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XLIF® With Lateral Plating

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The goal of single-approach arthrodesis is to address segmental pathology requiring stabilization while eliminating the need for an additional procedure. The extreme lateral interbody fusion (XLIF®, NuVasive®, Inc., San Diego, CA) approach allows application of a wide implant while preserving inherent stabilizing structures, the anterior and posterior longitudinal ligaments. It may not be necessary to maximize stability with posterior fixation, especially if a posterior decompression is not required to successfully treat the targeted segment. To preserve the minimally disruptive benefits of XLIF while increasing the segmental stability of the XLIF fusion construct, the XLP® and XLP Plus (NuVasive, Inc.) lateral plates have been implemented as supplemental fixation options.

TREATMENT OPTIONS

Before the XLIF approach became popular, direct anterior lumbar interbody fusion (ALIF) performed through a transperitoneal or retroperitoneal technique was the most common single-approach option for anterior column fusion. Advantages afforded by the ALIF approach include the ability to restore disc space and foraminal height with a large implant and avoidance of the neural elements of the posterior spine. Despite numerous clinical and biomechanical studies concluding that ALIF is an acceptable single-approach fusion technique when combined with anterior plating,[1-6] the direct anterior procedure has often been associated with high complication rates when compared with alternative approaches,[7] including reported delayed vessel rupture after anterior plating.[8] Biomechanically, ALIF may be further disadvantageous because the approach trajectory and vascular anatomy prevents the use of wider cages that span the apophyseal ring of the endplates that would decrease the risk of subsidence. Further, the procedure requires removal of the anterior longitudinal ligament, which is the only spinal ligament that limits motion in extension. As such, removal can cause significant reductions in segmental stability and increased facet loads compared with other procedures in which the anterior longitudinal ligament remains intact.[9] In addition to the biomechanical disadvantages and risk of complication, use of ALIF is limited in most settings because it requires the use of an access surgeon; logistically, this can be challenging in terms of availability and scheduling.

It is important to note that although most patients who are candidates for anterior single-approach fusion will also be candidates for posterior single-approach fusion, the converse may not be true if the patient requires direct decompression or if the segment is excessively unstable. Examples of single-approach anterior column fusion through a posterior approach include posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF). Both procedures afford access to the anterior column as well as options for supplemental fixation through the same approach. An advantage of posterior single-approach techniques is that the interbody and supplemental fixation techniques are universally taught and typically very familiar to treating surgeons. The shortcomings of posterior single-approach techniques include a constrained ability to perform indirect decompression via disc height restoration because of the limited size of interbody cages that can be safely placed from a posterior approach, risk of neurologic injury, elevated blood loss, and morbidity to the posterior musculature.[10-14] In patients who may not require a direct decompression it may be desirable to seek alternative methods.

RATIONALE FOR THE LATERAL APPROACH

In considering the alternative techniques for single-approach lumbar fusion, each requires removal of at least one spinal ligament, effectively reducing the stability of the segment. In contrast, XLIF with lateral plating preserves all of the spinal ligaments, which not only protects the stability of the segment but also allows the surgeon to take advantage of the ligamentotaxis of the annulus and intact ligaments, affording excellent correction ability in the face of mild deformity. Once the XLIF cage has been implanted, additional segmental stability is afforded with the use of a lateral plate. Unlike direct anterior approaches, in flexion and extension the range-of-motion is primarily limited by the implant and anterior longitudinal ligament rather than the plate. Biomechanical testing has confirmed that the two-bolt XLP lateral plate construct in combination with an XLIF implant is equivalent to unilateral pedicle screws in lateral bending and axial rotation motion planes.[15,16] The system is efficient with short operative times (6 to 10 minutes per level), adding stability to interbody constructs with reduced morbidity and without an additional incision.[12]

Subperiosteal stripping across spinal segments and muscle retraction in open posterior procedures has been associated with blood loss, tissue ischemia, and injury, which can delay wound healing and predispose the wound to infection.[17] In addition to the medical implications, insult to the multifidus muscle by retraction or muscle denervation has also been associated with increased intensity of patient-reported short- and long-term back pain.[18] These findings are critical because the methods for preventing postoperative complications include rapid mobilization to prevent pneumonia, ileus, and deep vein thrombosis.[19] In general, patients are more likely to begin immediate postoperative ambulation when pain is minimized, further supporting avoidance of posterior approaches when possible.

In cases of excessive disc height loss, removal of posterior elements may not appropriately decompress the neural anatomy as effectively as elevating the disc. Because the natural curve of the lumbar spine is lordotic, posterior implants are inserted through an approach where the disc height is the narrowest. As such, implants that are placed from the posterior spine are often limited in size and ultimately limit the amount of disc height restoration that is possible. The XLIF approach with lateral plating provides access to the anterior column for maximum restoration of disc height and superior cosmesis without the risks associated with a direct anterior or posterior approach.

Given these advantages, XLIF with lateral plating can be performed with a short hospital stay or potentially as an outpatient procedure in select patients.

TECHNIQUE

The lateral plating system consists of an option of a two-hole/two-bolt plate (XLP) or four-hole/four-screw or two-screw/two-bolt plate (XLP Plus), where the bolts or screws are inserted into the lateral aspect of the vertebral bodies above and below the treated disc. The procedure for lateral plating begins after the disc preparation and cage insertion has been completed using the standard XLIF technique and the surgeon is satisfied with the implant position and stability. The patient remains in the lateral decubitus position. When necessary the MaXcess® retractor (NuVasive, Inc.) can be expanded gently to accommodate the plate preparation and insertion, but retraction should be as limited as possible to reduce the risk of insult to the psoas muscle, lumbar plexus, and segmental arteries cephalad and caudad to the treated disc.

When osteophytes are present it is preferable to remove only the spurs that prevent the plate from seating on the lateral surface of the vertebral body. Excessive removal of osteophytes may result in unnecessary bleeding and potential psoas hematoma. Osteophyte removal is best controlled using hand-operated rongeur biters and bipolar cautery if bleeding is encountered. If bleeding is persistent, a hemostatic agent should be used to help reduce the likelihood of a postoperative psoas hematoma.

Plate selection through final positioning is depicted in Fig. 17-1. Plate sizing is dependent on the height of the interbody implant. Use of the smallest recom-

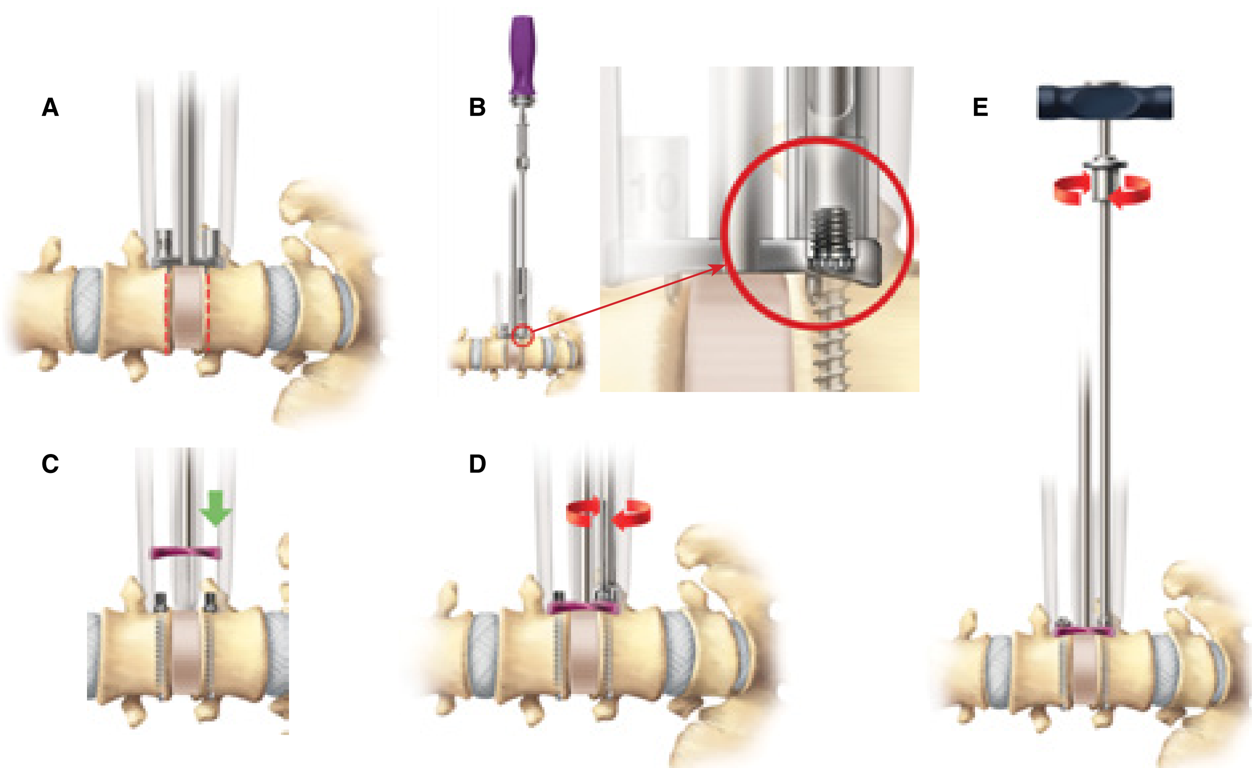

FIG. 17-1 **A,** AP view of the XLP® (NuVasive, Inc.) template centered over the disc space perpendicular to the spine. The spikes, which are visible on fluoroscopic images, indicate the position of the bolt and are used to anchor the guide into position for the creation of pilot holes using an awl, drill, or tap. **B,** The bolt is inserted through the guide barrel; stops on the guide help to keep chocks above the bone. Fluoroscopic monitoring of the bolt location relative to the contralateral side throughout insertion will help confirm the bolt length has been appropriately sized. **C,** After placing the bolts, the guide is removed and the plate is inserted over the bolt heads. **D,** Once the plate is seated over the chocks, the lock nuts are threaded over the bolts. **E,** Final tightening is conducted using a torque-limiting T-handle and plate holder countertorque.

mended plate will not only reduce intraoperative retraction and therefore reduce the likelihood of injury to the psoas and lumbar plexus during insertion, but will also position the bolts such that they are implanted through the stronger subchondral bone on either side of the interbody space rather than the cancellous bone of the vertebral body. Care should be taken, however, to avoid disrupting the integrity of the bony endplate when placing the bolts.

In the case of consecutive levels with lateral plating, use of appropriately sized plates will also reduce overhang and allow space for consecutive placement of segmental lateral plating. If there are previously placed pedicle screws in the vertebral body (a good indication for lateral plating, versus revision of posterior instrumentation), the plate size should be carefully templated to avoid bolt deflection when they are inserted.

When lateral plating is used at a level that is cranial to pre-existing pedicle screws at an adjacent level, either the bolt's trajectory can be planned directly cranial to the screws and caudal to the endplate, or a longer plate may be chosen and the bolt placed caudal to the pedicle screws. Placing the bolt cranial to the pedicle screws will allow the bolt to purchase more cortical bone, increasing the biomechanical strength of the construct; however, in some scenarios the bolt must be placed caudad to pre-existing pedicle screws because of a lack of clearance. The biomechanical strength of the construct will be best preserved if plates are not undersized from the recommended height based on the interbody implant size. When lateral plating is applied to consecutive levels, staggering bolts that are placed within the same vertebral body in the anteroposterior plane may help to prevent potential stress risers and vertebral body fracture.

Lateral fluoroscopy with the template may be used to verify targeted bolt position and to identify whether there is a need to rotate the plate to follow the contour of the vertebral column in the sagittal plane. This confirmation is especially useful at L4-5, where segmental lordosis is greatest, to identify appropriate placement on the L5 body. Bolts are most commonly placed parallel and approximately 2 to 3 mm off the endplates with bicortical purchase. This method will place the bolts through the hard bone around the endplates and provide additional stability with purchase in both cortices. Bicortical fixation of the bolt is desirable but it is not required. Divergent trajectories should be used with caution, because exceeding an 8-degree divergence may interfere with plate and lock nut insertion and increase the risk of construct failure.

To select the appropriate bolt length for the lateral plate construct, the surgeon should carefully examine the preoperative MRI to evaluate the neurovascular structures on the contralateral side. If a four-hole plate has been selected, typically the anterior screws will be shorter than the posterior screws or bolts to minimize the risk of neurologic or vascular injury. If the plate is very prominent, it may be appropriate to select bolts that are the same length as the interbody cage width; if the plate rests tightly on the vertebral body, the surgeon may prefer to select bolts that are 5 mm shorter than the cage width.

The plate is designed to easily slide within the aperture of the MaXcess blades and interdigitate with the bolts to prevent motion at their interface, allowing up to an 8-degree arc to facilitate assembly in vivo. When the plate is inserted, the MaXcess retractor should be opened just wide enough for the plate to slide along the retractor as it is inserted. It is not necessary to provide excessive clearance between the plate and retractor as it is inserted.

Once the plate is in position, it is secured through the locking nuts over the bolts; screws are locked to the plate via an integrated canted coil locking mechanism. The stability of the construct can be maximized by tightening the screws/bolts incrementally in alternating fashion until the locking nut reaches the torque limit, securing the bolt in place. The table should be flat rather than broken before final tightening to reduce stress at the screw–bone interface.

SPECIAL CONSIDERATIONS

Use of a wide interbody cage will distribute forces across a larger surface area of the endplate, reducing the risk of subsidence and adding stability to the construct. Endplate and vertebral body fracture leading to subsidence is the most common failure mechanism of the construct with XLP fixation. Factors leading to this occurrence are commonly attributed to patient selection, operative technique, construct component selection, or a combination of these factors.

Undersizing the plate is not advisable, because it does not allow for complete bony purchase when the bolts or screws are inserted; however, there are scenarios when the surgeon should consider choosing a plate that is longer than the recommended size. Examples include L4-5 cases in which the patient's anatomy dictates a more oblique bolt trajectory across the L5 vertebral body. Use of a longer plate will facilitate the trajectory through the L4 vertebral body and reduce stress at the bolt–bone interface, which increases the risk of a vertebral body fracture. Similarly, when performing XLIF cephalad to an adjacent fusion with existing pedicle screw instrumentation, a longer plate may be necessary to span fixation beyond the pedicle screws of the inferior vertebra.

It is imperative to preserve the anterior longitudinal ligament if the surgeon is relying solely on the plate for fixation. Anterior longitudinal ligament rupture will increase facet loading and result in extension instability, which is not addressed by a lateral plate. Should an anterior longitudinal ligament rupture occur, the surgeon may prefer to perform bilateral pedicle screw fixation or resort to an alternative interbody device with integrated fixation screws (e.g., CoRoent® XL-F; NuVasive, Inc.) to minimize the potential for graft migration.

REPORTED RESULTS

Biomechanical testing has shown that XLIF with lateral plating significantly reduces segmental range-of-motion in lateral bending and axial rotation when compared with stand-alone constructs.[16] As surgeons have gained experience with XLIF and supplemental lateral fixation, clinical evaluation of its application has begun to emerge. Youssef et al[20] reported reduced surgical time, blood loss, and hospital stay and comparable fusion in patients treated with XLIF and supplemental lateral fixation when compared with patients treated with XLIF and supplemental pedicle screw fixation. Similarly, Dakwar et al[21] reported on the outcomes of 15 XLIF patients treated with supplemental lateral fixation as part of a report on the early outcomes of 25 patients treated with XLIF for adult degenerative scoliosis. Supplemental fixation with lateral plating resulted in one incidence of hardware failure and one incidence of subsidence, both of which were asymptomatic. Although the clinical outcomes for patients treated with lateral fixation were not reported independently, overall the study reported successful treatment and favorable improvements in clinical outcomes in a challenging patient population that often experiences significant complications when treated surgically.

Despite favorable outcomes of XLIF with lateral plating, there have also been isolated incidences of endplate fracture with its use.[22,23] Although endplate fracture is a known risk of any interbody fusion procedure, these reports have attributed the complication specifically to lateral plating in osteoporotic patients. In response to such reports, preventive measures have been proposed to reduce the likelihood of endplate fracture with the use of lateral fixation: careful consideration before using lateral plate fixation in osteoporotic patients, avoidance of endplate violation during endplate preparation, avoidance of intervertebral overdistraction, preservation of the anterior longitudinal ligament, and careful patient positioning and appropriate surgical technique during implantation.[24] Though these preventive measures have yet to be demonstrated through clinical studies, the authors are optimistic that implementation of these considerations can effectively reduce the risk of complications with supplemental lateral plate fixation.

NEXT GENERATION

NuVasive has recently developed a next generation of lateral plating. It is an anterior/anterolateral plate system that includes titanium alloy plates, screws, and spikes in a variety of shapes and configurations to suit the individual pathology and anatomic conditions of each patient. Configurations include a two-hole plate with two screws or a four-hole plate with two screws and two spikes (Fig. 17-2). A translating feature on the plate is designed to allow compression of the plate length for easier insertion and reduction of retraction forces. If the surgeon prefers to insert the plate before reducing the table break, the translating plate will accommodate small changes in the patient's positioning as the table is repositioned. Once in position, the plate can be adjusted to the desired length and is locked to prevent future translation.

CASE EXAMPLES

Case 1

This 76-year-old large diabetic man with a history of anterior and posterior fusion with instrumentation from L4-S1 and L2-4 laminectomy for adjacent disease presented with back pain and right L3 radicular leg pain and weakness. Preoperative CT scans showed severe recurrent L3-4 stenosis with block of the dye (Fig. 17-3, *A*), advanced degenerative changes, and a solid fusion at L4-S1 (Fig. 17-3, *B* and *C*). The patient underwent

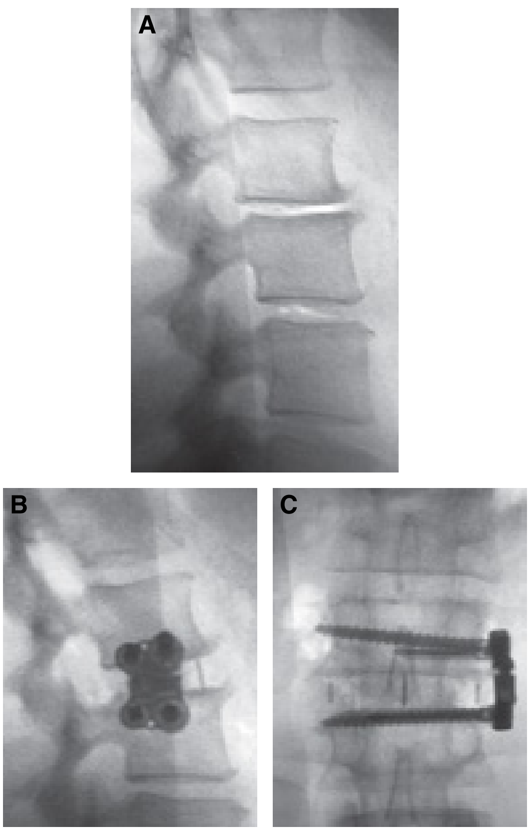

FIG. 17-2 Intraoperative fluororadiographs, **A,** before and, **B** and **C,** after single-level XLIF® (NuVasive, Inc.) with NuVasive's next generation lateral plate.

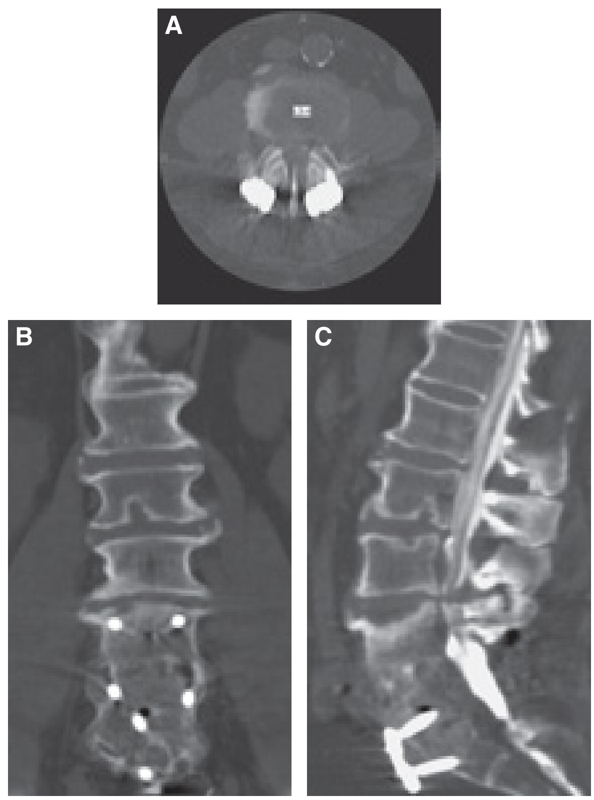

FIG. 17-3 **A,** Post-myelography CT scan demonstrating L3-4 stenosis. **B** and **C,** Preoperative CT demonstrating stenosis above solid fusion at L4-S1.

two-level XLIF from L2-4. Because of the myelography block and previous surgery, the surgeon determined a direct decompression was needed, which was carried out under the same anesthetic. The fusion was supplemented with lateral plating (XLP Plus) to prevent a large posterior dissection with hardware removal/revision. Intraoperative fluoroscopic images (Fig. 17-3, *D* and *E*) showed excellent restoration of disc and foraminal height. In the postoperative period the patient experienced marked improvement in both back and leg pain. AP and lateral radiographs taken 28 months postoperatively showed a solid mature fusion at both levels (Fig. 17-3, *F* and *G*).

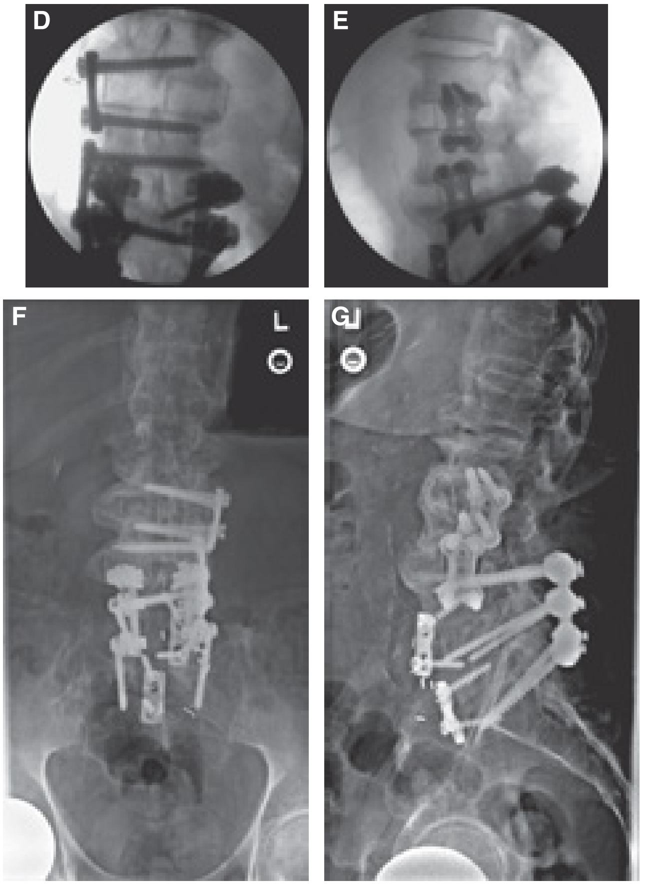

FIG. 17-3, cont'd **D** and **E,** Intraoperative fluororadiographs showing good restoration of disc height and good positioning of lateral plating. A four-hole/four-screw plate was used. **F** and **G,** 28-month plain radiographs showing solid mature fusion at L2-4.

Case 2

This 37-year-old man in good health presented with severe low back and left leg pain that had been ongoing for approximately 4 months. The patient's surgical history included two prior left L4-5 microdiscectomy procedures. Physical exam revealed significant back pain with stiffness and guarding, sciatic notch tenderness, and ankle plantar flexion weakness with L5 hypoesthesia. His preoperative MRI showed degenerative disc disease at L4-5 with a recurrent disc herniation (Fig. 17-4, *A*). The patient underwent XLIF at L4-5 with lateral plate fixation. The recurrent herniated disc fragment was addressed with indirect decompression. As such, dural tear risks associated with a re-exploration laminectomy were minimized. Intraoperative fluoroscopic views showed restoration of disc and foraminal height (Fig. 17-4, *C* and *D*). MRI taken 1 year following surgery showed complete resolution of the disc herniation (Fig. 17-4, *B*).

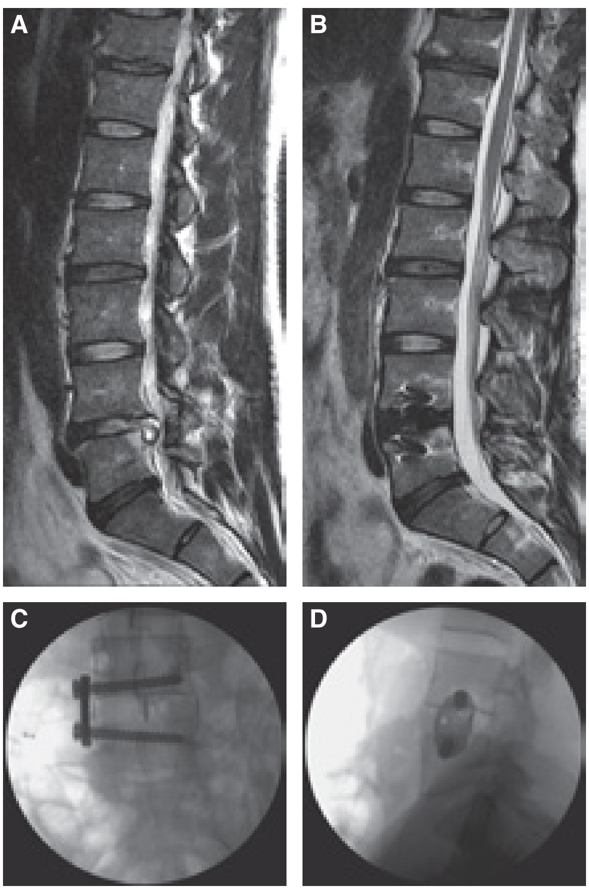

FIG. 17-4 MRI of disc herniation at L4-5 **A,** before and, **B,** 1 year after treatment with XLIF® (NuVasive, Inc.) and lateral plating. **C** and **D,** Intraoperative fluororadiographs after plate insertion.

LIMITATIONS

Spondylolisthesis can be successfully treated with lateral plating as long as the patient has good bone density at the adjacent endplates; lateral plating and the annular tension achieved in restoring a collapsed disc space results in adequate stability without additional posterior fixation. The surgeon may prefer alternative fixation methods when high-grade spondylolisthesis is present.

Osteoporosis is not always a contraindication for lateral plating; however, lateral plating should be applied in these cases with careful consideration of the bone density and the amount of disc height restoration required for successful treatment. When little disc space distraction is required and the bone density is not exceptionally low, osteoporotic patients can be successfully treated with lateral plating. If additional stability is warranted, the plate can be further supplemented with pedicle screws. In cases of severe bone loss or when significant disc space distraction is required, the risk of subsidence is increased and alternative fixation may be preferable.

Endplate fractures, which may occur in patients with or without osteoporosis, can compromise interbody implant stability and increase the chances of subsidence and construct failure. If an endplate fracture is observed before plate insertion, an alternative fixation option is recommended, such as bilateral pedicle screws for maximum stability. If endplate violation or cage subsidence is observed following plate insertion, a contralateral pedicle screw construct is recommended to supplement the plate. If poor bolt purchase is identified, which is most common in osteoporotic patients, the construct can be augmented with methylmethacrylate cement with or without additional posterior fixation.

At times, L4-5 may be partially blocked by the iliac crest. When this is the case, especially when angled instruments are used to achieve satisfactory insertion of the intervertebral implant, it may be prudent to refrain from lateral plating because of the extreme angles involved. In this example, the trajectory of the bolts would deviate obliquely across the vertebral body away from the subchondral endplate and could compromise fixation.

In all cases, it may be necessary to implement alternative fixation methods to augment or replace lateral fixation. Therefore the surgeon is encouraged to prepare in advance for such a procedure. If the surgeon is comfortable inserting pedicle screws in the lateral position, this transition can be quick and seamless. If the surgeon prefers placing pedicle screws in the prone position, the patient can be repositioned for screw placement.

CONCLUSION

XLIF with lateral plating offers a minimally disruptive single-approach treatment for lumbar fusion with supplemental fixation. This technique allows for supplemental fixation when pedicle screw fixation may not be possible because of small pedicles or prior posterior instrumentation, or in high-risk patients who cannot tolerate a lengthy operative procedure. In appropriately selected patients the technique can obviate the need for supplemental fixation through alternative approaches and ultimately result in reduced blood loss, procedure time, and hospital stay. Therefore it offers a viable fixation alternative for same-day or potentially outpatient lumbar fusion surgery in select patients.

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