as incomplete syndrome. However, the timing of surgery has been still controversial [2, 3, 6, 12–14].

According to a meta-analysis published in 2000, Ahn et al. performed meta-analysis of 332 CES cases using logistic regression analysis. This literature suggested that there was no evidence of neurologic improvement in surgical outcome between patients treated before 24 h and patients treated within 24–48 h, but there was a significant improvement of CES symptoms of patients who were treated within 48 h [6].

However, Kohles et al. reported a concern with a weak methodology, misinterpretation, and quantitative comparison of Ahn's published meta-analysis, in 2000, which led to elevated observed risk of delayed surgery (24 to 48 h). Especially, they emphasize prompt surgical intervention for

the injured nerve tissue, which progress slowly deteriorates by swelling and tightening of nerves [13].

In 2005, Todd N.V. had studied a meta-analysis of decompression time with internal comparison and suggested patients who were treated less than 24 h expected more sufficient recovery from bladder dysfunction [7].

However, limitations of Todd's meta-analysis were mentioned as inappropriate summary statistics and compared different clinical studies, which some studies are clinically heterogeneous studies and other studies are fixed effects models [14].

Chau, A.M. et al. reported meta-analysis of timing of surgical intervention of 374 animal and 2802 human clinical studies in 2014 and concluded there was no evidence of treating patient within 48 h after injury, but early and delayed surgery may improve neurologic deficits, and according to biological progress of nerve injury, which deteriorated in a continuous manner, the earlier intervention may result in more clinical improvement of neurologic deficit [14].

Compared with published literature, we performed anterior decompression less than 24 h after onset of CES. Our case patient had a surgical decompression within 8 h after he had got an injury and we consider earlier decompression resulted in earlier neurologic recovery from the bladder dysfunction.

The case patient presents incomplete CES symptoms with a retro-pulsed fracture fragment of S1, which compressed cauda equina anteriorly, and we consider a risk of infection with penetrating injury in perineal region. So we decided to perform anterior decompression with autogenous strut fibular bone graft. However, it is still challenging to determine the optimal strategy of surgical treatment for CES patients.

According to the current literature, CES may be commonly caused by central lumbar disc herniation and requires immediate surgical treatment with general manner of posterior decompression. Patients, who have penetrated injury in

Table 1 Literature cases of penetrating injuries to the cauda equina

Author (year)	Patients	Cause of injury	Treatment	Approach site	Prognosis
Simpson, R. K., et al. (1989)	160	142: GSW ^a 18: SW ^b	Posterior surgery	Lumbar laminectomy and intradural exploration	22% complication postoperatively No statistical difference in outcome between surgery and conservative treatment
Robertson DP et al. (1992)	33	30: GSW 3: SW	Posterior surgery	Lumbar decompressive laminectomy, wound debridement, and dural repair	5% complication Bowel or bladder dysfunction: non-improved
Pal D et al. (2006)	1	Wooden piece	Posterior surgery	Lumbar decompressive laminectomy and removal of wooden fragment	Early neurosurgical intervention may be beneficial but carries an increased risk of complication
Lee, K. H. et al. (2007)	1	Handle of the brake caliper	1st: MP ^c infusion 2nd: posterior surgery	L2 and L3 partial laminectomy and removal of fragments of cloth	6 months later, patient was mobilizing independently but the incontinence remained unchanged
Zhou, Z. et al. (2011)	1	Trans-rectal steel bar	1st: debridement and sigmoid loop colostomy and rectal repair 2nd: posterior surgery 3rd: repair of CSF ^d leakage	L4 and L5 laminectomy, removal of bone fragment and spinal fusion with internal fixation, L4–S1	5 months later, patient was mobilizing with crutch assistance and bladder continence
Mikami, Y. et al. (2012)	1	SW	Posterior surgery	L3 and L4 partial laminectomy and internal fixation	CSF leakage: complication Ambulation independently but could not control patient's voiding
Held, M. et al. (2012)	1	Trans-abdominal broken glass beer bottle	1st: laparotomy and damage control surgery 2nd: posterior surgery	At 8-month follow-up, sensory improved but motor unchanged At 2-year follow-up, no significant improvements	At 8-month follow-up, sensory improved but motor unchanged At 2-year follow-up, no significant improvements Neurologic deficit remained unchanged

^agunshot wound^bstab wound^cmethylprednisolone^dcerebrospinal fluid

lumbosacral region, are decompressed with posterior laminectomy and fusion (Table 1); [1–6, 10, 15–19]

Posterior approach widely was recommended for degenerative diseases, which are disc herniation, spinal stenosis, segmental instability, and pseudo-arthrosis. One of the advantages of posterior approach is the most familiar surgical technique to spinal surgeons, who are well trained. Second is posterior surgery provides excellent access to the nerve root entrapment and allows for posterior fusion through a single incision. However, surgeon should consider the iatrogenic paraspinal muscle injury with prolonged retraction and hard structures, which compress dura anteriorly, does not allow for thecal sac decompression with isolated posterior laminectomy, which is associated with bowstring effects of neural tethering. Furthermore, incomplete reduction and neurologic recovery may need additional anterior decompression [7, 9, 19].

On the other hand, anterior approach was recommended for infection and tumor removal, neural decompression, deformity reconstruction, and spine fusion. One of the advantages of anterior approach is excellent exposure of disc space, which permits rapid endplate preparation. Second is anterior surgery facilitates large implant insertion, which allows for correction of lordosis and foraminal height and may lead to high fusion rate [19].

Kirkpatrick et al. reported patients with incomplete deficit, especially those with a large retro-pulsed fragment and marked canal compromised was recommended with anterior decompression to provide adequate visualization of the anterior aspect of dura mater in traumatic thoracolumbar fracture and Kingwell, S.P. reported anterior decompression may offer potential benefits in terms of bladder recovery in traumatic injury of cauda equine [7, 20, 21].

However, surgeons should consider a patient's history of abdominal surgery, which causes adhesion of vascular structure and vascular injury, which is the most devastating complication of anterior approach, and Mobbs, R. J. reported spondylolisthesis, which is more than grade 2, is contraindication of anterior approach if there was no posterior fusion [19, 20].

Our case patients had trans-perineal penetrating trauma with a large retro-pulsed fragment of S1, which compromised canal nearly complete compression of dura at L5–S1. Firstly, if we perform posterior laminectomy, a large retro-pulsed fragment may compromise neurologic deficit due to the bowstring effect and does not allow for complete removal of a fragment without iatrogenic dural tear or additional facetectomy. Secondly, the rebar penetrated the outer layer of ligamentum flavum between interlaminar space of L5 and S1 to right side of L5 spinous process and tip of the L4 spinous process without injury of facet joint and posterior ligament complex of lumbar, so

we consider additional posterior surgery does not need for fusion or instrumentation and finally, inserting cage could be the risk factor of infection after penetrating injury.

So we perform a partial isolated corpectomy of the L5 vertebral body for removal of the fracture fragment of S1 through anterior approach, and after removal of fragment, the compressed dura was completely expanded. We finally confirm the stability after reinforcing L5 partial corpectomy site with autogenous strut fibular bone graft.

In conclusion, incomplete CES caused by non-missile penetrating injury is extremely rare, and as we know, this is the first case of CES following a rebar penetrating injury in perineal region, which was decompressed by anterior approach in a literature review. Although the anterior approach had a risk of vascular injury, posterior decompression does not allow for complete neurologic recovery in a retro-pulsed fragment due to bowstring effect of neural tethering. Here, we suggest that anterior approach of sacral lesion with retro-pulsed fragment to overcome the potential risk of neurologic injuries anteriorly, as well as to effectively perform decompression and prevent iatrogenic injuries of thecal sac and nerve rootlets.

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Author contributions JHK: Conceptualization, Main surgeon of the case report patient, writing/manuscript preparation : revision and editing, supervision. SWCg: Writing, manuscript preparation, writing initial draft, writing/manuscript preparation : revision and editing. VLN: Writing, manuscript preparation : review. DHHAM: Writing, manuscript preparation : review.

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Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate Hereby, I, Seong-Woo Chong, consciously assure that for the manuscript "Anterior approach for a stab wound with penetrating rebar injury causing incomplete cauda equina syndrome in lumbosacral spine lesion: A case report and literature review" the following is fulfilled: This material is the authors' own original work, which has not been previously published elsewhere. The patient has consented to the submission of the case report to the journal. The study was approved by the Research Institute of Clinical Medicine of Jeonbuk National University- Biomedical Research Institute of Jeonbuk National University Hospital, Institutional Review Board. (IRB File No. 2023-07-023)

Consent for publication All authors have read and agreed to the published version of the manuscript.

Availability of data and materials The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests The authors declare that they have no competing interests.

Ethical approval Hereby, I, Seong-Woo Chong, consciously assure that for the manuscript “Anterior approach for a stab wound with penetrating rebar injury causing incomplete cauda equina syndrome in lumbosacral spine lesion: A case report and literature review” the following is fulfilled: This material is the authors' own original work, which has not been previously published elsewhere.

Consent to participate The patient has consented to the submission of the case report to the journal.

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References

1. Gardner A, Gardner E, Morley T (2011) Cauda equina syndrome: a review of the current clinical and medico-legal position. *Eur Spine J* 20:690–697
2. Gleave JRW, Macfarlane R (2022) Cauda equina syndrome: what is the relationship between timing of surgery and outcome? *Brit J Neurosurg* 16(4):325–328
3. Reddy AP, Mahajan R, Rustagi T, Chhabra HS (2018) Bladder recovery patterns in patients with complete cauda equina syndrome: a single-center study. *Asian Spine J* 12(6):981
4. Robertson DP, Simpson RK (1992) Penetrating injuries restricted to the cauda equina: a retrospective review. *Neurosurgery* 31(2):265–270
5. Pal D, Timothy J, Marks P (2006) Penetrating spinal injury with wooden fragments causing cauda equina syndrome: case report and literature review. *Eur Spine J* 15:574–577
6. Ahn UM, Ahn NU, Buchowski JM, Garrett ES, Sieber AN, Kostuik JP (2000) Cauda equina syndrome secondary to lumbar disc herniation: a meta-analysis of surgical outcomes. *Spine* 25(12):1515–1522
7. Kirkpatrick JS (2003) Thoracolumbar fracture management: anterior approach. *J Am Acad Orthop Surg* 11(5):355–363. <https://doi.org/10.5435/00124635-200309000-00008>
8. Kim BG, Dan JM, Shin DE (2015) Treatment of thoracolumbar fracture. *Asian spine journal* 9(1):133
9. Harrop JS, Hunt GE, Vaccaro AR (2004) Conus medullaris and cauda equina syndrome as a result of traumatic injuries: management principles. *Neurosurg Focus* 16(6):1–23
10. Zhou Z, Song Y, Cai Q, Li T, Liu H (2011) Penetrating injury of rectum and vertebral body by steel bar causing cauda equina syndrome. *Spine* 36(12):E803–E807
11. Balasubramanian K, Kalsi P, Greenough CG, Kuskoor Seetharam MP (2010) Reliability of clinical assessment in diagnosing cauda equina syndrome. *Br J Neurosurg* 24(4):383–386
12. Todd NV (2005) Cauda equina syndrome: the timing of surgery probably does influence outcome. *Br J Neurosurg*. <https://doi.org/10.1080/02688690500305324>
13. Kohles SS, Kohles DA, Karp AP, Erlich VM, Polissar NL (2004) Time-dependent surgical outcomes following cauda equina syndrome diagnosis: comments on a meta-analysis. *Spine* 29(11):1281–1287
14. Chau AMT, Xu LL, Pelzer NR, Gragnaniello C (2014) Timing of surgical intervention in cauda equina syndrome: a systematic critical review. *World Neurosurg* 81(3–4):640–650
15. Simpson RK Jr, Venger BH, Narayan RK (1989) Treatment of acute penetrating injuries of the spine: a retrospective analysis. *J Trauma* 29(1):42–46
16. Lee KH, Lin JS, Pallatroni HF, Ball PA (2007) An unusual case of penetrating injury to the spine resulting in cauda equina syndrome: case presentation and a review of the literature. *Spine (Phila Pa 1976)*. <https://doi.org/10.1097/BRS.0b013e3182067a01>
17. Mikami Y, Tasaki A, Morita W, Kuroda E, Hoshikawa Y (2012) Penetrating injury to the cauda equina: a case report and review of the literature. *J Spinal Disord Tech*. <https://doi.org/10.1097/BSD.0b013e3182067a01>
18. Held M, Laubscher M, Navsaria P, Dunn RN (2012) An unusual case of a transabdominal, transdiscal stab wound to the spine. *SA Orthopaedic J* 11(4):61–64
19. Mobbs RJ, Phan K, Malham G, Seex K, Rao PJ (2015) Lumbar interbody fusion: techniques, indications and comparison of interbody fusion options including PLIF, TLIF, MI-TLIF, OLIF/ATP, LLIF and ALIF. *J Spine Surg* 1(1):2
20. Wood KB, DeVine J, Fischer D, Dettori JR, Janssen M (2010) Vascular injury in elective anterior lumbosacral surgery. *Spine* 35(9S):S66–S75
21. Kingwell SP, Curt A, Dvorak MF (2008) Factors affecting neurological outcome in traumatic conus medullaris and cauda equina injuries. *Neurosurg Focus* 25(5):E7

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