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Operative Technique

Minimally invasive lateral approach to the thoracolumbar junction for corpectomy

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ABSTRACT

Diseases that affect the thoracolumbar junction present a unique challenge to the spine surgeon. Various techniques have been described to treat this clinical entity from the anterior, lateral, or posterior direction. These can be associated with significant morbidity due to extensive tissue dissection, blood loss, and post-operative pain leading to a lengthy recovery. The use of a tubular retractor allows the surgeon to minimize tissue dissection and potentially reduce approach-related morbidity while obviating the need for an approach surgeon for exposure. The surgical technique of a minimally invasive lateral approach to the thoracolumbar junction for corpectomy is described in detail and two illustrative patients are presented.
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1. Introduction

Pathologic conditions that affect the thoracolumbar junction include metastatic and primary tumors of the spine, osteomyelitis, traumatic fractures, and degenerative spondylotic disease. Traumatic injuries alone are a widespread problem with significant personal and socioeconomic impact. Over 150,000 traumatic injuries to the spinal column occur each year in the United States, and the annual incidence in Europe has been estimated to be as high as 64/100,000.[1] Pyogenic vertebral osteomyelitis is less common with an estimated prevalence of 1.5–2 cases per 1,000,000.[2] Of the approximately 1.5 million new patients diagnosed with cancer annually, 5% present with metastatic spinal cord compression. The majority of presentations involve the thoracic or lumbar spine and of those 80% affect the anterior spinal column.[3] Over the last 20 years recommended treatment strategies for the surgical management of these disease processes have continued to evolve. The principal tenants of surgical intervention are to stabilize the bony architecture of the spine, decompress the neural elements and minimize neurologic injury while restoring normal alignment in the acute and long term setting.[1]

The thoracolumbar junction presents a unique anatomic challenge. It lies in the transition zone between the thorax and abdomen and often requires multiple surgical teams for complete access. Several methods have been described to access this area.[4] The posterior approach is familiar to all spine surgeons and a circumferential approach to pathology can be achieved through a transpedicular, postereolateral costotransversectomy, or lateral extracavitary technique.[4] This allows early exposure of the neural elements for decompression. Disadvantages include poor visualization of anterior pathology and poor long-term stability in posteriorly based fusion constructs in the setting of disruption of the anterior spinal column.[5] Anterior approaches include transthoracic, retropleural, and transabdominal. They offer direct decompression of the neural elements and reconstruction of the injured anterior spinal column, but suffer from late visualization of the thecal sac and spinal cord, significant risk to the thoracic and abdominal contents including major vascular structures, and prolonged recovery time.[4,5] Transthoracic patients often require lung deflation and chest tube placement. Perioperative complications include respiratory insufficiency, pneumothoraces, pneumonia, hematoma, gastrointestinal bleeding, cerebrospinal fluid leakage, pulmonary embolisms, pleural effusions and visceral herniation through iatrogenic defects in the fascia and diaphragm.[6]

Both anterior and posterior approaches have shown to be effective clinically,[5,7] but morbidity from long surgery times, significant blood loss, and prolonged recovery periods have led many authorities to consider the use of less invasive techniques. In the treatment of thoracolumbar spine pathology, laparoscopic or endoscopic thoracotomy significantly reduces operating room time and blood loss when compared to traditional open approaches, but is technically difficult and requires a steep learning curve, extensive operator experience, multiple surgical teams, and expensive equipment not available in many surgical centers.[5] Minimally invasive variations of posterior approaches include the use of percutaneous pedicle screws for posterior stabilization and kyphoplasty for vertebral augmentation, and many authors have demonstrated their efficacy.[1,8,9] Minimally invasive posterior vertebrectomy has also been described but it is technically challenging and offers a more narrow exposure of the neural elements for decompression and bony elements for stabilization.[10]

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The lateral retropleural approach to the thoracolumbar junction with the use of a tubular retractor system is a less invasive variant of the lateral retropleural thoracotomy. It combines many advantages of both the anterior and posterior techniques while reducing the risk of injury to the thoracic cavity and its contents. A thoracic or general surgeon is usually not required for mobilization of the diaphragm and intrathoracic access. The use of tubular retractors minimizes tissue dissection and incision size while providing sufficient exposure to achieve a ventral decompression of the neural elements and appropriate stabilization.[4] This technique is described in detail and two clinical patients are illustrated.

2. Surgical technique

After informed consent is obtained, the patient is brought to the operating suite and undergoes general endotracheal anesthesia. A Foley catheter is placed. Sensory and motor evoked potentials and electromyography are monitored throughout. Preoperative antibiotics are administered 30 minutes prior to skin incision. The patient is placed in a true lateral position with the left side up. The patient is positioned such that the level of pathology lies directly over the articulation of the operating table. The chest and hip areas are secured to the table with 3 inch tape (Fig. 1a). All pressure points are padded. An axillary roll is placed under the right axilla, and both legs are slightly flexed. The table is then slightly flexed to provide greater exposure. Precise anteroposterior (AP) and lateral fluoroscopic images are obtained and final adjustments of the table are made. On an AP view, the spinous processes must be centered and the end plates parallel. A proper lateral view shows no parallax of the pedicles and endplates. Accurate fluoroscopic views determined preoperatively are critical to the success of the surgery as with any minimally invasive technique. The appropriate vertebral body is located with AP and lateral fluoroscopy and its superior and inferior endplates are drawn over the skin (Fig. 1b). The rib chosen for resection lies within the marked vertebral endplates allowing a direct path to the vertebra based on the intraoperative imaging and may vary slightly, though in general the tenth rib is resected for access to the T12 vertebral body and the eleventh rib for L1 and so forth.

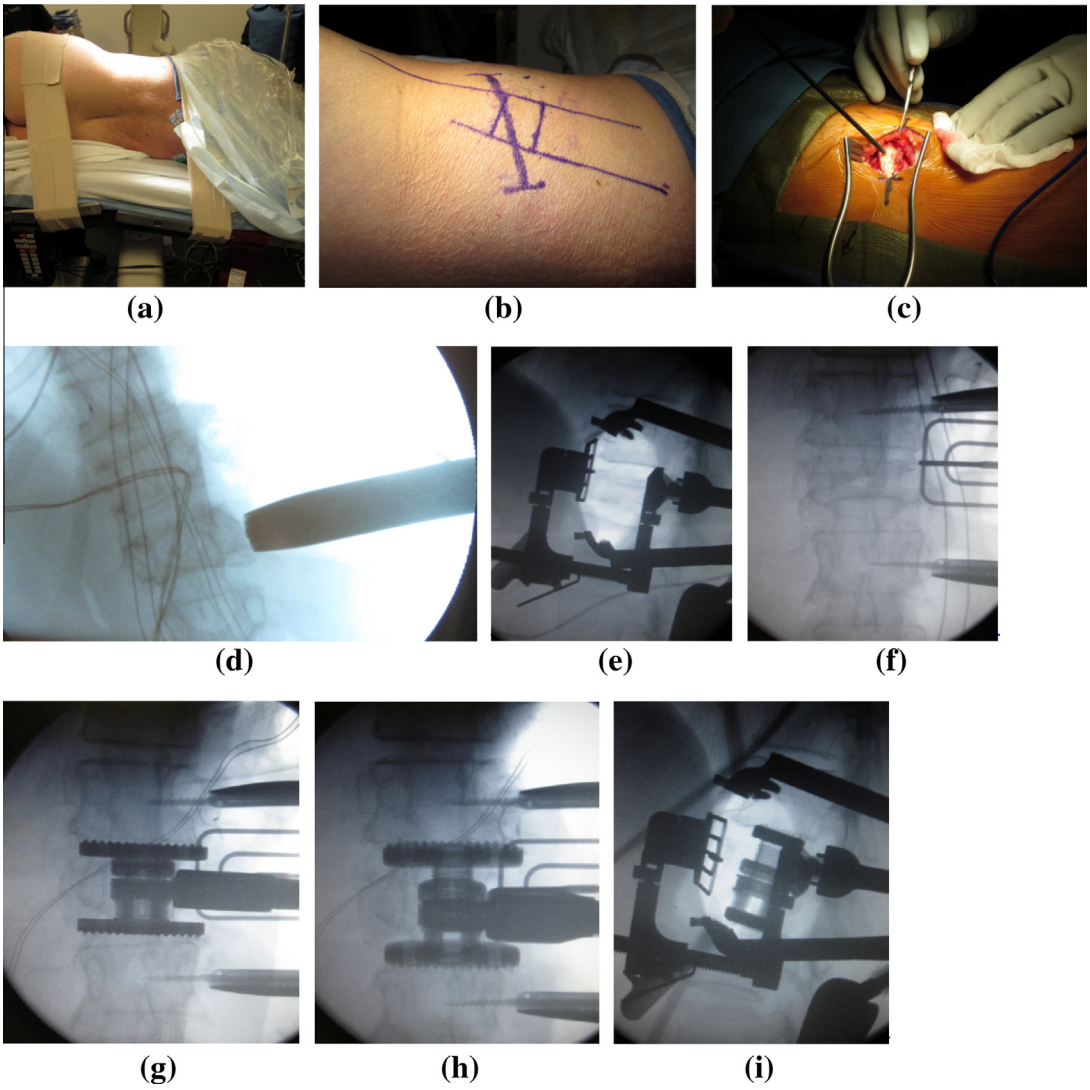

Fig. 1. Illustration of the surgical technique. (a) The patient is placed in the direct lateral decubitus position with the left side up. The hip and chest are secured with tape to the operating table and the table is flexed at the level of pathology. (b) Preoperative skin markings delineate the superior and inferior extent of the vertebral body targeted. A 6 cm incision is planned along Langer's line parallel to the underlying rib. (c) Subperiosteal exposure of the rib which will be dissected free from the surrounding tissue and underlying neurovascular bundle prior to removal. (d) Lateral fluoroscopic view after safely docking the tubular dilator on the vertebral body. (e) Anteroposterior view following expansion of the retractor. (f) Lateral fluoroscopic view following placement of pins in the vertebral bodies (g–i). Fluoroscopic views showing placement of an expandable intervertebral device into the corpectomy defect (Xcore1; NuVasive, San Diego, CA, USA) before (g) and after (h,i) expansion restoring height and alignment. This figure is available in colour at <www.sciencedirect.com>.

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A 6 cm incision is marked along Langer's line centered approximately over the vertebral body of interest and parallel to the course of the underlying rib (Fig. 1b).

After the patient is prepped and draped in the usual fashion the incision is infiltrated with a local anesthetic with epinephrine. The incision is made and the underlying rib exposed in the typical subperiosteal fashion (Fig. 1c). The rib is dissected from the surrounding soft tissue and underlying neurovascular bundle circumferentially with the use of an Alexander and Doyen elevator. Approximately 5 cm of the rib is cut with a rib cutter and morselized for later use in the fusion construct. The underlying parietal pleura is then identified and care is taken to protect it. A retropleural blunt dissection follows, sweeping the pleura away from the chest wall with a finger or sponge stick. The junction of the rib head and transverse process is palpated and the first dilator is docked onto the vertebral body of interest as confirmed with both AP and lateral fluoroscopy. A series of Access4 dilators are passed followed by the insertion of a working channel (NuVasive, San Diego, CA, USA) which in turn is affixed to an adjustable arm (Fig. 1d). At this stage the parietal pleura and the lung parenchyma are vulnerable, and care must be taken to avoid injury as the blunt dilators and working channel are inserted. The tubular retractor is expanded anteriorly and a pin is placed in the vertebral bodies above and below the indicated level to maintain adequate exposure (Fig. 1e, f). An additional retractor blade is placed anteriorly to protect the lung parenchyma. The parietal pleura is reflected off of the vertebral body with monopolar cautery parallel to the anterior longitudinal ligament. The segmental vessels are ligated and divided with bipolar cautery and a #15 blade on a long handle. Great care is needed as the dissection proceeds to the lateral areas to avoid entering the foramen to preserve the important radicular medullary feeders. The left crus of the diaphragm is detached and blunt caudal dissection provides adequate exposure of the caudad vertebra for instrumentation. The retropleural approach to the thoracolumbar junction is above the diaphragm and therefore the insertional fibers of the diaphragm onto the vertebral body can be simply swept caudally for adequate exposure in most patients using monopolar cautery as needed. Of note, if the L1 vertebral body or below is included in the exposure, the posterior and lumbar attachments of the diaphragm can be sharply excised from the lateral transverse process of L1 and swept anteriorly for better exposure. Discectomies are performed above and below with a scalpel on a long handle, pituitary rongeur, and curettes. The diseased vertebral body is resected with the Leksell and pituitary rongeurs, and bony fragments are carefully removed away from the thecal sac under direct visualization. These fragments can be prepared for arthrodesis. A complete decompression is confirmed with visualization and palpation of the thecal sac. The corpectomy defect is irrigated copiously and meticulous hemostasis is obtained with bipolar cautery and the application of liquid hemostatic agents. An appropriately sized spacer is filled with morselized autograft and bone graft extenders and placed in the corpectomy defect. The spacer is then expanded restoring normal height and alignment. Proper placement is confirmed with AP and lateral films (Fig. 1g–i). A lateral plate is placed over the vertebral bodies above and below, and secured with bicortical screws. If the parietal pleura is violated during the retropleural approach, it is prudent to place a chest tube prior to closure. In our experience it is unnecessary to reattach the diaphragm which is minimally displaced. The wound is then closed in the usual fashion.

3. Illustrative patients

3.1. Patient 1

A 67-year-old woman with a history of osteoporosis, diabetes and hypertension sustained a fall 3 weeks prior to her clinic visit. She complained of severe back pain and diffuse proximal muscle weakness hindering her ability to ambulate. Her examination was consistent with 4/5 proximal leg weakness with normal sensation and reflexes. She required a walker for ambulation. Outpatient MRI showed a T12 burst fracture with spinal cord compression (Fig. 2a, b). She was admitted for surgical management and her preoperative work-up revealed hyponatremia which was corrected over several days. She underwent a minimally invasive lateral T12 corpectomy without complications (Fig. 2c–g). Length of surgery was 4.5 hours. Estimated blood loss was 300 cc. She required no blood transfusions after surgery. Given the modest blood loss and minor tear observed in the parietal pleura, a chest tube was not placed. Her postoperative course was uneventful. She was neurologically stable and was ambulatory with assistance. Serial postoperative chest radiographs showed a small apical pneumothorax that resolved. A postoperative CT scan showed early subsidence of the interbody device into L1 (Fig. 2c). Given her history of osteoporosis, she was brought back to the operating room 1 week after her first procedure for T11 to L1 percutaneous pedicle screw instrumentation (Fig. 2e, f). Length of surgery was 1 hour and estimated blood loss was 25 cc. She was discharged to rehabilitation without requiring postoperative blood transfusions. At her 6 month follow-up, she was neurologically intact and ambulated with a cane with minimal back pain (Fig. 2g). She required no oral analgesics. Follow-up radiographs demonstrated no evidence of hardware failure or further subsidence.

3.2. Patient 2

A 58-year-old woman was transferred from an outside hospital with severe back pain after a fall down the stairs while inebriated. She also complained of significant weakness in her legs. She denied any loss of sensation or incontinence. Her physical examination was notable for diffuse 4/5 weakness of the lower extremities with no sensory deficits noted. Reflexes were hyperactive. MRI revealed a burst fracture of the L1 vertebra with significant loss of height and compression of the conus medullaris (Fig. 3a, b). She underwent an urgent minimally invasive L1 corpectomy from a lateral approach. Surgery time was 5 hours. Estimated blood loss was 2000 cc due to bleeding from the acute fracture site during corpectomy. No chest tube was placed. A total of four units of packed red blood cells were transfused intraoperatively and in the postoperative period. Her hospital course was notable for a moderate left sided pleural effusion for which a thoracentesis was performed. She was discharged to rehabilitation. At her 1 year follow-up, she was neurologically intact with moderate residual bilateral foot dysesthesias requiring pregabalin. Postoperative imaging studies revealed a complete decompression of the spinal cord and no evidence of instrumentation failure (Fig. 3c–e).

4. Discussion

The morbidity associated with standard anterior or posterior surgical approaches to the thoracolumbar spine has led to a growing interest in the application of minimally invasive techniques. The open posterior approach requires disruption of the posterior ligamentous complex and mobilization and devascularization of the paraspinal musculature. Significant muscle atrophy has been shown in several studies.[1,11,12] In a recent review of these techniques for vertebral corpectomy, extensive muscle dissection, copious blood loss, and an oblique view of the neural elements often necessitating sacrifice of nerve roots were considered significant limitations to the open posterior approach. Rampersaud et al.[1] evaluated the use of posterior minimally invasive techniques in the setting of thoracolumbar trauma. This included percutaneous

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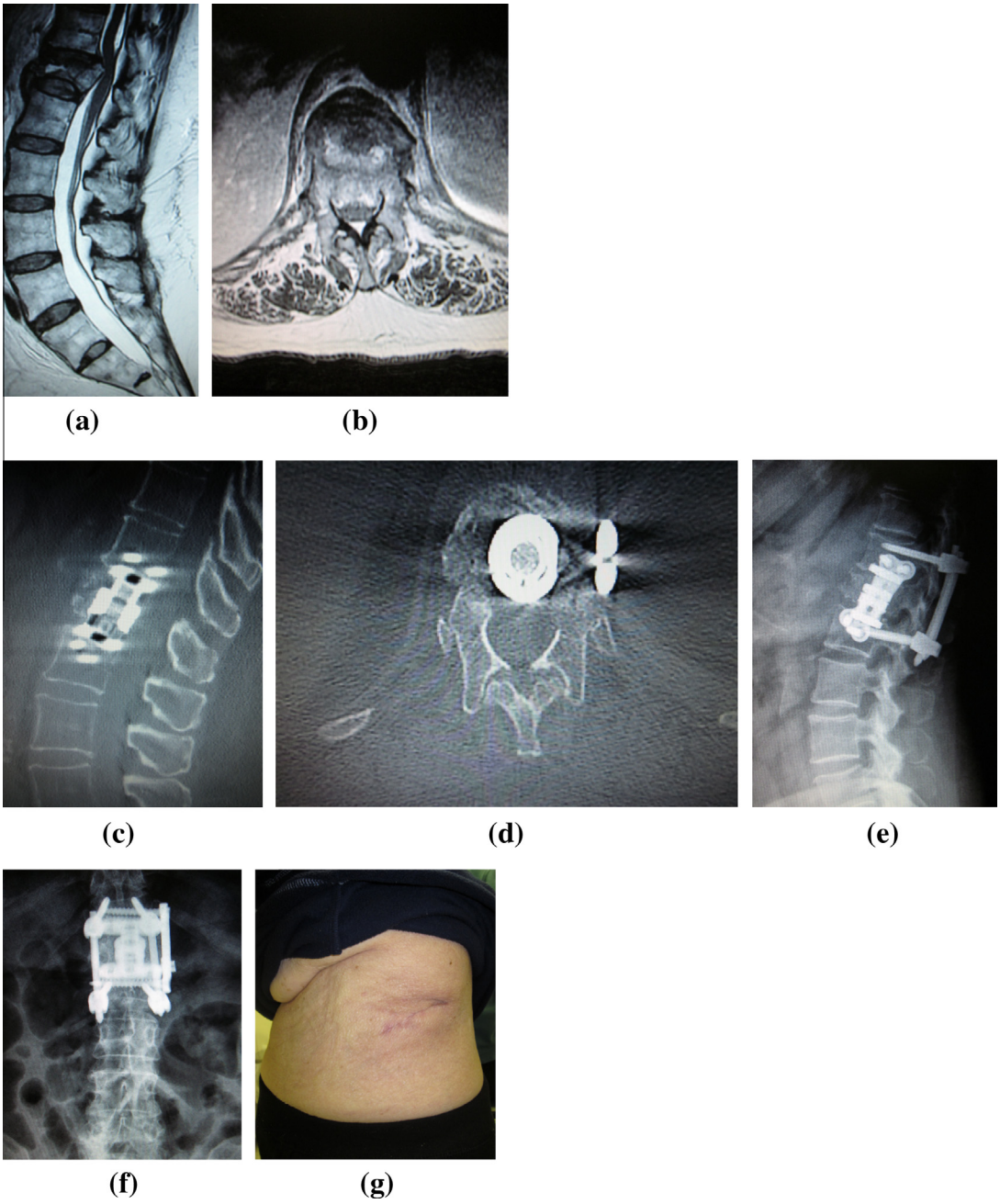

Fig. 2. (a) Sagittal T2-weighted MRI demonstrating a fracture of the T12 vertebral body with retropulsion into the canal. (b) Axial MRI at the level of the fracture showing retropulsion into the canal and compression of the spinal cord. (c) Postoperative sagittal CT scan showing the placement the intervertebral spacer and screws. There is slight subsidence of the spacer into the inferior L1 vertebral body. (d) Postoperative axial CT axial view. (e) and (f) anteroposterior and lateral radiographs showing percutaneous pedicle screw insertion. (g) Postoperative photograph showing the healed 6 cm incision. This figure is available in colour at <www.sciencedirect.com>.

posterior fusion as a standalone option for thoracolumbar burst fractures. Long-term results were comparable to more invasive approaches without the need for direct decompression of the neural elements and anterior column stabilization. The minimally invasive transpedicular corpectomy described by Fessler et al. is an alternative that provides the ability to directly decompress and stabilize the bony elements, but is limited by a narrow working corridor.[5,13] A bilateral transpedicular approach for a more complete vertebral resection has been reported by Chou.[14]

The advantage of an anterior or lateral approach to the thoracolumbar junction is that it provides maximum exposure for corpectomy while preserving the posterior ligamentous complex and avoiding disruption of the paraspinal musculature. The lateral retropleural approach with a tubular retractor system is an extension of the increasingly popular lateral approach for interbody fusion in the lumbar spine.[10] A number of studies have demonstrated the safety and efficacy of this approach in the lumbar region with a reduction in blood loss, surgery time and complications.[15–18] The use of tubular retractors has been shown to lower infection and transfusion rates, decrease postoperative pain and shorten hospital stays.[15–17,19] In a prospective analysis of 600 retroperitoneal lateral interbody fusions through a tubular retractor, Patterson et al. found an average hospital stay of 1.21 days, postoperative hemoglobin change of 1.38, and a total perioperative complication rate of 6.2%, without vascular or visceral injuries or infection.[16] The lateral approach with a tubular retractor avoids the need for an ap-

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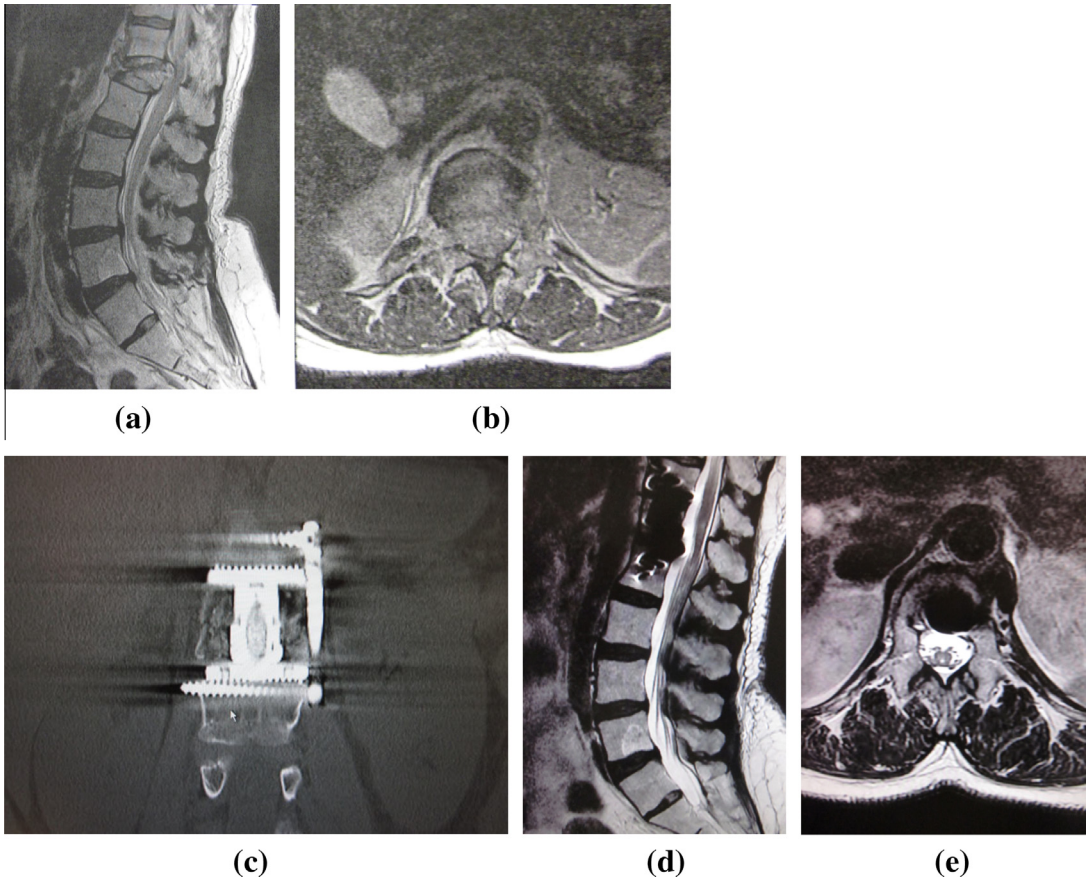

Fig. 3. (a) Sagittal T2-weighted MRI shows a fracture of the L1 vertebral body with retropulsion and loss of height. The conus medullaris is compressed. (b) Axial MRI showing the level of the fracture. (c) Postoperative CT scan with coronal reconstruction showing the spacer and lateral plate with bicortical screw placement. Postoperative sagittal (d) and axial (e) T2-weighted MRI showing decompression of the spinal cord and restoration of height and alignment.

proach surgeon. It also reduces the morbidity of a trans-thoracic exposure by decreasing lung trauma, minimizing violation of the pleura and obviating the need for lung deflation. The anterior approach facilitates a direct decompression of the neural elements and allows reconstruction of the anterior column with a robust construct. A cadaveric feasibility study by Uribe et al.[4] examined the use of this approach for the thoracolumbar trauma patient. They achieved adequate exposure for decompression and stabilization in all cadaveric dissections and in their case illustrations. The only significant complication was one pleural tear which was managed by the placement of a chest tube without incident. In a larger series of patients with traumatic thoracic or lumbar fractures treated with a mini-open lateral approach, a lower rate of blood loss, decreased operative time, and a lower complication rate when compared to historical controls was observed.[20] Seventy-three percent of patients were neurologically intact or suffered slight residual deficits postoperatively. Almost half of patients required additional posterior instrumentation.

Both patients described herein had an excellent recovery following surgery without perioperative complications. Neurologic function was nearly completely restored and once recovered pain was minimal without the use of oral opiates. The approach provided adequate exposure to allow for a complete decompression of the neural elements and the insertion of a robust intervertebral spacer and lateral plating system. There were no injuries to thoracic or abdominal contents and significant dissection of the diaphragm was not required. In the first patient presented, a posterior percutaneous stabilization procedure was performed given her history of osteoporosis and subtle graft subsidence on postoperative imaging. Supplemental fixation was not required in the second patient presented despite the junctional nature of her fracture. The application of a robust intervertebral prosthetic device with broad coverage of the endplates contributed and conferred additional stability. All patients undergoing anterior corpectomy at the thoracolumbar junction without posterior instrumentation should be followed carefully with serial imaging studies. We elected in both patients not to place a chest tube even though small violations of the parietal pleura were present. At the time of closure, a red rubber catheter was inserted into the sealed thoracic cavity with its proximal end submerged in a basin of sterile saline and repeated Valsalva maneuvers created to evacuate additional intrathoracic air. Both patients had small pneumothoraces after surgery that were inconsequential. The second patient developed a moderate pleural effusion that required drainage. This effusion was both serous and sanguinous from postoperative bleeding from the corpectomy site. We recommend the placement of a chest tube in cases of significant bleeding during corpectomy or when significant pleural tears are encountered.

5. Conclusions

The minimally invasive lateral approach to the thoracolumbar junction for corpectomy is safe and effective. Adequate exposure can be achieved to perform both decompression of the neural elements and fusion/stabilization. The use of a tubular retractor system minimizes tissue disruption and obviates the need for an approach surgeon. The retropleural nature of this technique avoids significant dissection of the diaphragm.

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