Transforaminal Interbody Fusion

Yong Soo Choi and Sang-Ho Lee

Introduction

Transforaminal lumbar interbody fusion (TLIF) was first popularized by the modification of posterior lumbar interbody fusion (PLIF) by Harms et al. [1], Which overcomes the problem of neural retraction. TLIF is a surgical technique that can achieve anterior column stability with posterior screw fixation through postero-lateral approach [2]. In recent times, TLIF is being performed by numerous spinal surgeons. The TLIF technique for thoracic spine has been undergoing since 2005 [3]. A modified transfacet pedicle-sparing decompression and fusion for TDHs was reported by Bransford et al. [4]. Machino et al. reported transforaminal thoracic interbody fusion (TTIF) including three patients with TDH [3].

Transforaminal thoracic interbody fusion (TTIF) is one of the minimal invasive spinal surgery to treat thoracic pathologies. The advantages of minimal invasive surgical procedures include less soft tissue injury, decreased blood loss, decreased hospital length of stay, and earlier recovery while resulting in clinical outcomes similar to the equivalent open procedure [5].

Y. S. Choi (✉) · S.-H. Lee
Department of Neurosurgery, Chungdam Wooridul Spine Hospital, Seoul, Korea
e-mail: yong@wooridul.co.kr

The posterior lateral transforaminal approach allows the lesion to be seen directly and the intervertebral disc can be easily removed even if the disc has escaped and attached to the dura mater. In addition, the operation is relatively simple with a low recurrence rate [6].

The use of TTIF technology has several advantages compared to other previously described techniques for accessing the thoracic disc space. The TTIF approach reduces lung morbidity compared to the open or laparoscopic thoracic approach [7].

In the present study, the clinical results of TTIF were comparable with the results of anterior spinal fusion (ASF) and anterior-posterior combination surgery in terms of surgical invasion, improvement of neurological deficits, and bone fusion. The postoperative recumbent period was significantly shorter in TTIF compared to ASF. Although TTIF was able to correct the local kyphotic angle by 6° on average, a few corrective losses were observed during the follow-up period, which was similar to the results in ASF and A-P combined surgery [3].

TTIF achieves posterior decompression and fixation with instrumental fusion, anterior decompression, and reconstruction of the anterior column by interbody fusion. This procedure is able to provide postoperative early ambulation without respiratory problems. TTIF can be a useful option for decompression and reconstructive surgery of the thoracic spine [3].

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Indications

The indications of transforaminal thoracic interbody fusion are as follows :

- Disc herniation
- Spinal instability (Degenerative or traumatic)
- Spinal canal stenosis
- Fracture and dislocation (e.g., Chance fracture)
- Required wide decompression (OPLL, OLF, or other neural stenoses)
- Deformity

Thoracic disc herniation is rare in comparison to cervical or lumbar disc herniation with an occurrence rate of 0.15–4.0 % of all disc herniation [8]. To treat disc herniation, TTIF is considered when nerve damage is a concern, postoperative instability is expected, or extensive neural decompression is required. Wide neural decompression without fixation may lead to spinal instability after surgery, which may result in a poor prognosis and require additional surgery. When thoracic fractures or dislocations occur, good fusion rate is obtained through interbody fusion with transforaminal approach [9]. In addition, this surgery produces a normal arrangement even for thoracic spinal malalignment.

Surgical Technique

The technique of transforaminal thoracic interbody fusion includes neural decompression, wide discectomy, placing an interbody cage, and pedicle screws fixation.

After general anesthesia induction with endotracheal intubation, the patient is placed in a prone position on a surgical table with motor evoked potentials (MEPs) and somatosensory evoked potentials (SSEPs). Neuromuscular monitoring is not essential, but it is able to be a help for safe procedures and predict the difference in nerve function before and after surgery.

Surgical level is performed with fluoroscopy or portable radiograph. After aseptic draping, a standard midline skin incision is used (Fig. 1a). Sometimes, a paraspinal skin incision can be used to approach the posterolateral direction (Fig. 1b). A midline skin incision provides a wide surgical field for neural decompression. Periosteal muscular dissection is performed to secure surgical field of laminar, facet joint, and transverse process. When bilateral decompression is necessary, periosteal muscle dissection on both sides is performed (Fig. 1c). In addition to conventional retractors, a tubular retractor may be used for minimally invasive surgery. Using mobile radiographic imaging, a tubular retractor can be placed from the skin to the surgical target to identify the lamina and the facet joint (Fig. 1d). After the posterior resection and the facet joint removal by inserting a drill and mechanical tools into the tubular retractor, the intervertebral disc removal and cage insertion can be performed by checking the neural structures.

After placement of the retractor system, entire facet joint and lamina are removed with a high-speed drill or an osteotome. The extended laminectomy would be performed for wide decompression. Ligamentum flavum is carefully removed with mechanical tools. The lateral border of dural sac, exiting nerve root, upper border of lower pedicle, lower border of upper pedicle, and intervertebral disc are identified to gain sufficient decompression and exposure (Fig. 2a). Entire facetectomy and sufficient exposure protect spinal cord and nerve root and provide safe working space. The annulus of intervertebral disc is perforated by surgical mess with protection neural structures to avoid retraction of the spinal cord (Fig. 2b). Retraction of the spinal cord on thoracic level occurs neural deficit following by spinal cord injury. A discectomy is performed using mechanical tools including pituitary rongeurs, Kerrison punch, and curette which is for end plate preparation proving graft bed to fuse vertebral body with a cage and immigrated bone that is autologous bone or allograft bone. Anterior longitudinal ligament is maintained to protect large-sized vessels and thoracic organs.

Polyetheretherketone (PEEK) cage or metal cage with autologous bone from the removed facet or allograft bone is placed between vertebral body. Curved cage or straight cage is used. In recent,

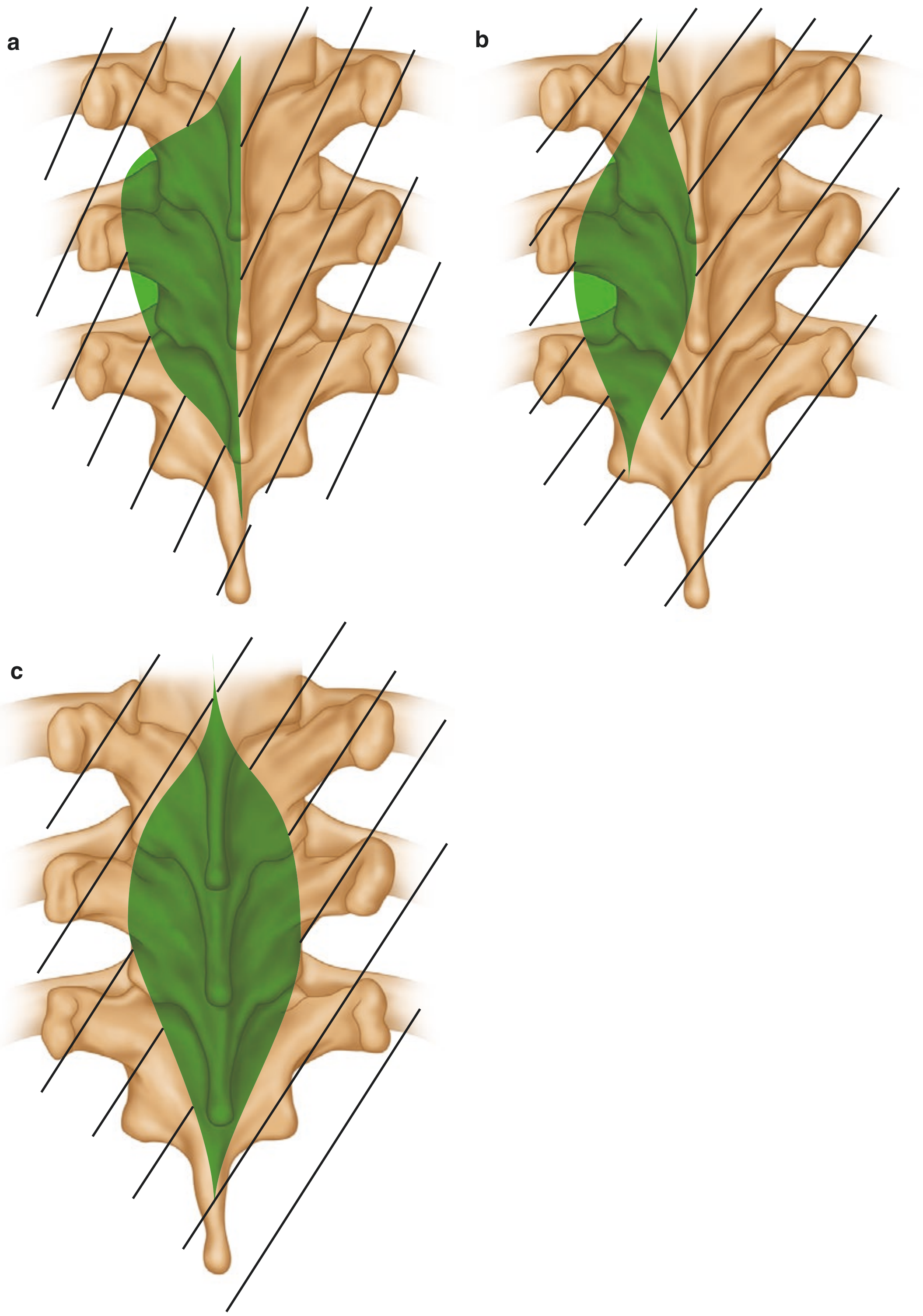


Fig. 1 (**a**) Standard unilateral midline skin incision and muscle dissection for TTIF. (**b**) Paraspinal skin incision and muscle dissection for TTIF. (**c**) Standard bilateral midline skin incision and muscle dissection for TTIF. (**d**) Application of tubular retractor for TTIF

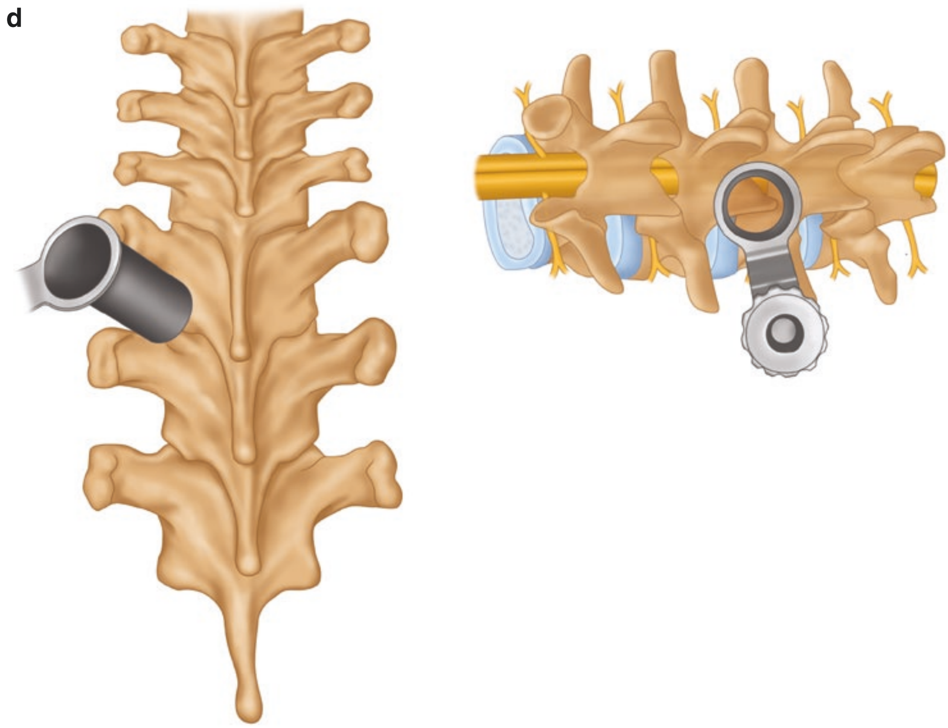


Fig. 1 (continued)

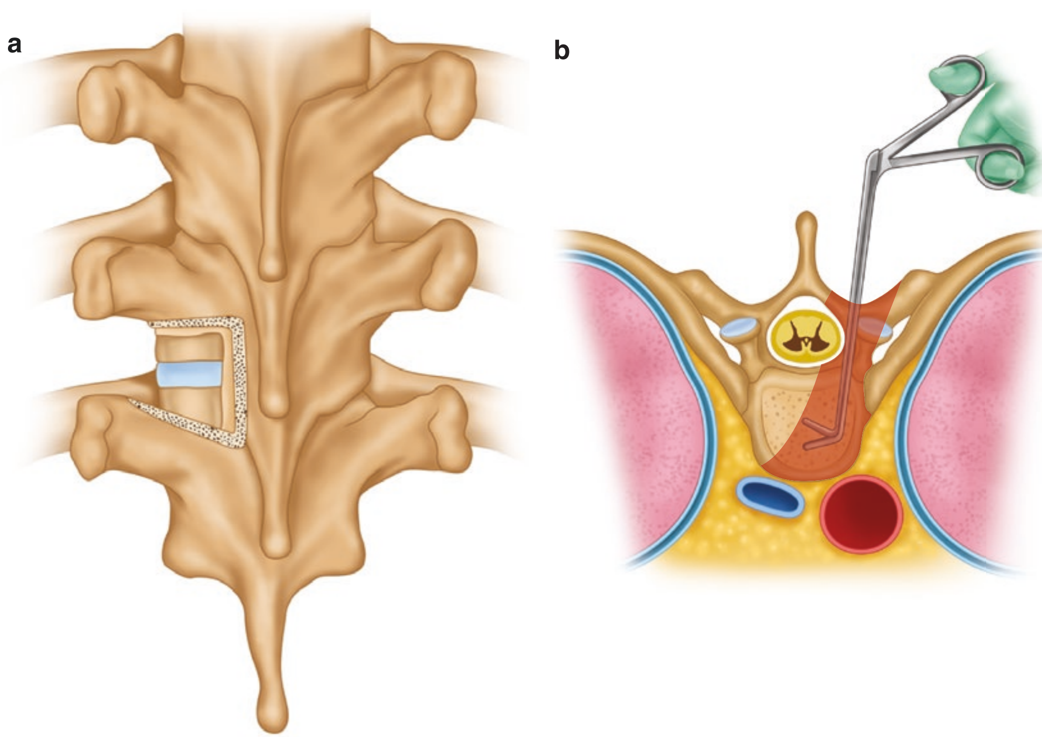


Fig. 2 (**a**) Bony resection for discectomy and interbody instrumentation. (**b**) Safety of discectomy to protect neural structures, major vessels, and respiratory structures

there are many kinds of three-dimensional printed cage. If the intervertebral space is narrow, intervertebral distractor is applied to provide enough intervertebral height for the insertion of a cage.

Pedicle screw fixation is performed at the fusion level bilaterally with a standard fashion. Percutaneous screws fixation or open screws fixation could be performed selectively. Secure and safe fixation should be considered first, followed by preservation of normal tissue with minimal invasive techniques.

Postoperative Care

Early mobilization is helpful to reduce medical complications and hospital days. Postoperative intravenous antibiotic therapy for 48 h after the surgery or until the drain catheter is removed. Radiologic findings after surgery provide to check the position of instrumentations, neural decompression, and confirming of any complications. Analgesics could be used to reduce postoperative pain of surgery site. Neurologic examination and vital signs are checked during hospital days.

Case Illustration

Case 1

A 35-year-old male complained of chest tightness, back pain, low back pain, and numbness in the limbs of the legs, showing prosthesis of both legs. His symptoms had continued to get worse gradually over the 6 months. He showed difficulty in walking due to weakness of both legs. His motor power of hip flexion was grade 3 and knee extension was grade 4 on both sides. Deep tendon reflexes were normal. On the radiologic evaluations, hard disc extrusion with spinal cord compression on left T11–12 level on the MR images and CT scan (Fig. 3a, b). The pathologic level was revealed segmental kyphosis on the simple radiography (Fig. 3c). He underwent a unilateral transforaminal thoracic interbody fusion with hard disc removal. Single straight PEEK cage packing with allograft bone was implanted and short segment percutaneous pedicle screws and rods on T11 and T12 levels were inserted (Fig. 3d, e). His symptoms were alleviated within a month and the weakness on his legs improved to normal and he could walk alone without any assistance.

Case 2

A 75-years-old female could not bend her body forward, and when she bent forward, she could not stand because of bilateral weakness on both legs. And she always had back pain, and the pain stretched to the front of her chest and was unable to do her daily life. Her symptoms worsened over the years, and she had a walking disability 3 months before she came to the hospital. When she saw the doctor at the hospital, she stood hard, and when she tried to walk, her body leaned forward, and her legs fell loose. On her MR images, The spinal cord was severely compressed by the intervertebral disc in the anterior on T11–12 level, and segmental kyphosis on index level with a decrease in disc height was revealed (Fig. 4a, b). Bilateral decompression with transforaminal thoracic interbody fusion was done to treat spinal cord compression and segmental kyphosis (Fig. 4c, d). The pathological symptoms improved gradually over the 3 months after the surgery, so she was able to bend her body free without any symptoms and walk freely and live a normal life.

Case 3

A 72-year-old male had a burning pain in front of his neck and chest and had pain in his back neck and radiating his arm for a year. He also suffered back pain, burning pain and numbness in both legs, and often fell down because of lack of leg strength while walking. Heart, stomach, and esophagus examinations were normal, and the evaluation of cervical spine showed no abnormality. His MR images revealed disc degeneration with Modic change on T8–9 level compressing spinal cord (Fig. 5a, b). After undergoing transforaminal thoracic interbody

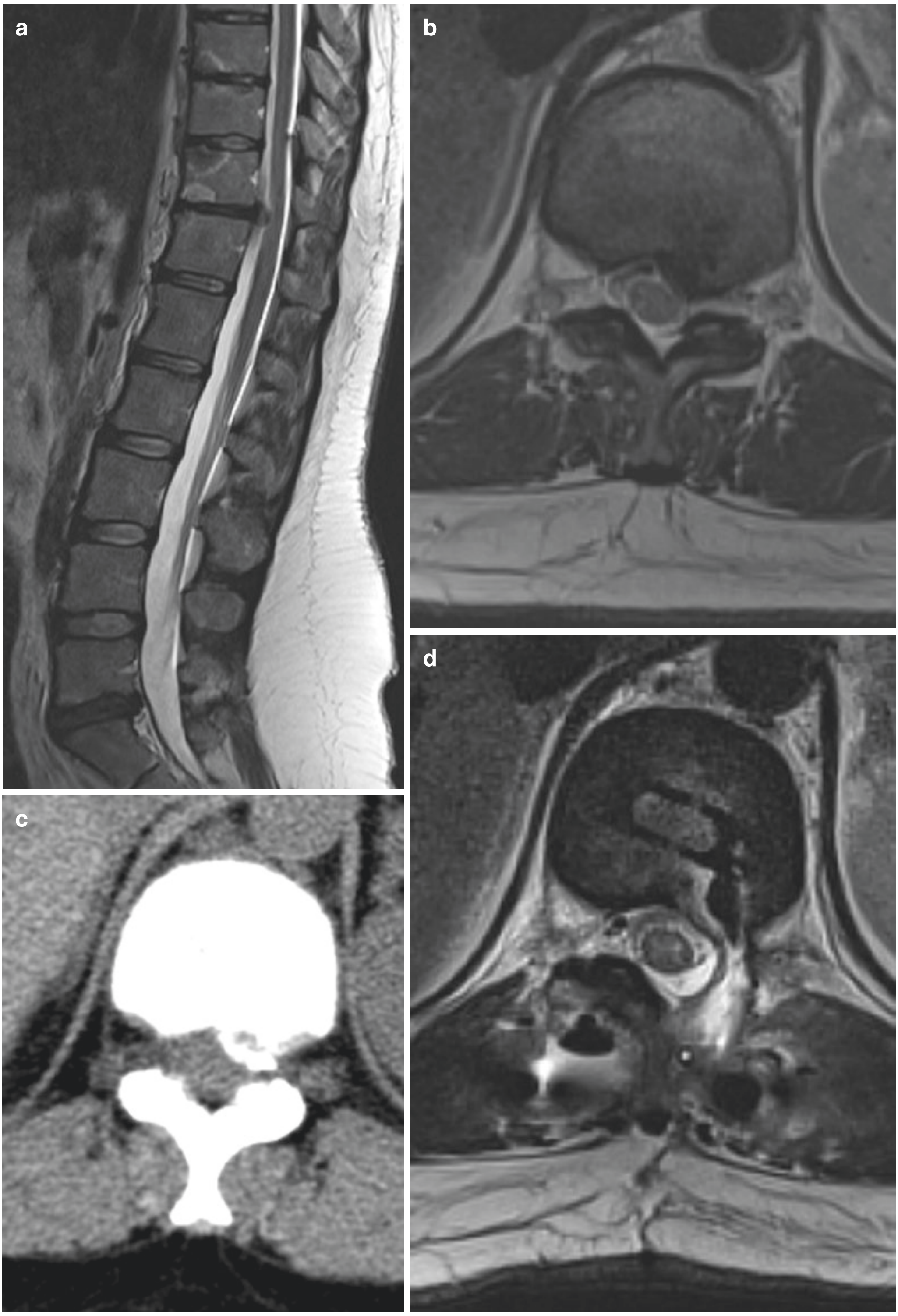
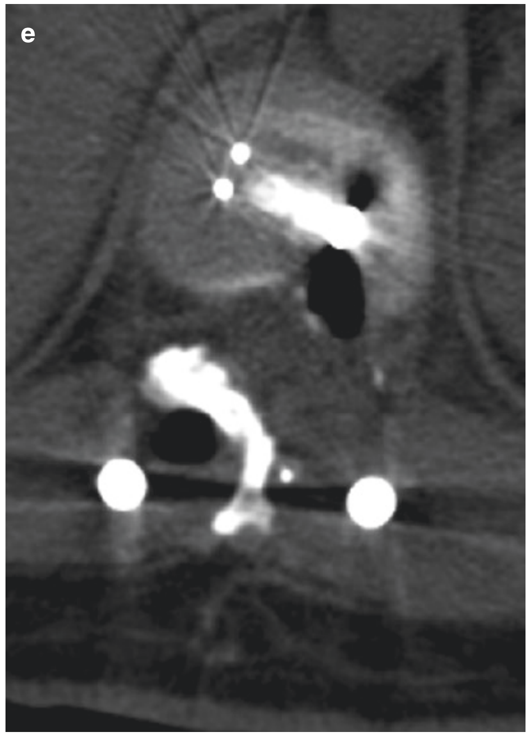


Fig. 3 Preoperative sagittal MR image (**a**), axial MR image (**b**), and CT scan (**c**) demonstrating hard disc extrusion compressing spinal cord on T11–12 level. After TTIF on left, axial MR image (**d**) and CT scan (**e**) showing decompression of spinal cord with removal of hard disc extrusion

Fig. 3 (continued)



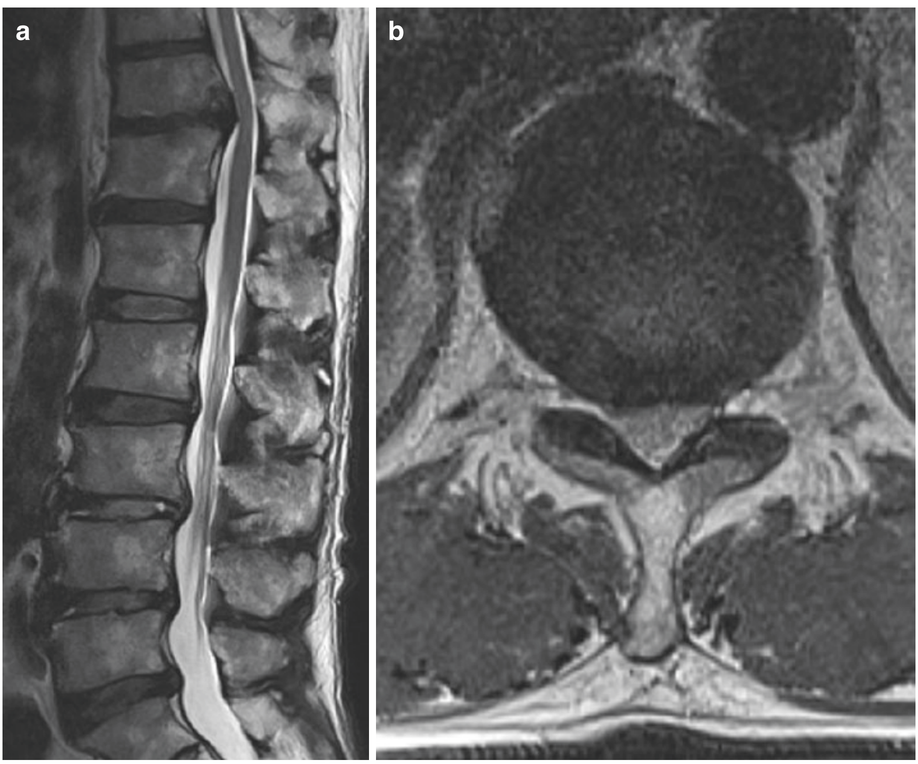


Fig. 4 Preoperative sagittal and axial MR images (**a**, **b**) showing extruded disc compressing spinal cord and segmental kyphotic curvature on index level. Bilateral decompression and PEEK cage insertion with percutaneous screw fixation were done (**c**, axial MR image; **d**, lateral simple radiography)

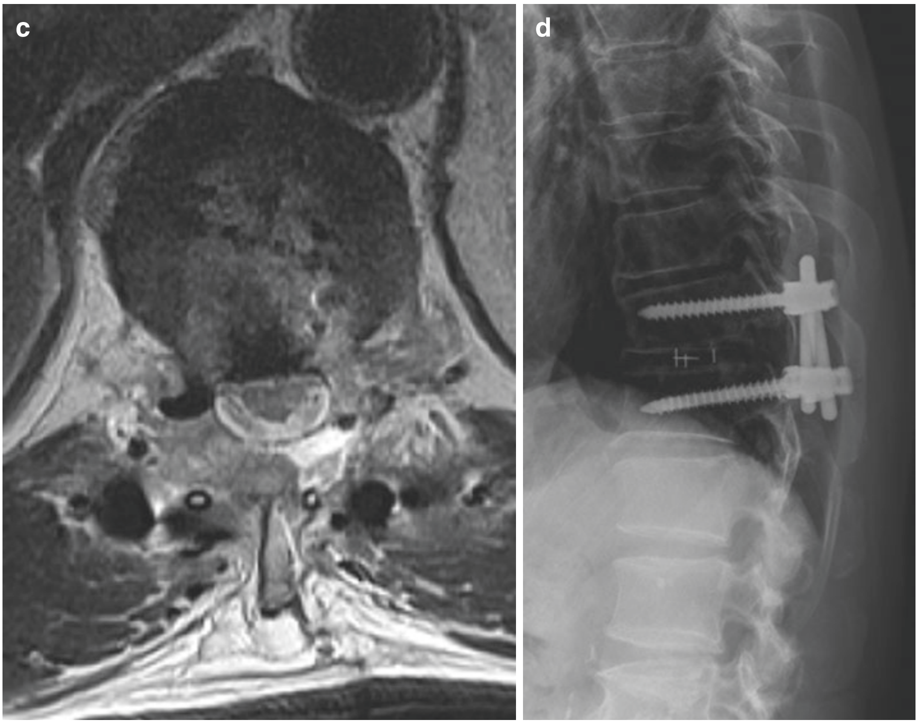


Fig. 4 (continued)

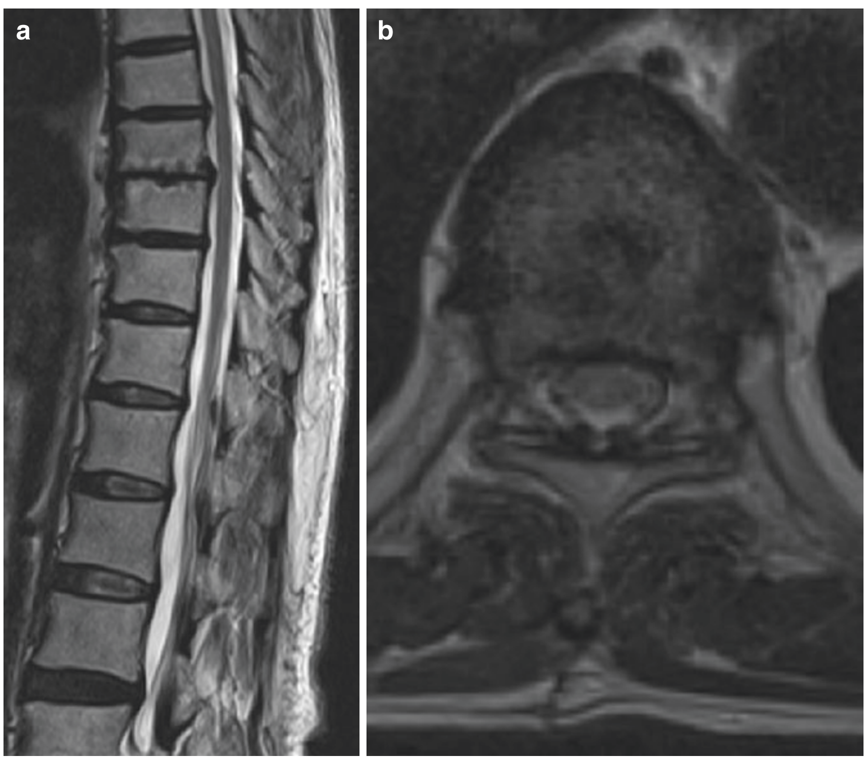


Fig. 5 Preoperative sagittal and axial MR images (**a**, **b**) reveal disc height shortening with Modic change on T8–9 level. Single metal cage and percutaneous screws were inserted from left side after removing whole nucleus (**c**, lateral simple radiography; **d**, Sagittal MR image; **e**, Axial MR image)

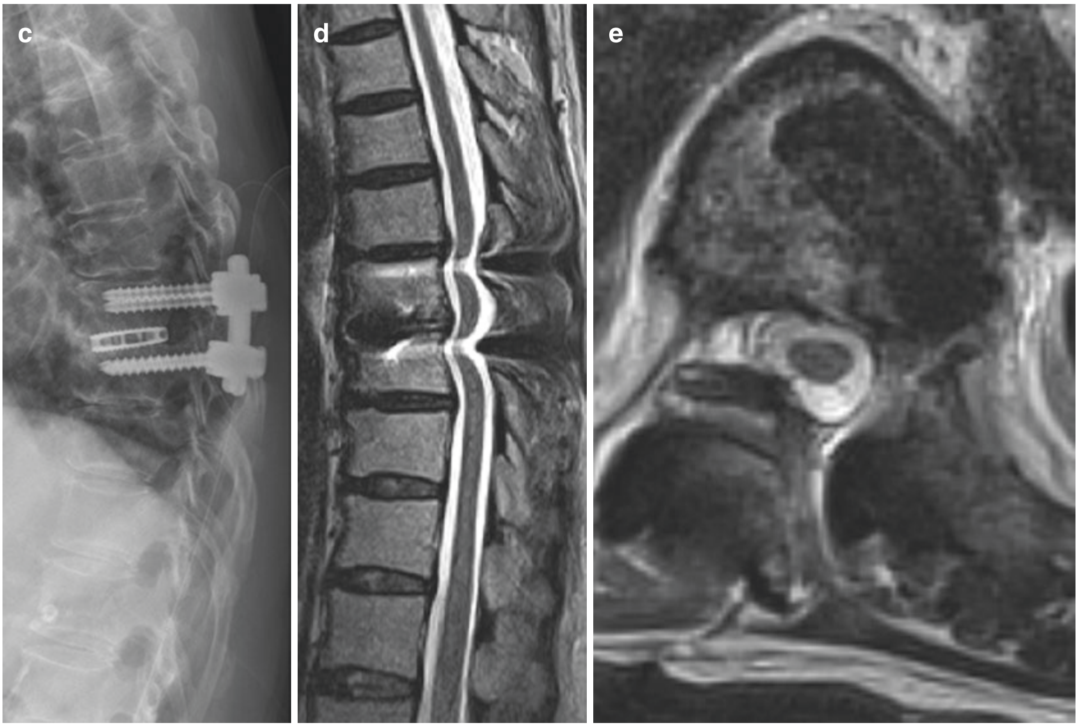


Fig. 5 (continued)

fusion with a metal cage and posterior screws fixation (Fig. 5c–e). The nonspecific symptoms that bothered him were gone, and he could do his normal work without pain, numbness, or other abnormalities.

Summary

Transforaminal thoracic interbody fusion (TTIF) offers safe neural decompression and stability without pulmonary or thoracic complications. Accurate understanding of safe surgical procedures, indications, and avoidance of complications is able to result in successful TTIF.

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