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Case Report

Treatment strategy on traumatic mid-lumbar spondyloptosis with concomitant multiple injuries: A case report and literature review

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ABSTRACT

Spondyloptosis in the clinic is rarely reported. We herein present a 47-year-old female, who suffered from a crush injury directly by a heavy cylindrical object from the lateral side. She was diagnosed to have traumatic L₃ spondyloptosis with multiple traumas. Staged surgical procedures were conducted and a three-year follow-up was obtained. Eventually, normal spinal alignment was restored, and neurological deficits were gradually improved. At three years follow-up, the motor strength scores and function of the sphincters were incompletely improved. Previously published reports on traumatic lumbar spondyloptosis were reviewed and several critical points for management of this severe type of spinal injury were proposed. First, thoracolumbar and lumbosacral junction were mostly predilection sites. Second, numerous patients involving traumatic lumbar spondyloptosis were achieved to American Spinal Injury Association grade A. Third, lumbar spondyloptosis was commonly coupling with *cauda equina* injury. Finally, the outcomes were still with poorly prognosis and recovery of patients was correlation to spondyloptosis severity. Based on this case report and literatures review, we highlighted that the spinal alignment restoration relying on staged operations and following rehabilitation hereof are both important once facing with multiple traumas. Furthermore, we suggested to perform routine CT angiography during lumbar spondyloptosis to justify whether there are large vessel compression or injury.

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Introduction

According to Meyerding classification, spondyloptosis is described as a unique Grade V spondylolisthesis, which presents as beyond 100% subluxation and dislocation during two vertebrae.¹ Although spondyloptosis cases are rarely reported in the clinic, this injury still needs to be stressed in view of the poor prognosis and outcomes due to the complete loss of spinal column alignment.²

The characteristics of spondyloptosis mainly include congenital dysplasia of the spinal column, high-energy trauma, infective disorders, ever-evolving degeneration, and neurofibromatosis.^{3–5} For traumatic spondyloptosis, traffic accidents and fall from height are major causing factors.⁶ Traumatic spondyloptosis is rigidly associated with neurological deficits, resulting in paraplegia in about 80% of cases.⁷ Herein, we report a rare severe case of traumatic mid-lumbar spondyloptosis with multiple traumas. Staged surgical

operations were performed. At three years follow-up, the patient's neurological function was partially improved. This report also reviewed related literatures on traumatic lumbar spondyloptosis and proposed several specific points on the management of mid-lumbar traumatic spondyloptosis.

Case report

A 47-year-old female sustained a crush injury by a heavy cylindrical object from her right side. The patient complained of severe lower back pain, right shoulder pain, and thoracalgia. Radiological examinations in local hospital revealed multiple injuries, comprising L₃ vertebra fracture-dislocation, scapular fracture, rib fractures, and left femoral shaft fracture (Fig. 1).

The patient was managed following the advanced trauma life support protocol in the local hospital and then was transferred to our hospital for further treatment. Making an accurate diagnosis commonly depends on the stability of vital signs and a comprehensive evaluation rely on damage control. On admission, the patient was conscious and hemodynamically stable, classified as American spinal injury association (ASIA) grade A. In this patient, injury severity score (ISS) and abbreviated injury score (AIS)

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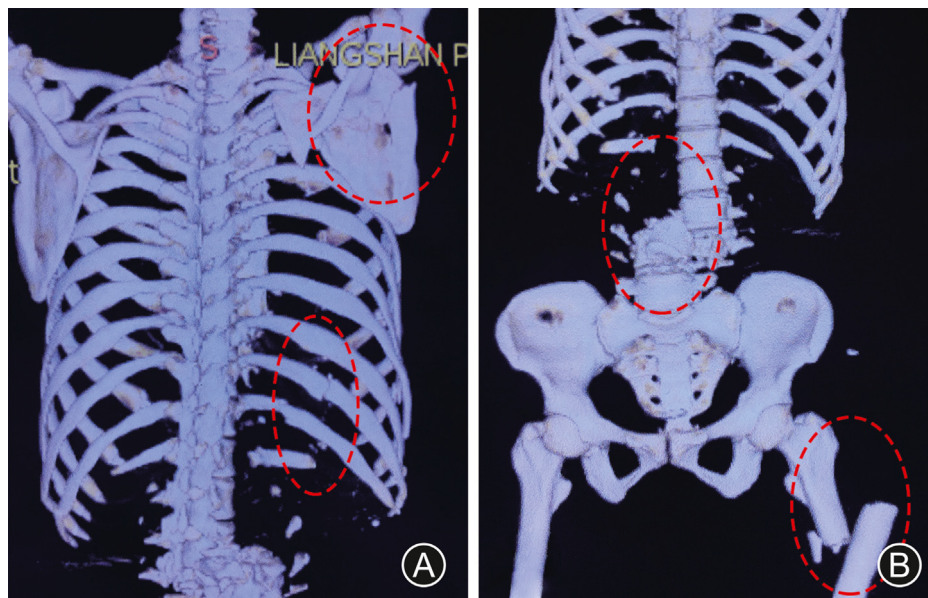


Fig. 1. Three-dimensional reconstruction of CT scans in local hospital. Scapular fractures and rib fractures (A), L₃ spondyloptosis combined with proximal femoral fracture and lumbar vertebra fracture (B) were enclosed by the red ellipse.

reached 43 and 15 respectively so that regarded as severe injury. Physical examination found shortened, swollen, and malformed left lower extremity. There exists paraparesis, including limited activity in the bilateral lower extremity and dysfunctional urination and defecation. Perirectal sensation diminished and anal sphincter tone was absent. Spinal CT indicated a complete anterior spondyloptosis of L₃ to inferior vertebral body, and concomitant fractures. The L₃ vertebra was downright parallel to L₄ vertebra (Figs. 2A–C). L₃ vertebral fracture was confirmed by three-dimensional reconstruction (Fig. 2D). But the anterior dislocation of lumbar vertebra associated with vertebral body fracture and the position with large vessels required to be further clarified. As a result, compression of both inferior vena cava and abdominal aorta was implied on consecutive CT axial planes and CT angiography (Figs. 2E and F). Blood test showed an elevated level of D-dimer.

The strategy of staged surgical procedures was drafted in concept of orthopedic damage control. The L₃ spondyloptosis was closely adjacent to the inferior vena cava and abdominal aorta, leading to thrombosis of the left common iliac vein. The risk of perioperative incidence of pulmonary embolism (PE) was significantly increased. Venography demonstrated filling defect at the origin of the inferior vena cava and the lumen stenosis was about 90% (Supplementary video). Therefore, inferior vena cava filter was implanted through the internal jugular vein (Figs. 3A and B). To stabilize the spinal alignment, posterior bilateral pedicle screw fixation and rods construction were performed on segments L₁, L₂, L₄, and L₅ vertebral bodies in prone position (Figs. 4A–C). Intraoperatively it was found that the *cauda equina* was injured and right nerve root of L₃ was lacerated. A tiny tear of the dura mater was noted, which was covered with gelatin sponge. Layer by layer watertight sutures were ensured. Fortunately, there was no postoperative cerebral spinal fluid leakage. Satisfactory spinal sagittal balance was restored.

Postoperative CT and three-dimensional reconstruction of CT angiography demonstrated that the main body of the fractured L₃ vertebrae was retracted a little while at the expense of graver compression of the abdominal large vessels (Figs. 4D–F).

A II stage surgical intervention was performed on postoperative day 5. After anesthesia, the patient was placed in right lateral prone position, and the femoral shaft fracture was fixed by anterograde

intramedullary interlocking nail. Further anterior spinal exposure was carried out through left anteriorlateral approach. Intraoperatively, it was observed that the abdominal aorta was elevated by the dislocated vertebrae body of L₃. Then the completely fractured L₃ vertebrae body was removed en bloc (Fig. 5A) and a cage of 26 mm in diameter with cancellous bone from L₃ vertebrae was implanted between L₂ and L₄ (Fig. 5B). Reconstruction of the anterior sagittal spinal balance was enhanced by pedicle screw system, which has been implanted into L₂ and L₄. Postoperative radiography (Figs. 5C and D) demonstrated a restored stability of the spine and decompression. The patient was discharged and referred for further rehabilitation in a local hospital.

Scheduled postoperative course was obtained. The patient returned for removal of the inferior vena cava filter at 1 month after the primary surgery. At 6-month follow-up, the patient's neural compromise had a gradual improvement. The patient had motor strength scores of 4/5 in left hip flexors and knee extensors, and 3/5 in foot dorsiflexion and plantar flexion, while 2/5 in right lower extremities (Figs. 6A and B). However, perirectal sensation was still diminished accompanied with overflow incontinence and relaxation of the anal sphincter tone. Sensation at the right lower limb (right medial and left lateral zone) disappeared. Plain radiography (Fig. 6C) and CT sagittal reconstruction (Fig. 6D) indicated a stabilized spinal alignment balance.

Discussion

In this report, we described a rare severe traumatic mid-lumbar spondyloptosis case with multisystem damages. The shear-type mechanism of injury was caused by lateral crushing from the right side. The fractured L₃ vertebral body was dislocated in front of L₄ vertebra, meanwhile, the L₂ vertebral body was displaced laterally with respect to the L₃ vertebra body. In this rare situation, there were two types of spondyloptosis including L_{2/3} in coronal plane and L_{3/4} in sagittal plane, which had not been reported in the literatures before. The fractured L₃ vertebral body was a free bone fragment without any connection to adjacent vertebrae. In this special situation, vertebral displacement cannot be completely corrected through single posterior surgical approach. The staged surgical strategy combined with anterior-posterior pedicle screw

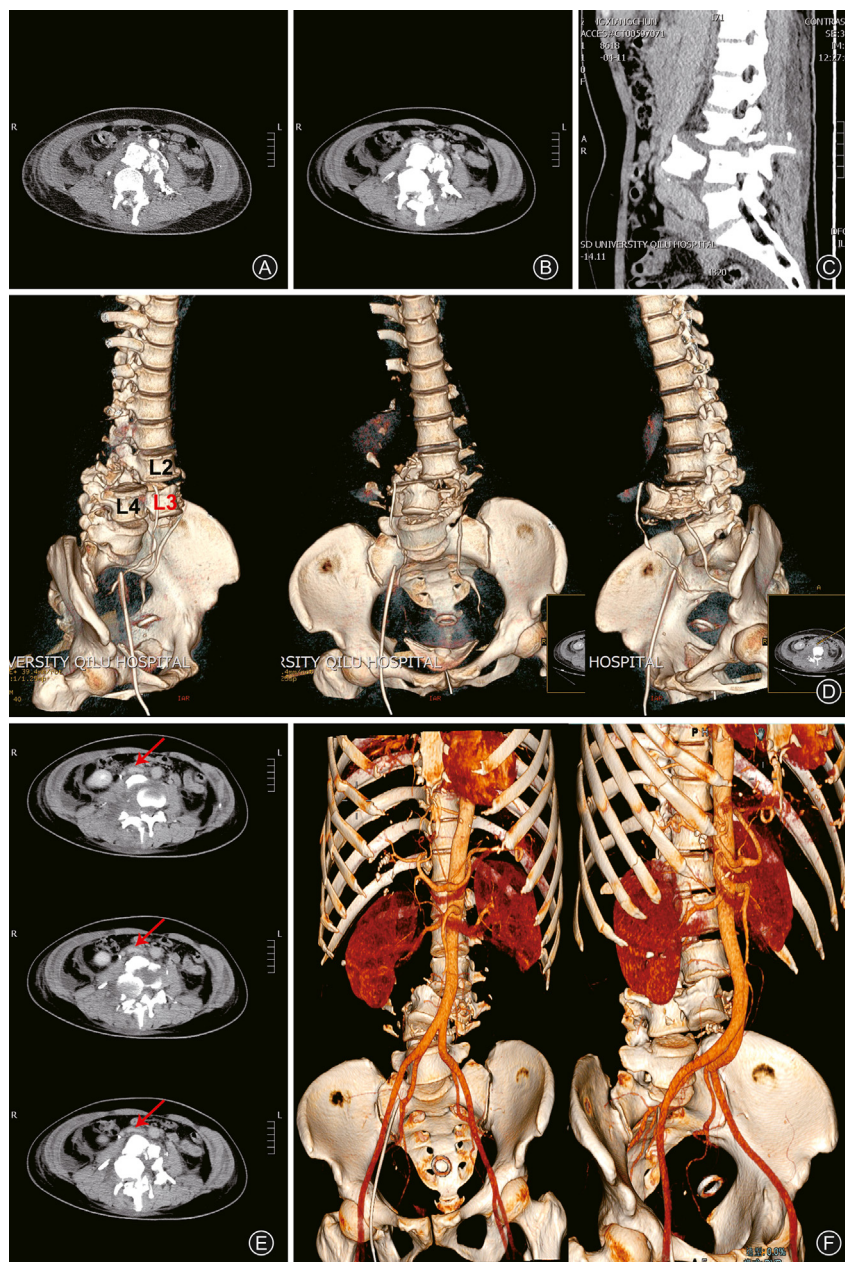


Fig. 2. Detailed L₃ spondyloptosis and its relationship with anterior large vessels. Complete anterior spondyloptosis of L₃ was confirmed by two separate intensified or non-intensified CT planes (A and B), sagittal scan (C) and reconstruction images (D). Further CT angiography was conducted, compression of large vessels comprising both inferior vena cava and abdominal aorta were discovered from several CT axial planes (E) and reconstruction images (F).

systems was the definitive fixation plan for this challenging traumatic spondyloptosis cases. Segmental of spinal fusion is determined by the severity of the traumatic spondyloptosis. In this case, posteriorlateral fusion in L₁₋₅ levels and anterior fusion in L₂₋₄ levels were applied respectively. Stabled segmental fixation systems restored the spinal sagittal and coronal balance to facilitate rehabilitation.

According to the available literatures, a total of 40 traumatic lumbar spondyloptosis cases (from year 1999–2020) have been reported.^{1,2,6,8–29} Their demographics and clinical characteristics are shown in Table 1. Herein, the age range of patients reported previously was 3–56 years. Among them, males contributed the majority, 82.5%. Motor vehicle accident (25%), fall from height (25%), and crushing accident (22.5%) were the main causes. The injury mechanism is attributed to severe shear force and

hyperextension. Moreover, thoracolumbar junction (25%) and lumbosacral junction (27.5%) were mostly predilection sites which may be closely association with structural development. About 35% patients with traumatic lumbar spondyloptosis had concomitant severe injuries. In addition, about 75% patients involved in traumatic lumbar spondyloptosis achieved ASIA grade A and only a few of them escaped the disaster of paraplegia of the lower extremity. Furthermore, lumbar dislocation-fracture was commonly coupled with *cauda equina* injury, leading to micturition and defecation problems. Collectively, surgical interventions, involving anterior, posterior, or combined anterior-posterior pedicle screw systems, are the most common approaches for spondyloptosis management. Finally, the prognosis was poor and the recovery of patients was correlated with the spondyloptosis severity.

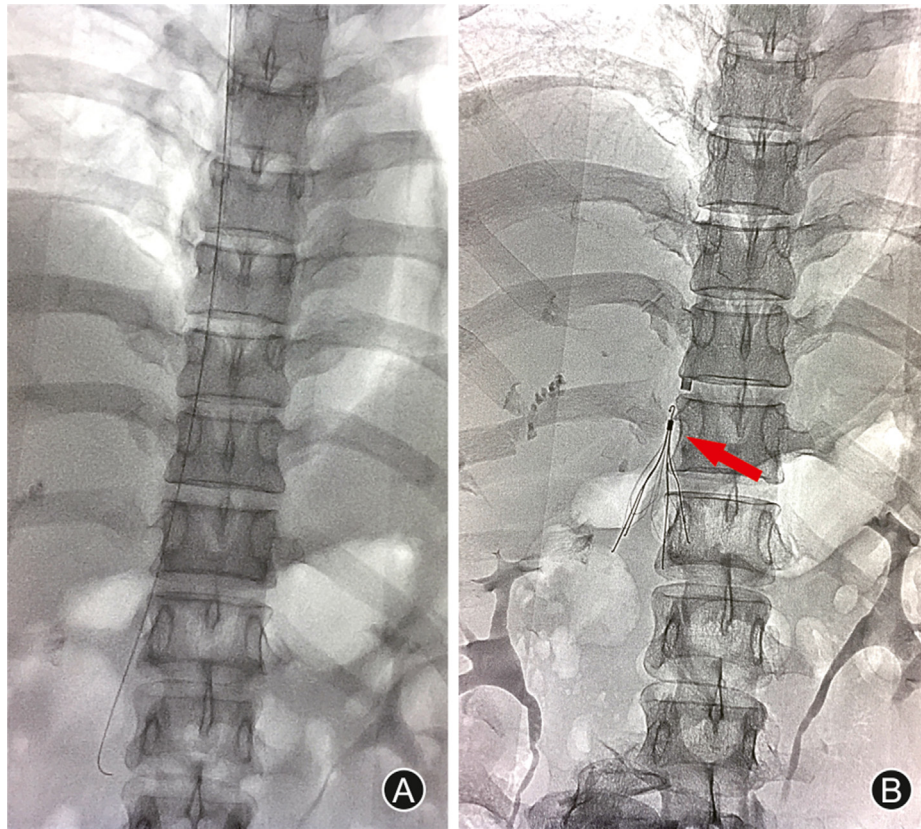


Fig. 3. The placement of vena cava filter. To prevent thrombosis caused by vascular stenosis, a vena cava filter was imbedded into the inferior vena cava and the position was ensured (A and B).

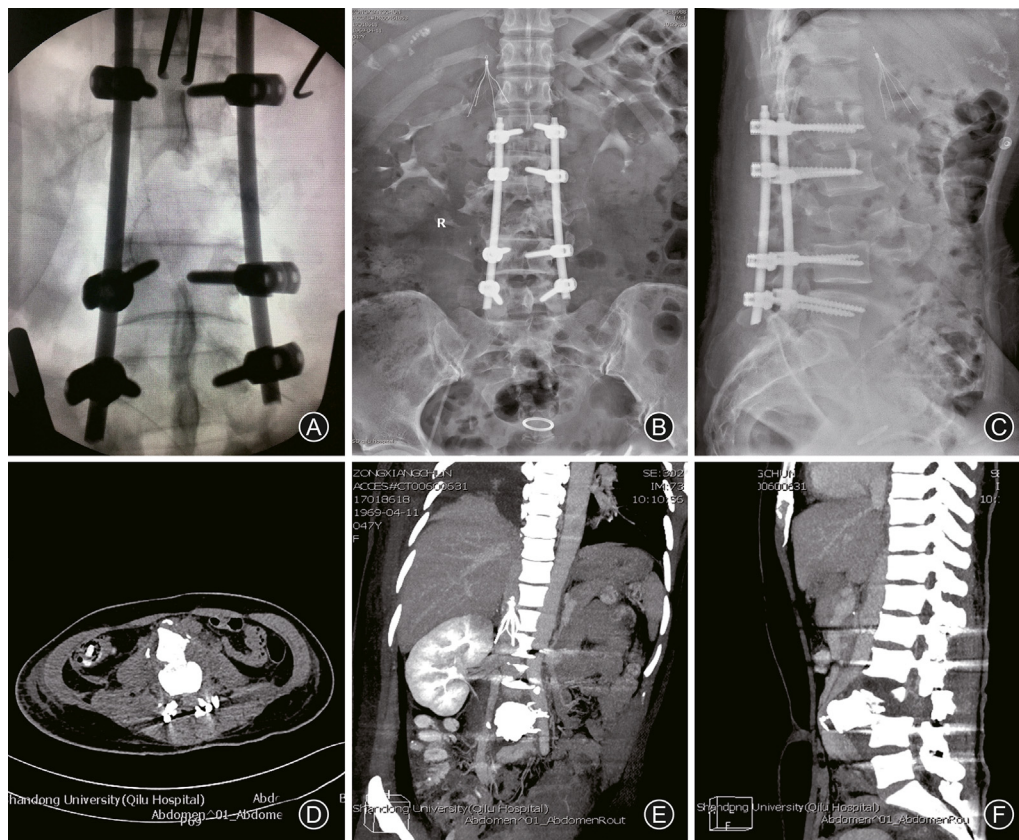


Fig. 4. First posterior internal fixation. To stabilize the spinal alignment balance, posterior bilateral pedicle screw fixation and rods construction were performed on segment L₁, L₂, L₄, and L₅ vertebral bodies. Intraoperative fluoroscopy (A) and postoperative radiography, coronal (B) and sagittal (C), demonstrated successful restoration. Cut plane (D), coronal (E) and sagittal (F) CT scan revealed a mild retraction of L₃ vertebra.

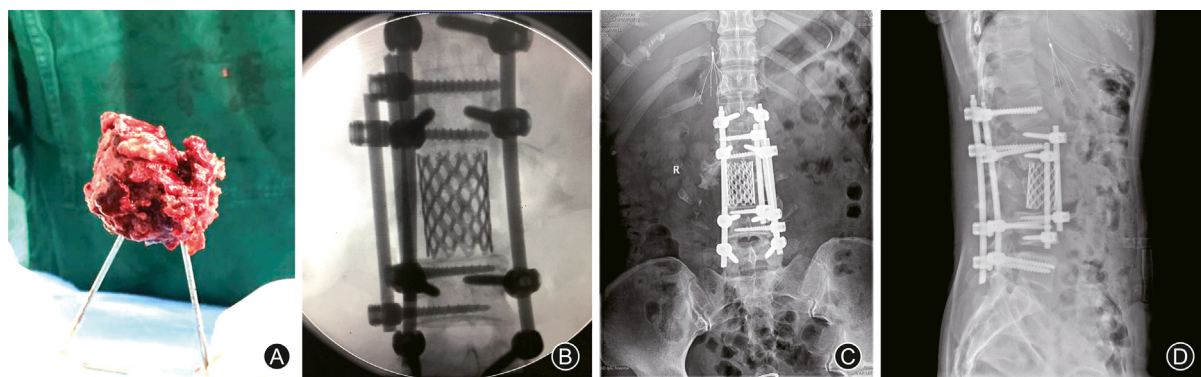


Fig. 5. Second anterior internal fixation. We performed vertectomy of the fractured L₃ vertebrae body (A) and placed a cage between L₂ and L₄ (B). Morselized bone harvested from L₃ was packed into cage. The spinal alignment was restored as implied by postoperative radiography plain of coronal (C) and sagittal (D).

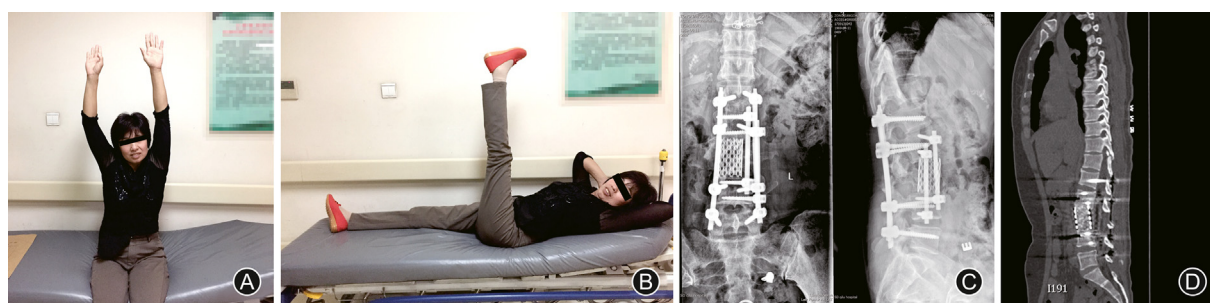


Fig. 6. Rehabilitation functions at postoperative 6-month follow-up. At postoperative 6-month, this patient was identified to have incomplete neurological improvement (A and B). Postoperative radiography plain (C) and CT scan (D) demonstrated a stable spinal alignment.

Table 1

Previous reported traumatic lumbar spondyloptosis.

Year	Authors	Age (year)	Gender	Mechanism of Injury	Affected level	Other severe injuries	ASIA grade	Neurological deficits	Surgical treatment	Outcomes
1999	Kaplan et al. ⁸	18	M	MVA	L ₅ -S ₁	None	NA	Yes	First L ₄ -L ₅ and L ₅ -S ₁ discectomy, L ₅ and S ₁ laminectomy, posterior PSF at L ₃ , L ₄ , and S ₁ , arthrodesis from L ₄ -S ₁ ; Second tibial allograft, anterior fixation of L ₄ and S ₁	Ambulation recovered
2003	Meneghini and DeWald ⁹	15	F	MVA	L ₅ -S ₁	None	A	Yes	Posterior PSF of L ₄ , L ₅ , and S ₁ , intrasacral fixation by Cotrel-Dubousset instrumentation	Partial neurological improvement
2007	Bellew and Bartholomew ²	36	F	MVA	L ₂ -L ₃	Open knee joint	A	Yes	Laminectomy of L ₂ , posterior PSF of T ₁₁ -L ₁ and T ₃ -S ₁ , autograft	Complete neurological improvement
2008	Yadla et al. ¹⁰	21	M	MVA	L ₁ -L ₂	Pneumothorax, renal and splenic laceration and scapular fracture	C	Yes	Early splenectomy, posterior T ₁₀ -L ₄ fusion, L ₁ -L ₃ laminectomy, partial L ₁ -L ₂ corpectomy	Ambulation recovered
		44	M	Roof collapse	T ₁₂ -L ₁	Significant scalp laceration	A	Yes	Posterior T ₁₀ -L ₃ fusion, anterior T ₁₁ -L ₂ fusion, partial L ₁ corpectomy	No neurological improvement
2009	Daniels et al. ¹¹	38	M	MVA	L ₄ -S ₁	None	E	No	First laminae, pedicles, and facet joints of L ₄ -L ₅ were excised, posterior PSF of L ₂ -S ₁ , L ₂ -L ₃ posterior arthrodesis; Second anterior discectomy and fusion	Unchanged

(continued on next page)

Table 1 (continued)

Year	Authors	Age (year)	Gender	Mechanism of Injury	Affected level	Other severe injuries	ASIA grade	Neurological deficits	Surgical treatment	Outcomes
2009	Cherian and Dhawan ¹²	4	F	FFH	L ₁ -L ₂	None	A	Yes	of L ₃ -L ₄ , L ₄ -L ₅ , and L ₅ -S ₁ L ₂ and L ₃ laminectomy, laminar hooks and rods fixation	Left limb neurological improvement
2009	Verhelst et al. ¹³	6	M	CA	L ₅ -S ₁	Morel-Lavallée lesion over the left hip and gluteal area	A	Yes	L ₄ -S ₁ laminectomy, posterior PSF of L ₃ , L ₄ , S ₁ , and S ₂	No neurological improvement
2010	Zhou et al. ¹⁴	19	M	CA	L ₄ -L ₅	None	A	Yes	Laminectomy, foraminotomy, posterior PSF of L ₄ -L ₅ , interbody fusion between L ₄ and L ₅ , bilateral posterolateral arthrodesis by autograft from posterior iliac crest and the laminectomy of L ₅ vertebral body	Complete neurological improvement
		13	M	RTA	L ₄ -L ₆	None	A	Yes	Posterior laminectomy of L ₅ vertebral body, PSF of L ₃ , L ₄ , and S ₁ , bilateral posterolateral arthrodesis by autograft from posterior iliac crest and the laminectomy of L ₅ vertebral body	Complete neurological improvement nearly but with right drop-foot
2011	Chandrashekhara et al. ¹	10	M	CA	L ₄ -L ₅	None	A	Yes	L ₂ , L ₃ , L ₄ , and L ₅ PSF and rod connection	Mild improvement
		16	M	MVA	L ₃ -L ₄	None	A	Yes	PSF at L ₁ -L ₂ and L ₄ -L ₅	No improvement
		20	M	FFH	T ₁₂ -L ₁	None	A	Yes	PSF at T ₁₁ and L ₂	No improvement
2011	Wilkinson et al. ¹⁵	16	F	MVA	L ₃ -L ₄	Right ulnar fracture and ischial avulsion fracture, pneumothorax, right adrenal hemorrhage, hepatic contusion, and retroperitoneal hematoma	A	Yes	PSF of L ₁ -L ₃ , L ₅ -S ₁ , and the iliac crests, laminectomy from L ₃ to L ₅ , distractible cage placed with local autograft from the vertebrectomy of L ₄	Incomplete neurological improvement
2012	Wangtaphan et al. ¹⁶	45	M	Roof collapse	L ₅ -S ₁	None	A	Yes	Lumbar and sacral in situ stabilization by L ₃ and S ₁ PSF, L ₅ -S ₁ fusion by L ₅ vertebral autograft	Complete neurological improvement
2013	Goni et al. ¹⁷	32	M	CA	L ₅ -S ₁	None	E	Yes	None	Free from low back pain
2013	Francis et al. ¹⁸	19	M	MVA	L ₃ -L ₄	Bilateral pulmonary contusions	B	Yes	PSF of L ₁ -L ₂ and L ₄ -L ₅ , autograft	NA
2014	Akesen et al. ¹⁹	28	M	CA	L ₅ -S ₁	None	E	No	First laminectomy of L ₅ and inferior and superior parts of the laminae of L ₄ and S ₁ , posterior instrumentation from L ₄ -S ₁ ; Second anterior lumbar interbody fusion	Fecal and urinary incontinence improvement
2014	Amesiya et al. ²⁰	38	M	Concrete wall collapse	L ₄ -L ₅	None	A	Yes	L ₄ laminectomy, PSF of L ₄ -L ₅	Partial neurological improvement
2015	Baek et al. ²¹	57	M	CA	L ₅ -S ₁	Crescent fracture of the pelvis	A	Yes	Posterior bilateral L ₄ , L ₅ , and S ₁ PSF and iliac screws fixation	Incomplete neurological improvement
2015	Mishra et al. ⁶	45	M	RTA	T ₁₂ -L ₁	Retroperitoneal hematoma	A	Yes	L ₂ -L ₃ laminectomy	No improvement
		25	M	FFH	L ₁ -L ₂	None	A	Yes	L ₁ -L ₂ laminectomy, T ₁₁ -T ₁₂ and L ₁ -L ₂ PSF	No improvement
		20	M	FFH	T ₁₂ -L ₁	None	A	Yes	T ₁₂ -L ₁ laminectomy, T ₁₀ -T ₁₁ and L ₁ -L ₂ PSF	No improvement, leg amputation due to bed sore
		18	M	FFH	L ₁ -L ₂	T9 compression fracture	A	Yes	L ₂ corpectomy, T ₁₂ -L ₁ and L ₃ -L ₄ PSF	Death
		35	M	FFH	T ₁₂ -L ₁	None	A	Yes	T ₁₁ -L ₃ laminectomy, L ₁ partial corpectomy, T ₁₁ -T ₁₂ to L ₂ -L ₃ PSF	No improvement
		12	M	CA	L ₄ -L ₅	None	A	Yes	L ₂ -L ₅ PSF	

Table 1 (continued)

Year	Authors	Age (year)	Gender	Mechanism of Injury	Affected level	Other severe injuries	ASIA grade	Neurological deficits	Surgical treatment	Outcomes
		30	M	RTA	T ₁₂ -L ₁	Right-side pneumothorax	A	Yes	T ₁₂ , L ₁ , and L ₃ -L ₄ PSF	No improvement, development of lumbar hernia
		40	M	FFH	L ₁ -L ₂	None	A	Yes	T ₁₁ -T ₁₂ and L ₁ -L ₂ PSF	No improvement
		25	M	RTA	T ₁₂ -L ₁	Head injury	A	Yes	Partial L ₁ corpectomy, L ₁ laminectomy, T ₁₁ -L ₂ PSF	Death
		35	M	CA	L ₁ -L ₂	None	A	Yes	T ₁₁ -T ₁₂ and L ₃ -L ₄ PSF	Death
		22	F	FFH	T ₁₂ -L ₁	None	A	Yes	T ₁₁ -T ₁₂ and L ₁ -L ₂ PSF	No improvement
2015	Sandquist et al. ²²	20	M	MVA	T ₁₂ -L ₁	None	A	Yes	L ₁ vertebrectomy, PSF of T ₈ -L ₄ , T ₁₂ -L ₂ interspace autograft from L ₁ vertebrectomy	No neurological improvement
2015	Gabel et al. ²³	27	M	MVA	L ₅ -S ₁	Massive trauma to the right lower quadrant of the abdomen	A	Yes	L ₂ to sacroiliac posterior instrumented fusion with L ₅ vertebrectomy and placement of an interbody cage	No neurological improvement
2017	Tandon et al. ²⁴	3	F	Fall on the ground	L ₅ -S ₁	None	E	No	Posterior L ₃ -S ₂ PSF	Pain-free
2018	Yamaki et al. ²⁵	4	F	Wall collapse	L ₅ -S ₁	None	D	No	L ₅ -S ₁ disectomy, anterior plaque fixation of L ₅ -S ₁ , L ₄ -L ₅ laminectomy, PSF at L ₂ -L ₃ and a crest iliac screw fixation	No improvement
2018	Garg et al. ²⁶	18	M	RTA	L ₁ -L ₂	None	A	Yes	T ₁₂ -L ₁ and L ₃ -L ₄ PSF, L ₂ corpectomy	No improvement
		50	M	RTA	T ₁₂ -L ₁	None	A	Yes	T ₁₀ -T ₁₂ and L ₂ -L ₃ PSF, L ₁ corpectomy	No improvement
2019	Cabrera et al. ²⁷	42	M	CA	L ₃ -L ₄	Ribs fracture, left hemopneumothorax, retroperitoneal hematoma	NA	Yes	L ₃ vertebrectomy, Installation of an expandable cage between L ₂ and L ₄ , posterior and anterior PSF at L ₂ and L ₄	Partial neurological improvement
2020	Xu et al. ²⁸	42	M	FFH	L ₃ -L ₄	None	E	No	L ₃ -L ₄ fusion, PSF at L ₂ -L ₄ and S ₁	Pain-free
2020	Zhao and Lan ²⁹	56	M	FFH	L ₂ -L ₃	Ribs fracture, right hemopneumothorax	A	Yes	L ₂ corpectomy, L ₂ vertebra body in situ autograft, T ₁₂ to L ₄ posterior fusion	Partial neurological improvement

ASIA: American spinal injury association M: male; F: female; MVA: motor vehicle accident; FFH: fall from height; CA: crushing accident; RTA: road traffic accident; NA: not available; PSF: pedicle screw fixation.

Spondyloptosis leads to severe spinal mal-alignment, sagittal or coronal planes dislocation.^{2,14} The occurrence position of spondyloptosis could be unequivocally on cervical, thoracic, lumbar, or even sacral spine through radiological examinations, resulting in serious neurological deficits.^{18,30–32} Current surgical interventions are commonly conducted on reduction of spine column as well as decompression and stabilization of associated dislocation-fracture segments. Notably, the following rehabilitation trainings are important to the grade of neurological improvements, whereas, the recovery outcomes tend to be patient specific. Based on previously published studies, conservative treatment is not recommended for spondyloptosis irrespective of symptoms status. A persistent unstable spinal alignment eventually leads to spinal deformity (kyphosis or lordosis), which might be associated with low back pain.^{16,33} Meanwhile, early surgical reduction may be beneficial by improving neurological symptoms.

Spondyloptosis located on mid-lumbar spine is sparse in the clinic. Considering that the anatomic situations of large vessels such as abdominal aorta and inferior vena cava are closely contiguous to lumbar vertebrae.¹⁸ The major issue is to imperil large

vessels in abdomen on extrusion and even rupture threat. Overall anterior, posterior or lateral dislocation of superior vertebral body for inferior vertebra exacerbate volume jostling at the same segmental axial plane. Lumen stenosis and congestion of large vessels is advantageous to thrombosis formation which is causative for pulmonary embolism attack that serves as the most troublesome for survival. Moreover, bony fragments from vertebra fractures are easily embed in these vessels that lead to unbearable results. Therefore, routine CT angiography is suggested to evaluate whether large vessel injury exist in terms of the considerations above.

Traumatic mid-lumbar spondyloptosis with polytrauma is a challenging situation to manage in the clinic. Herein, we presented a case of a complete L₃ spondyloptosis combined with polytrauma through the whole body. The current report mainly focused on spondyloptosis and combined injuries according to the concept of damage control orthopaedics. The spinal alignment restoration relying on individual staged operations and subsequent rehabilitation are the key points. For patients with multiple injuries, especially those with spinal fractures and dislocations, it is

necessary to pay attention to the first choice of early appropriate spinal intervention and to evaluate the degree of pressure near the vessels by computed tomography angiography before operation. These patients are mostly at a high risk for deep vein thrombosis and pulmonary embolism. It is recommended to implant intravenous vena cava filter through internal jugular vein. Meanwhile, for patients with better functional recovery, an observation of the posterolateral spinal fusion in the follow-up process is essential to avoid failure of spinal implant fixation.

Taken together, based on the major premise of stable vital signs, strategy of staged surgical procedures for spondyloptosis is dominate in terms of orthopedic damage control. Early spinal alignment reestablishment is commonly regarded as the superior choice relative to the fixation of limb fractures in spondyloptosis which accompanied with concomitant multiple injuries. Ultimately, the imperative of postoperative rehabilitation exercise is also critical for the functional recovery.

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Nil.

Ethical statement

This study was approved by the Institution Review Board of Qilu Hospital of Shandong University and written informed consent was obtained from this patient.

Declaration of competing interest

The authors declare that they have no competing interests.

Author contributions

Lin Cheng and Cheng Qiu conducted literature research, collected data, and drafted and revised the manuscript. Xin-Yu Liu and Xi-Guang Sang revised the manuscript. All authors read and approved the final version of manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.cjtee.2022.06.006>.

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