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XLIF® Corpectomy: Clinical Experience and Outcomes

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Note: The use of vertebral body replacement devices is not FDA-cleared for the treatment of active infection. The surgeon should verify that the intervertebral disc space is clear of infection prior to implantation of CoRoent® or X-CORE® devices.

Minimally invasive surgery (MIS) is rapidly replacing conventional surgery for most degenerative spine procedures.[1] This shift has been hastened by the development of modern MIS approaches and instrumentation that allow for more straightforward procedural adoption and surgical efficiency compared with endoscopic approaches, the mainstay of minimally invasive spine surgery through the 1990s.[2-7] Over the last 10 years, clinical and economic outcomes with these modern exposures have been shown to be equivalent or superior to conventional open procedures with notable advantages in perioperative morbidity (hospital length of stay [LOS], estimated blood loss [EBL], and complication rates).[8-17] In more advanced applications—such as anterior corpectomy for trauma, tumor, or infectious lesions—where blood loss of greater than 1000 mL[18] and infection rates as high as 10% are common,[19,20] the potential benefits of MIS are significant, although the safety and utility of these approaches for these indications must be evaluated.

At least 150,000 traumatic injuries to the spine and its neural structures occur within the United States each year. In addition, the spine is the most common site of metastatic lesions, with 40% of the 570,000 who die each year from cancer having a spinal metastasis. Of these approximately 200,000 spinal metastases cases, approximately 10% (18,000 to 25,000) each year will require surgical treatment.[21-23] Many of these lesions (traumatic and metastatic) can cause paralysis, deformity, pain, and loss of function. Management with appropriate decompression, reduction, and fusion via corpectomy can mitigate these long-term devastating injuries in this challenging population[24] and provide substantial pain, function, and life expectancy improvements.[22,23,25]

Conventional open thoracotomy, considered the gold standard exposure, is accompanied by substantial approach-related and postoperative complications that decrease the value gained by the large anterior exposure. The mini-open extreme lateral approach, while originally described for standard lumbar degenerative indications, has been shown to provide a direct pathway to these more complex lesions while mitigating many of the complications common to open surgical exposures.[26-30] This approach employs familiar and standard surgical techniques without extensive soft-tissue dissection or an extended learning curve, which allows for relative ease of adoption with safe and reproducible results.[31,32]

TREATMENT OPTIONS/RATIONALE FOR THE XLIF APPROACH

There are many pathways, both traditional and contemporary to the treatment of spinal lesions that require corpectomy. Approaches are typically defined by the superficial access plane. The most common approaches are posterior/posterolateral or anterior/lateral. Surgical exposures are defined along a continuum from open to mini-open (direct visualization) and endoscopic designations, which can be applied to procedures used in most approach planes.

Posterior/posterolateral approaches include laminectomy, transpedicular decompression/corpectomy, costotransversectomy, and extracavitary.[33-39] These posterior approaches prevent morbidity associated with entry into the chest and provide a large field for direct decompression or removal of the posterior elements with the ability to place posterior pedicle screw–based segmental fixation for alignment correction and stabilization through a single-incision approach. However, the spinal cord in tumor, infection, and trauma cases is almost exclusively compressed from the front, resulting in dorsal displacement of the neural elements.[40] Using a posterior or posterolateral approach, the ability to adequately decompress and reconstruct the anterior column is limited without spinal cord retraction or nerve root retraction or sacrifice. Furthermore, the incidence of infection tends to be elevated through posterior-based approaches, especially with extensive instrumentation that results in significant blood loss and paraspinal muscle atrophy.[41,42]

Anterior/lateral approaches generally only include the conventional thoracotomy (transpleural or retropleural) and, more recently, less invasive approaches including thoracoscopy and extreme lateral interbody fusion (XLIF®, NuVasive®, Inc., San Diego, CA).[27,29,43-45] Transthoracic approaches have traditionally been considered the gold standard in the management of many pathologic conditions of the anterior thoracolumbar spine.[46] This approach provides adequate access to the ventral spine and allows decompression without the associated risks of spinal cord or nerve root manipulation.[47-49] However, the pathologic process is faced first, and the neural elements are not visualized until the anterior decompression is completed. In addition, the anterior approach involves a large incision, lung and rib retraction, and extensive muscle dissection. All of these factors contribute to postoperative pulmonary dysfunction (pulmonary contusions, atelectasis, pleural effusions, hemothorax, and chylothorax), significant perioperative and postoperative pain from extensive rib resection, and, at the thoracolumbar area, risk of abdominal wall paresis.[44,50-54] Ultimately, these factors result in longer hospitalization and recovery periods for the patient.[55-57] Anterior approaches also often require the involvement of multiple surgical specialties (e.g., spine surgeon and thoracic access surgeon), which can potentially delay treatment, particularly limiting in acute traumatic situations that require emergent intervention.[58,59]

MIS exposures used for anterior corpectomy include the mini-open costotransversectomy and mini-open transpedicular, thoracoscopic, or mini-open lateral (XLIF) approaches.[27,33,37,42,45] Posterior MIS techniques are retractor-based exposures that offer limited view of the anatomy, typically through an oblique view of the dural elements, but based on the ability to move the decompression further laterally, access to the mid-body bilaterally can be obtained. An advantage of posterior MIS exposure is that it avoids many of the potential open anterior exposure (thoracotomy) complications, which occur in as many as 12% of cases and tend to prolong hospitalization and resource utilization.[55] Both cadaveric and clinical outcome studies support the possible use of this exposure, but by not exposing the anterior spinal cord directly the approach requires the use of blind down-pushing instruments into anatomy that is often irregular (e.g., burst fractures). In addition, the placement of instruments and anterior structural support for anterior column reconstruction is limited (wide footprint interbody devices cannot be used) compared with anterior approaches. As previously mentioned, this also requires spinal cord retraction and, often, nerve root sacrifice, increases demand for multiple fixation points for deformity correction, and makes effectively addressing multi-level lesions difficult. Of note, the difficulty in placing anterior instrumentation from a posterior-only approach may lead to increased biomechanical failure.[27]

Thoracoscopic exposures brought the promise of minimally invasive anterior reconstruction to thoracic and lumbar surgery.[32] This allowed for direct anterior decompression during corpectomy without the risks associated with spinal cord manipulation, and with substantially less blood loss and soft-tissue dissection than traditional open anterior or posterior exposures. However, endoscopic approaches did not fulfill the promise of minimally invasive spine surgery in general, as they instead introduced a new set of challenges, especially when used for more advanced applications, such as corpectomy. Disadvantages of endoscopic approaches include the requirement for single-lung intubation, a steep and long learning curve (40 to 150 cases), representation of three-dimensional anatomy in two-dimensions, extensive and expensive instrumentation, the need for highly trained staff, extended operative times, a relative inability to manage intraoperative complications without emergent conversion to an open exposure, and difficulty in placing large reconstructive anterior instrumentation (e.g., expandable vertebral body replacement [VBR] devices).[32,44,45,60,61] These procedural challenges have resulted in the limited adoption of endoscopy for spine surgery for all but a few surgeons.

The mini-open lateral XLIF approach for thoracolumbar corpectomy, however, mitigates many of the drawbacks related to anterior thoracotomy and thoracoscopy without the extensive tissue and bony dissection associated with the posterior approaches. In contrast to the posterolateral approach, the XLIF approach permits direct visualization of the dural elements and allows the surgeon to expose the lateral canal without the need to dissect or potentially sacrifice the intercostal nerves or intraforaminal radiculomedullary artery.[62,63] When the approach is retropleural, there is no violation of the pleural or peritoneal cavity.[30] Thus the lateral approach poses less risk of complications associated with open thoracotomy, including the development of a duropleural cerebrospinal fluid fistulae.[64-66] The amount of kyphosis correction achieved is equivalent to that achieved with open anterior procedures.[65,67] Additional benefits include the ability of the approach to be performed without rib resectioning and while using standard dual-lumen ventilation. This approach is an alternative to both endoscopic and open conventional approaches, maximizing the benefits of both while preventing many of their respective drawbacks.

SURGICAL TECHNIQUE AND SPECIAL CONSIDERATIONS

Understanding the exact vertebral level, number of ribs, and number of non-ribbed lumbar vertebrae will ensure accurate intraoperative localization. If the pathology is predominantly on one side of the spine, an ipsilateral approach is used. When the pathology is centrally located, then the approach is from the right side for the upper levels (T4-8) and from the left side on the lower levels (T9-12) to avoid the great vessels. The location of the great vessels should also be noted for any aberrancy.

The XLIF approach for thoracolumbar corpectomy has previously been described, with the approach to the lateral aspect of the lumbar spine for lumbar corpectomies roughly following the original XLIF approach for lumbar degenerative disease described by Pimenta in 2006.[26,27,68]

After general endotracheal intubation, an arterial line, venous access, a Foley catheter, and neurophysiologic monitoring (motor evoked potentials [MEP], somatosensory evoked potentials [SSEP], and/or electromyography [EMG]) electrodes are placed. The patient is then positioned in the true lateral decubitus position with the operative side up and overlying the flex point of a bendable, radiolucent operative table (Fig. 33-1). An axillary roll and sequential compression devices are placed. The knees are flexed with a pillow between them to relax the psoas muscle, and all pressure points are padded. The arm on the operative side is placed on a

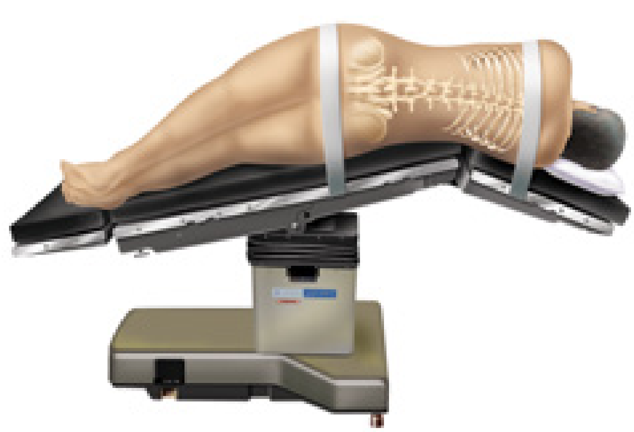


FIG. 33-1 Posterior view of table break for XLIF® (NuVasive, Inc.) or XLIF corpectomy procedure.

table-mounted armrest. The patient is secured to the table with wide tape both over the hip and just below the axilla. Intraoperative fluoroscopy is used to ensure that the patient is placed and secured in a true lateral position, with the lateral working corridor of the operative level confirmed to be 90 degrees lateral (orthogonal) to the floor. In confirming true anteroposterior (AP) and lateral orientation, the C-arm should be set at 0 degrees or 90 degrees, and the table should be rotated to establish this safe working position. Preoperative antibiotics and steroids may be given. Because MEP or EMG intraoperative monitoring is essential to the approach, the use of paralytics or muscle relaxants in anesthesia should be sparingly used. Positive confirmation of intact motor pathways also should be identified with neuromonitoring before the procedure begins. The patient is prepped and draped in the usual sterile fashion. Intraoperative fluoroscopy is used to identify and mark the appropriate index level (Fig. 33-2).

Three approaches are possible when using the XLIF approach for thoracolumbar corpectomy. The first is for lumbar-only exposures and follows the standard XLIF approach for lumbar pathology, as described by Ozgur et al.[26] For thoracic or thoracolumbar junction cases, two alternative approaches are possible: transthoracic or retropleural.[30]

FIG. 33-2 The target vertebral body localization *(box)* and rib *(line)* on the lateral aspect of the body for the XLIF® (NuVasive, Inc.) corpectomy approach. The incision will roughly follow the orientation of, though between, the ribs.

For the transthoracic approach, a 4- to 6-cm oblique incision is made directly over the targeted level 90 degrees off-midline between the ribs following the angle of the ribs (Fig. 33-2). Monopolar cautery is used to dissect through the subcutaneous tissue, latissimus dorsi, and intercostal muscles. The endothoracic fascia and parietal pleura are then sharply divided to enter the thoracic cavity. The lung is deflected anteriorly with the surgeon's finger as sequential dilators are placed under fluoroscopy over the targeted level (Fig. 33-3), and a table-mounted retractor is placed over the dilators (Fig. 33-4); proper placement is confirmed with fluoroscopy.

For the retropleural approach, a 5- to 6-cm oblique incision is made directly over the rib that is overlying the targeted pathology on lateral fluoroscopy. Monopolar cautery is used to dissect through the subcutaneous tissue, latissimus dorsi, and intercostal muscles. The periosteum of the rib is incised with the monopolar cautery along its exposed length. The periosteum is elevated circumferentially off the rib with Alexander and Doyen periosteal elevators, with care taken to prevent injury to the neurovascular bundle at the inferior edge of the rib or parietal pleura deep to the rib. A rib cutter is then used to excise approximately 6 cm of rib. The cut edges are waxed for hemostasis. Immediately underlying the rib, the endothoracic fascia, which fuses with the periosteum, is identified and sharply cut to expose the parietal pleura. The plane between the parietal pleura and endothoracic fascia is developed using the surgeon's finger, Kittner sponges, and sponge sticks. The pleura is swept free in the cranial and caudal direction as well as anteriorly until the lateral surface of the vertebral bodies and disc spaces are visualized. Then a table-mounted retractor is placed over the targeted level to maintain exposure (Fig. 33-5). Accurate placement is confirmed with intraoperative fluoroscopy.

For all corpectomy exposures, once accurate placement of the retractor has been confirmed and adequate exposure is achieved (Fig. 33-6), the goals of surgery are accomplished using the traditional methods. An anterior retractor blade can be used to more adequately expose the entire vertebral body for corpectomy (Fig.

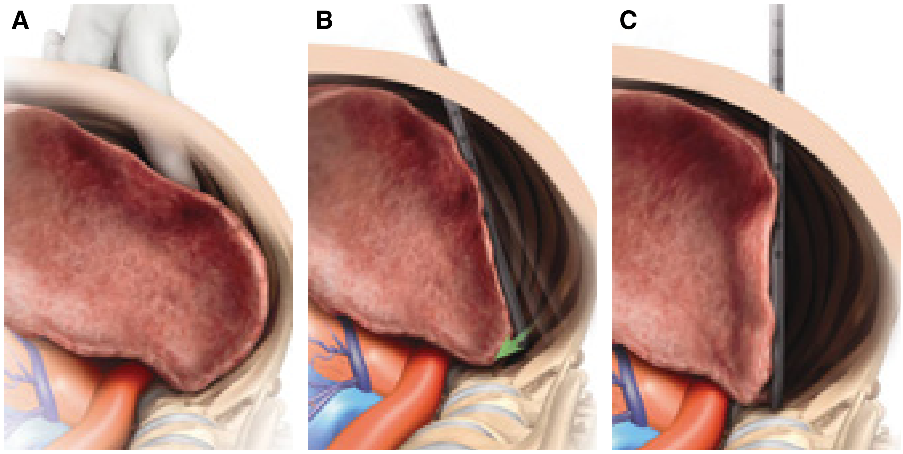


FIG. 33-3 **A,** Digital access into the thoracic space with inflated-lung deflection performed by, **B,** the access dilator passing on the posterior border of the thoracic cavity (to prevent violation of the lung with the leading end of the dilator), **C,** accessing the lateral aspect of the disc space.

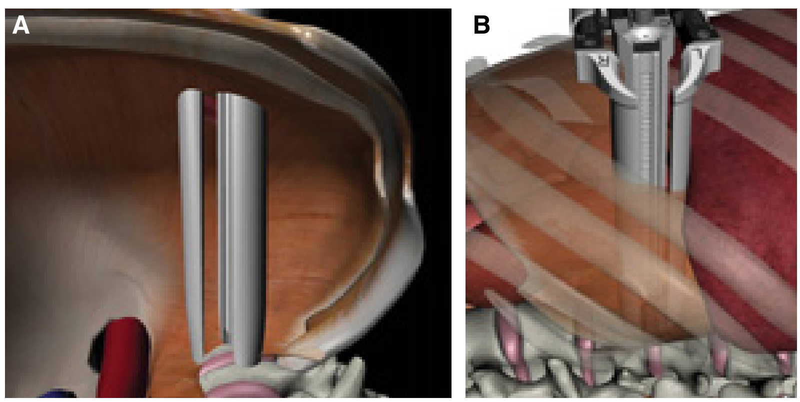


FIG. 33-4 **A,** Inferior and, **B,** posterolateral views showing MaXcess® retractor (NuVasive, Inc.) docking on the lateral border of the thoracic disc space.

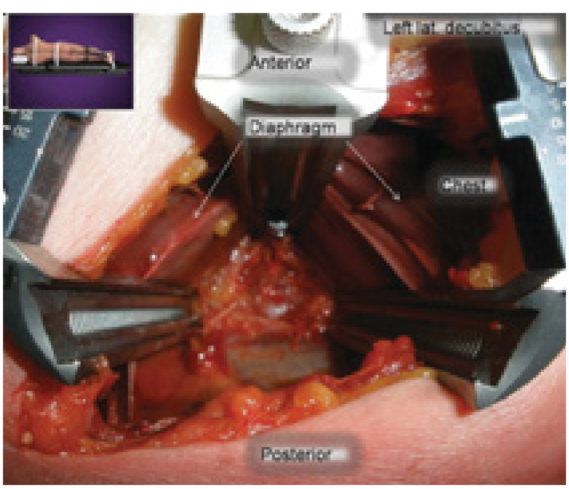


FIG. 33-5 Lateral view of retropleural access to the lateral disc space for XLIF® (NuVasive, Inc.) corpectomy.

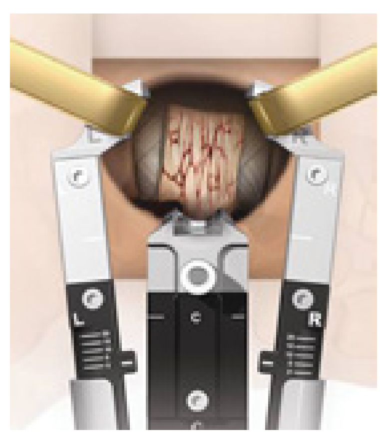


FIG. 33-6 Lateral view showing MaXcess® (NuVasive, Inc.) retractor access to the index level for an XLIF® (NuVasive, Inc.) corpectomy.

33-7). The segmental vessels that cross the index level must be coagulated and divided (Fig. 33-8). The disc spaces above and below the targeted vertebral body are incised and discectomies are performed using curettes and rongeurs (Fig. 33-9). Then under fluoroscopic guidance, an osteotome is used to make an anterior and posterior cut line in the vertebral body, creating a large defect. A high speed drill and down-pushing curettes are used to push the remaining posterior portion of the vertebral body into the created defect and away from the cord. By working in this orientation, orthogonal to the disc space and floor with the posterior blade of the MaXcess® retractor (NuVasive, Inc.) placed anterior to the dural elements, a safe working corridor is created that provides the ability to work in this 90-degree channel with the posterior neural elements protected by the retractor and the approach trajectory. This is especially important when either trauma or tumor has altered the local anatomy. The posterior longitudinal ligament must also be resected to ensure complete decompression of the spinal canal. Once complete decompression is achieved, the endplates are prepared and a wide-footprint expandable cage (X-CORE®, NuVasive, Inc.) is placed with graft materials of the surgeon's preference (Fig. 33-10, *A*). Anterior fixation such as anterolateral plating can be placed through the retractor (Fig. 33-10, *B*) to achieve single-incision decompression, corpectomy, and supplemental internal fixation.

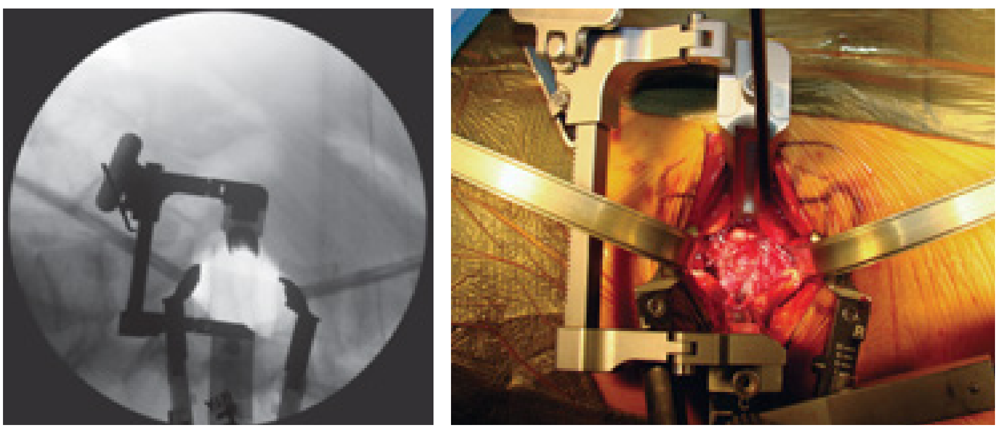


FIG. 33-7 Lateral intraoperative fluoroscopy *(left)* and photograph *(right)* showing MaXcess® (NuVasive, Inc.) retractor access to the index level for an XLIF® (NuVasive, Inc.) corpectomy.

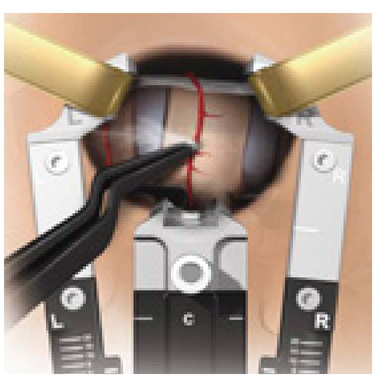
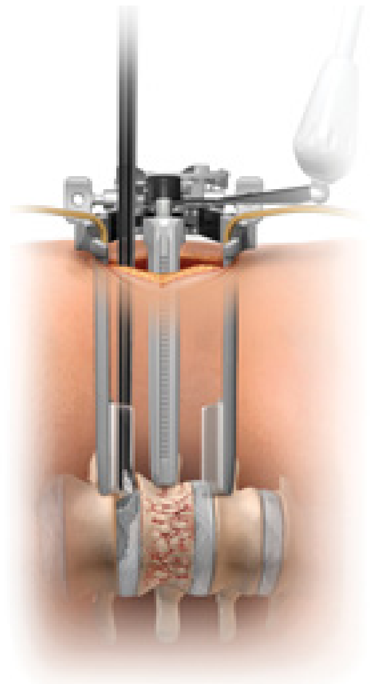


FIG. 33-8 Lateral view showing segmental vessel ligation using bipolar cautery during an XLIF® (NuVasive, Inc.) corpectomy.



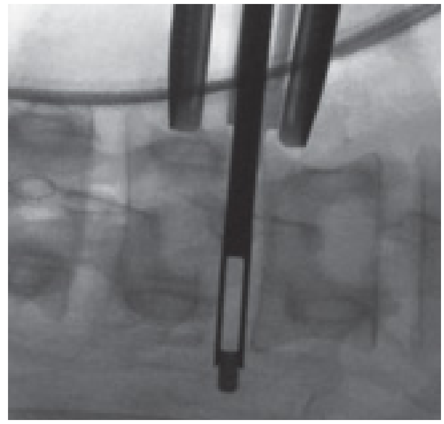


FIG. 33-9 Illustration *(left)* and intraoperative fluoroscopic image *(right)* showing discectomy prior to corpectomy during an XLIF® (NuVasive, Inc.) corpectomy procedure.

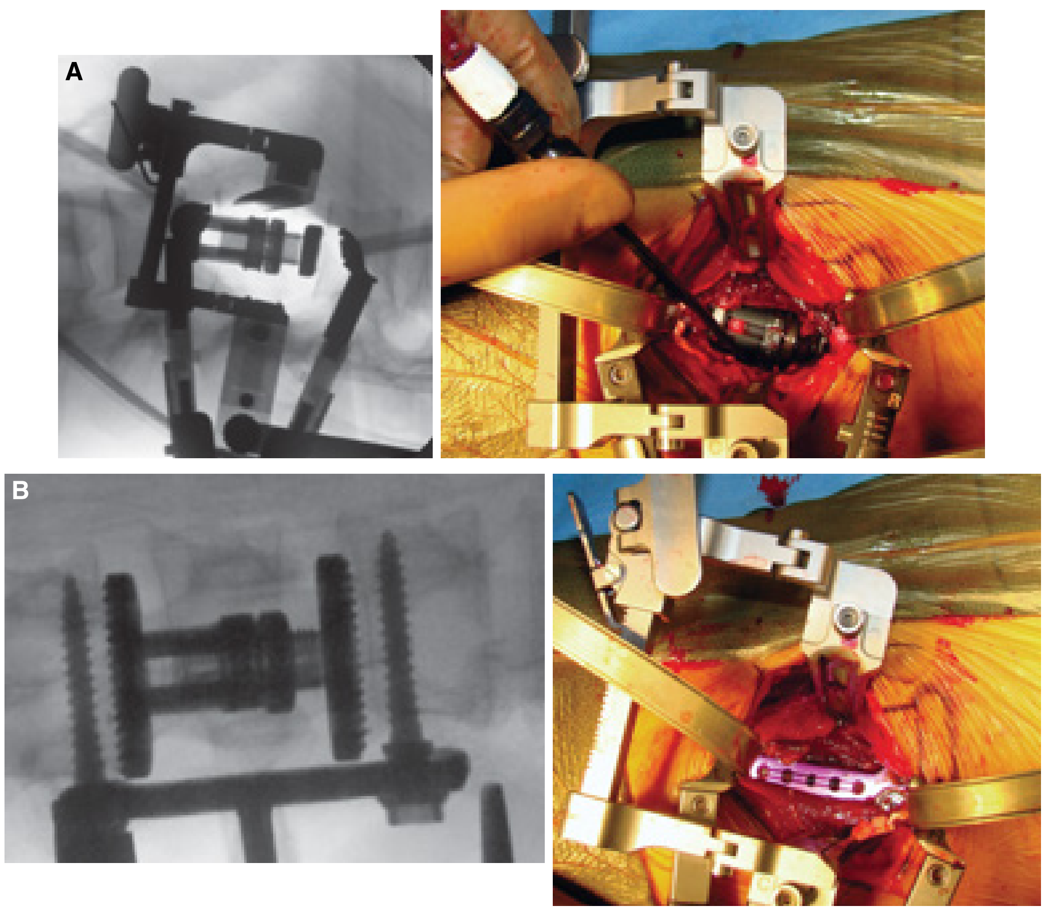


FIG. 33-10 **A,** Lateral fluoroscopic image *(left)* and photograph *(right)* showing placement of X-CORE® (NuVasive, Inc.) wide-footprint expandable cage for vertebral body replacement. **B,** Anterior fluoroscopic image *(left)* and photograph *(right)* showing placement of X-CORE wide-footprint expandable cage for vertebral body replacement and Traverse® (NuVasive, Inc.) plate.

If during these approaches the visceral pleura is violated or an air leak is identified, then a chest tube must be placed. If the approach is completely retropleural, no chest tube is required. If the parietal pleura is violated but no air leak is identified, a red rubber valsalva technique can be used to expel all excess air out of the thoracic cavity. A red rubber catheter is placed in the thoracic cavity with a purse string suture placed around its exit hole. A valsalva maneuver is then performed and held until all air is expelled. The red rubber catheter is then quickly removed and the purse string suture secured.

REPORTED RESULTS

Table 33-1 summarizes the studies published on the treatment of thoracolumbar spine pathology. A variety of exposure techniques and treatments are discussed, in-

TABLE 33-1 Summary of Reported Results of XLIF and Alternative Approaches for Corpectomy Following Trauma, Tumor, Infection, or Deformity

Author	Procedure	Internal Fixation	Exposure	Approach	Indication
XLIF					
Smith et al[27]	Corp	Lat plate/bilped	MaXcess	Ant (lateral)	Trauma
Uribe et al[29]	Corp	Lat plate/bilped	MaXcess	Ant (lateral)	Tumor
Uribe et al[30]	Corp	Lat plate	MaXcess	Ant (lateral)	Trauma/tumor
Khan et al[69]	Corp	Lat plate/bilped	MaXcess	Ant (lateral)	Trauma/tumor/infection
Baaj et al[28]	Corp	Lat plate/bilped	MaXcess	Ant (lateral)	Trauma/tumor/infection
Weighted average					
***Endoscopic**[32,45,48,50,60 61,70-72]	Corp	Lat plate/bilped/hooks/rods	Endoscopic	Ant (lateral)	Trauma/tumor/infection
Mini-open[67,73-76]	Corp	Lat plate/bilped	Mini-open	Ant (lateral)/postlat	Trauma/tumor/deformity
Open Corp[37,43,77-88]	Corp	Lat plate/bilped/hooks/rods	Open	Ant/post/360°	Trauma/tumor/infection/deformity
Open PLF[84,88,89-92]	PLF	Bilped/hooks/rods	Open	Post	Trauma

*Numerical results reported as an average across cited studies.
360°, Combined anterior and posterior column fusion; *Ant,* anterior; *Bilped,* bilateral pedicle screws; *Comps,* complications; *Corp,* corpectomy; *EBL,* estimated blood loss; *Lat,* lateral; *LOS,* length of hospital stay; *NR,* not reported; *OR,* operative time; *PLF,* posterolateral fusion; *Post,* posterior; *Postlat,* posterolateral; *Reops,* reoperations.

cluding mini-open lateral (XLIF), mini-open posterior/posterolateral, endoscopic, and open anterior/posterior/combined. Operative and perioperative details such as operative (OR) time, EBL, LOS, complication rate, and reoperation rates are compared for the different techniques.

To date, five studies have been published reporting promising results of thoracolumbar corpectomy using the mini-open XLIF approach.[27-30,69] In 2010, Smith et al[27] treated 52 patients with thoracic or lumbar traumatic spinal pathologies. Each patient had a one-level corpectomy (T7-L4) performed through the mini-open exposure followed by reconstruction with a titanium cage and lateral plate fixation. In some cases, supplemental pedicle screws were placed through a posterior incision. The mean OR time, EBL, and LOS were 128 minutes, 300 mL, and 4 days, respectively. There was a total complication rate of 15.4%; 1.9% required reop-

No. of Levels	Levels	Total n	OR (minutes)	EBL (mL)	LOS (days)	Total Comps (%)	Reops (%)
1	T7-L4	52	128	300	4	15.4	1.9
1-2	T8-12	13	124	374	3.5	7.7	0
1	T11-L2	4	300	460	6.25	25	0
1-2	T5-L4	25	189	423	NR	0	0
1	T7-L4	80	NR	NR	NR	12.5	2.5
		35	*151*	*350*	*4.0*	*11.5*	*1.7*
1-3	T3-L5	82	271	894	7.2	12	0
1-3	T2-L5	34	237	829	8.4	20.2	6.4
1-4	T1-L5	47	342	1,658	13.8	36.8	9.4
1-9	T-L	42	257	1,448	20	44.4	28.4

eration. Neurologic status was stable or improved in all cases. The first two thirds of patients were treated with standard expandable cylindrical titanium VBR devices; the remaining patients were treated with wide-footprint expandable titanium vertebral body replacement (VBR) devices (X-CORE). Subsidence was noted in 7 of the 34 (21%) patients treated with cylindrical VBRs, with one requiring reoperation. No instances of subsidence were observed in the 18 patients treated with wide-footprint VBRs.

Uribe et al[29] reported their results following one- or two-level corpectomy in 13 patients with spinal tumors (T8-12). Reconstruction was performed with a titanium cage and lateral plate, and in some cases, supplemental pedicle screw fixation, similar to the series by Smith et al.[27] Despite the dissimilar pathology, the results were comparable to the traumatic series. Mean OR time was 124 minutes, mean EBL was 374 mL, and mean LOS was 3.5 days. One (4.8%) complication occurred (pneumonia), and there were no reported reoperations. Pain (as measured by the visual analog scale [VAS]) and disability (measured by the Oswestry disability index [ODI]) improved from preoperative to last follow-up by 62.3% and 52.8%, respectively. Two patients subsequently died as a result of their metastases, one at 6 months and one at 12 months postoperative.

Uribe et al[30] published a cadaveric feasibility study and included four case reports utilizing the same mini-open technique through a retropleural exposure. The study included both trauma patients and those with tumor pathologies, each of which underwent a single-level corpectomy (between T11 and L2). Titanium cages and lateral plates were similarly used for spinal reconstruction. Mean OR time, EBL, and LOS were slightly greater at 300 minutes, 460 mL, and 6.3 days, respectively. One complication occurred, a pleural tear with chest tube placement, with none of the four needing reoperation. These slightly elevated treatment variables may be related to the procedures being performed within a teaching institution, compared with patients treated in a mix of community and academic hospital settings as in the previous reports.

Khan et al[69] reported on 25 patients with traumatic, tumor, or infectious pathology who were treated with a single- or two-level corpectomy (from T5 to L4) utilizing the mini-open MaXcess system. The authors, however, performed the procedures with a modification to the standard XLIF approach, docking more anteriorly for lumbar corpectomies, anterior to the psoas muscle. Retropleural approaches, as previously described, were used in thoracic cases, while an extrapleural, subdiaphragmatic, transthoracic approach was used at the thoracolumbar junction. Again, reconstruction was performed with a titanium cage, lateral plate, and, in some cases, pedicle screws. Mean OR time was 189 minutes, and mean EBL was 423 mL. There were no reported complications or reoperations. Sixty-four percent of patients did not require blood products postoperatively, and 84% of patients were extubated immediately postoperatively. Two patients died from metastases during follow-up. Pain (based on VAS) improved by an average of 62% at last follow-up.

Baaj et al[28] recently reported a large XLIF corpectomy series (80 cases), with results focused only on perioperative complications. In the series, the authors found an overall complication rate of 12.5% with a reoperation rate of 2.5%. Complications included two instances each of dural tears, intercostal neuralgia, and DVT and one case each of pleural effusion, hardware failure, wound infection, and hemothorax. Of the two reoperations, one was for unplanned closure of the vertebral body replacement device following improper locking in an expanded position, and the second was for washout of left cavity fluid collection (hemothorax) without evidence of active bleeding. Neither patient experienced any long-term sequelae.

As a whole, these reported results for corpectomy performed through the mini-open XLIF approach resulted in a weighted average OR time of 151 minutes (range 124 to 300), EBL of 350 mL (range 300 to 460), and LOS of 4.0 days (range 3.5 to 6.25). Postoperative complications occurred at a mean rate of 11.5% (range 0% to 25%) and included pleural effusions, intercostal neuralgia, dural tears, deep venous thrombosis, wound infection, and graft subsidence. On average, less than 2% (range 0% to 2.5%) of patients required reoperation.

The XLIF approach for corpectomy compares favorably with reports of alternative approaches in the literature. Endoscopic techniques have provided another minimally invasive portal to the thoracolumbar spine. Khoo et al[32] published a large series, reporting on 371 patients with traumatic thoracic or lumbar fractures. Single-level corpectomies were performed between T3 and L3. Reconstruction was performed with a titanium cage, a lateral plate, and, in some cases, pedicle screws. In this series, mean OR time was 360 minutes and mean EBL was 650 mL, with a 9.7% complication rate. LOS or reoperation rate were not included in the results. In their comparison with a similarly treated cohort of 30 patients undergoing open thoracotomy for corpectomy, 42% less narcotics were required for pain management in the thoracoscopy group. Eight other studies reported results using this technique.[45,48,50,60,61,70-72] Corpectomies were performed for traumatic, tumor, or infectious etiologies and included one-, two-, or three-level procedures from T3 to L5. Reconstruction included VBRs, anterolateral plating, and posterior instrumentation such as pedicle screws, hooks, or rods. Total patients in these studies ranged from one small case series ($n = 4$) to large retrospective reviews ($n = 371$). Mean operative time was 271 minutes (range 60 to 408), mean EBL was 894 mL (543 to 1,450), and mean LOS was 7.2 days (range 6.5 to 8.7). Postoperative complications were similar to the XLIF outcomes and occurred at an average rate of 11.5% (range 0% to 29%); no reported patients required reoperation (reoperation was reported in only three studies).

Other mini-open retractor systems have also enabled access to the spine in a less destructive fashion. The largest of these studies was by Kossmann et al in 2001.[73] The authors reported on 65 patients who underwent single-level corpectomies for traumatic or tumor pathology (between T6 and L4). Only a cage and an anterolateral plate were used for reconstruction. Mean OR time, EBL, LOS, and complication rate were 170 minutes, 912 mL, 13 days, and 7.7%, respectively. Reoperation rate was not reported. Five other studies also published results of a similar technique.[37,67,74-76] These additional studies had a mean n of 34 patients (range 7 to 65), with an average OR time of 237 minutes (range 101 to 450), EBL of 829 mL (350 to 1,857), and LOS of 8.4 days (range 4.7 to 13). The average complication rate was 20.2% (range 0% to 42%) with a reoperation rate of 6.4% (range 0% to 15%).

In contrast, open procedures have more traditionally been used to remedy thoracolumbar pathology. Numerous authors have published their results on open surgical corpectomies dating as far back as 1979 and as recently as 2010.[37,43,75,77-88] Clinical results of these historical controls were all less favorable when compared with more modern less invasive approaches: mean operative time was 342 minutes (range 210 to 617), mean EBL was 1,658 mL (range 710 to 3,136), mean LOS was 13.8 days (range 6-38), mean complication rate was 36.8% (range 7.5% to 79.2%), and mean reoperation rate was 9.4% (range 0% to 26.1%), These studies included anterior, posterior, and combination approaches for traumatic, tumor, infectious, and deformity pathologies from T1 to L5. Reconstruction included cages, lateral plates, and posterior instrumentation with pedicle screws, hooks, and rods.

When traumatic burst fractures were treated with a posterior-only approach for decompression and instrumentation, more extensive fixation was required (range 1 to 9 levels) because of limited anterior support.[84,88-92] In such cases, reconstruction included posterior instrumentation with pedicle screws, hooks, and rods. In such cases, average OR time was 257 minutes (range 138 to 370), EBL was 1,448 mL (460 to 2,275), and LOS was 20 days (range 10 to 33.5). The average complication rate was 44.4% (range 21% to 104%), with a reoperation rate of 28.4% (range 7.7% to 55.5%). Significant common complications in these open cases included hardware failure, wound infections, and dural tears.

These results demonstrate that corpectomy performed via modern minimally disruptive systems results in decreased OR time, EBL, LOS, complication rate, and reoperation rate compared with the more traditional open procedures, with similar long-term outcomes. In particular, the mini-open XLIF technique also compares favorably with other less invasive procedures, such as the endoscopic approach, by offering a similar anterior exposure and working environment to traditional thoracotomy without the adjuvant morbidity.

CASE EXAMPLES

Case 1

This 43-year-old obese man with stage 1 squamous cell carcinoma of the tongue was treated in 2009 with radiation therapy and glossectomy. Recurrence occurred in 2010 in the left side of the neck and resulted in a left radical neck dissection. The patient presented in 2012 to the emergency room with severe back pain and bilateral lower extremity paresis. CT revealed a pathologic compression fracture of the T12 vertebral body with an approximately 2-cm T11 left vertebral body and pedicle lesion consistent with metastasis. MRI of the brain revealed an enhancing mass in the lateral aspect of the right cerebellar hemisphere, consistent with further metastases. The patient underwent a retropleural exposure for T12 corpectomy using a wide-footprint expandable cage (X-CORE) and lateral laminectomy and facetectomy followed by anterolateral plating (Traverse®, NuVasive, Inc.) (Fig. 33-11). No intraoperative complications occurred, and the patient was discharged to hospice ten days postoperative.

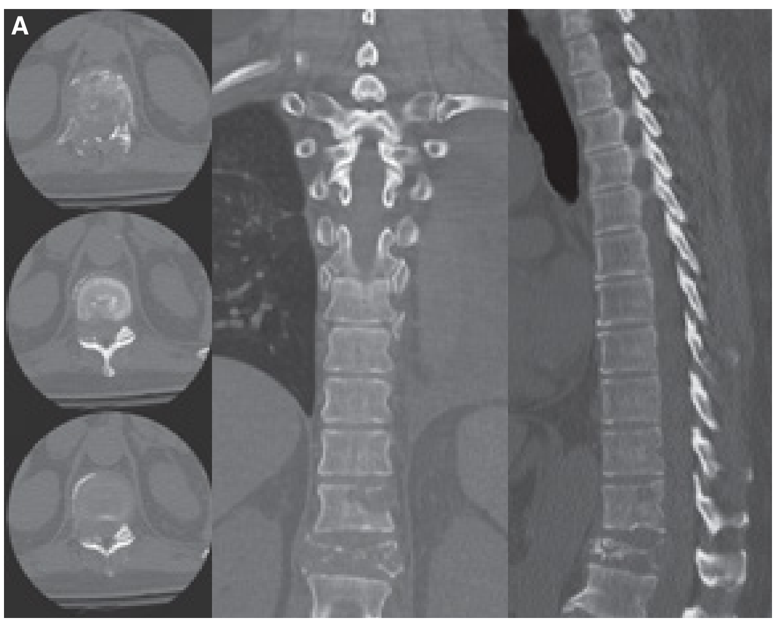


FIG. 33-11 **A,** Preoperative CT showing T11 metastasis in the vertebral body and pedicle. The patient was treated with a retropleural approach for lateral corpectomy, laminectomy, and facetectomy.

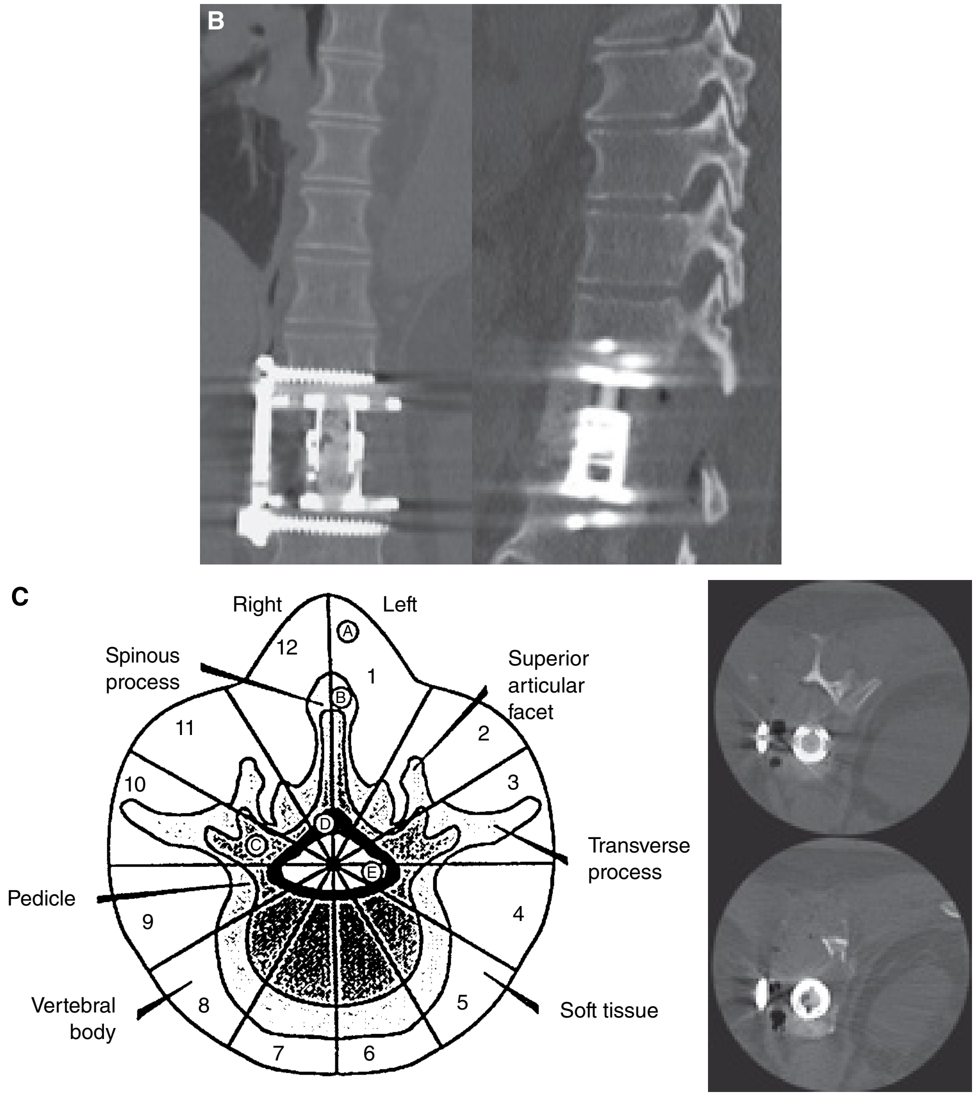


FIG. 33-11, cont'd **B,** A wide-footprint expandable cage (X-CORE®, NuVasive, Inc.) with anterolateral plating (Traverse®, NuVasive, Inc.) was placed. **C,** Postoperative axial CT shows area of decompression (approximately zones 4 through 11 on the Weinstein-Boriani-Biagini scale) available through the lateral XLIF® (NuVasive, Inc.) approach for corpectomy.

Case 2

This 59-year-old man presented to the emergency room after having fallen off of a ladder and experiencing persistent paresthesia when upright. MRI revealed an L2 burst fracture (Fig. 33-12, *A*) and an American Spinal Injury Association (ASIA) score of E. Following L2 XLIF corpectomy with a wide-footprint expandable cage (X-CORE) and anterolateral fixation (Traverse) (Fig.

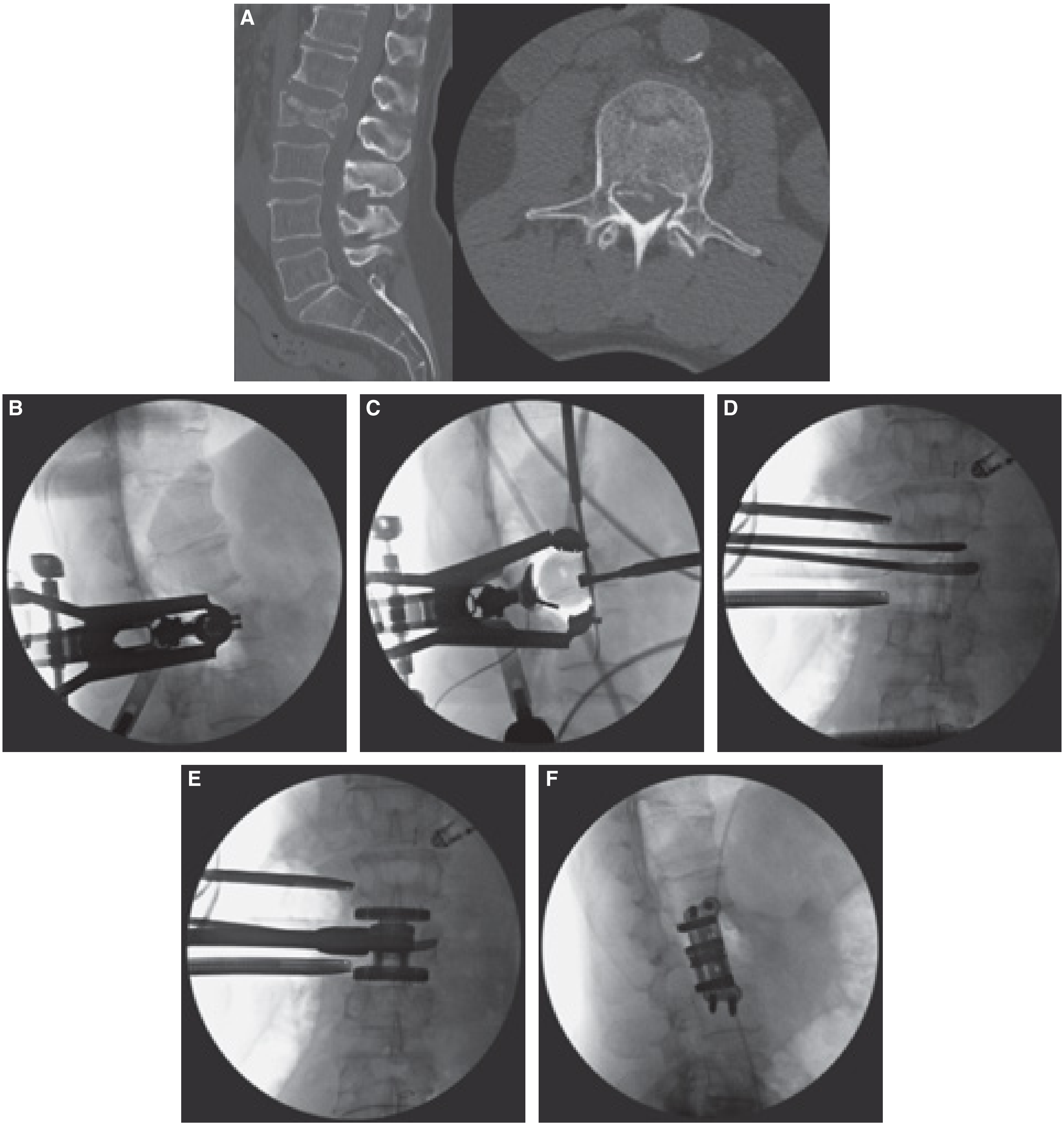


FIG. 33-12 **A,** Preoperative CT scans showing an L2 burst fracture. **B,** Intraoperative fluoroscopic image showing spinal access at the index level with the MaXcess® (NuVasive, Inc.) retractor, followed by **C,** retraction and exposure of the burst fracture, **D,** corpectomy, and **E** and **F,** placement of wide footprint vertebral body replacement device (X-CORE®, NuVasive, Inc.) anterolateral plating (Traverse®, NuVasive, Inc.).

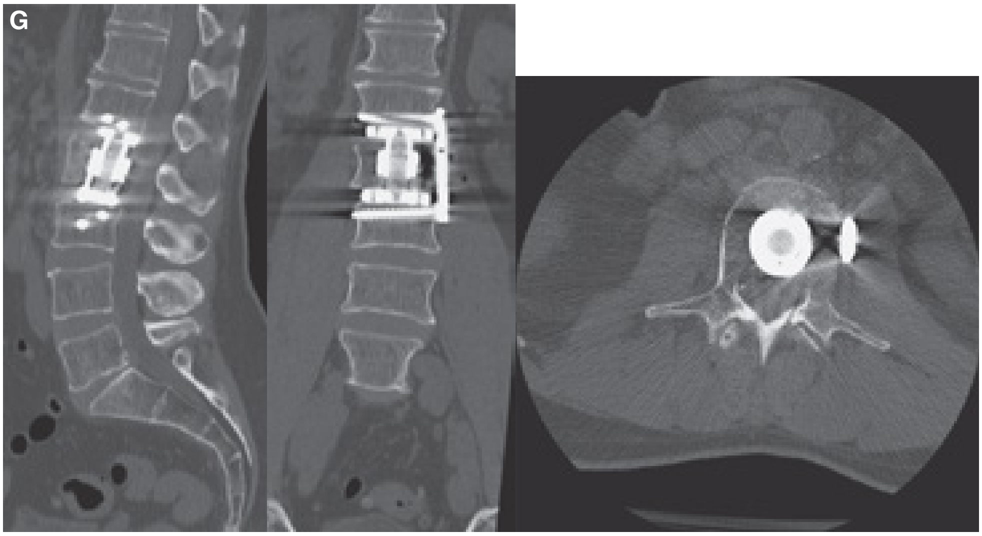


FIG. 33-12, cont'd **G,** Postoperative CT scans showing restoration of alignment and decompression following XLIF® (NuVasive, Inc.) corpectomy.

33-12, *B* through *F*), the patient was discharged on the first postoperative day with complete resolution of paresthesia (Fig. 33-12, *G*).

LIMITATIONS

There are several drawbacks to the minimally invasive lateral transthoracic/retropleural approach to the thoracic spine. For example, when posterior decompression or instrumentation is required, a second, posterior incision is needed. Also, the lateral approach requires a long working distance in a relatively narrow working space, which can result in a long lever arm from the surgeons' hands to the pathology, though this is rarely an issue in practice and can be overcome by marginal widening of the exposure portal. In addition, retropleural dissections may not be feasible following a previous ipsilateral thoracotomy secondary to scar-tissue adhesions. Similarly, patients with osteomyelitis of the spine or spinal metastases may have marked paraspinal pleural reactions with adhesive thickening of the parietal pleura and infiltration of the pleura by tumor or inflamed fibrous tissue. This should be evaluated by MRI preoperatively for adequate planning. Furthermore, if there is primary involvement of the posterior elements with bilateral pedicle invasion, a posterior-based approach may be advisable.

The lateral approach is also limited from the upper thoracic and lower lumbar levels. At the upper thoracic levels (T1-4), the mediastinum anteriorly and axilla laterally limit the exposure to the vertebral bodies. In addition, the great vessels that branch out from the aorta at these levels increase the risk of vascular injury. Caudally, the lumbar plexus is dense at the lower lumbar spine around the L3-5 vertebral bodies. Thus, corpectomy at these levels may have an increased risk of lumbar plexus injury and should be performed with caution, especially at L4. At L5, with the position of the iliac crest likely blocking a safe approach trajectory to the L5 vertebral body, the XLIF approach is likely not possible.

CONCLUSION

The advantages of MIS surgery are often realized in the more complicated procedures. Many early studies of simple discectomy or decompression failed to show a benefit of MIS over open surgical approaches. Open lumbar and thoracic corpectomies from an anterior approach, while often effective, carry an extremely high risk profile. Posterior-only corpectomies can be performed, but exposure, visualization, and decompression can be limited with a long-term increased rate of biomechanical and clinical failures. These higher failure risks are particularly important because the patient population requiring these procedures are often sick, debilitated, and have a limited life expectancy (in metastatic patients) or have multi-system issues (in the polytrauma patient). In those with limited life expectancy, surgery is often palliative, and a hastened improvement in quality of life postoperatively often means more time spent with family and friends than recovery following extended hospitalizations and large surgical exposures.

Given these considerations, patients who will obtain the maximum benefit from MIS procedures are often those that require the largest and most complex of procedures and who are simultaneously some of the highest risk patients. The benefit of MIS is then found not in smaller incisions, but in efficient surgical procedures, fewer complications, shorter hospital stays, and hastened return to a quality life.

The mini-open lateral approach blends the benefits of anterior thoracic approaches without the difficulty of thoracoscopic approaches while maintaining the biomechanical advantages absent in posterior-only surgery. It completes the promise of MIS in complex surgery while offering a relatively manageable learning curve and use of standard instrumentation and surgical techniques, in a safe and reproducible platform.

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