Complications of lateral plating in the minimally invasive lateral transpsoas approach

Clinical article

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Object. The aim of this study was to review the authors’ experience with 101 cases over the past 3 years with minimally invasive lateral interbody fusion using a lateral plate. Their main goal was to specifically look for hardware-associated complications. Three cases of hardware failure and 3 cases of vertebral body (VB) fractures associated with lateral plate placement are reported. The authors also review the literature pertaining to lateral plates and related complications.

Methods. This study is a retrospective review of a database of patients who underwent minimally invasive lateral interbody fusion in the thoracolumbar spine during a 3-year period.

Results. Six complications were identified, resulting in an incidence of 5.9%. Three hardware failures, 2 coronal plane VB fractures, and 1 lateral VB fracture were identified. All complications occurred in multilevel cases. All cases presented with recurrent back pain except one, which was identified incidentally.

Conclusions. Minimally invasive lateral interbody fusion is a safe and direct technique that is practical, especially when trying to avoid other approaches for hardware insertion, and it also avoids the complications associated with other types of instrumentation such as pedicle screws. Careful consideration during patient selection and during the operation will aid in the avoidance of complications. (DOI: 10.3171/2011.11.SPINE11653)

Key Words • extreme lateral interbody fusion • lateral plate • complications • minimally invasive lateral approach • transpsoas approach • fracture • technique

MINIMALLY invasive lateral interbody fusion is a technique that can be used safely and effectively for thoracolumbar interbody fusions. A retroperitoneal transpsoas approach is used for lumbar fusions, and a retropleural or transpleural approach can be used for thoracic fusions.

A lateral plate (Fig. 1), which spans the disc space, has been commonly used as a supplement to the large interbody cage that is placed intraoperatively. The titanium plate has a rostral and a caudal screw hole, and it is available in varying lengths. It is seated on 2 bicortical titanium screws that are placed across the width of the VB parallel to the adjacent endplate.

Biomechanical comparisons to stand-alone, unilateral pedicle screw, and bilateral pedicle screw constructs have demonstrated the lateral plate’s increased rigidity compared with a stand-alone construct to promote arthrodesis. Lateral plates provide a very favorable range of motion restriction in lateral bending, with only bilateral pedicle screws offering slightly more rigidity. However, unilateral and bilateral pedicle screws are much more rigid overall in comparison with lateral plates.

Dua and colleagues recently reported a 15% incidence of lateral plate–associated complications based on a small series of 13 patients. Because of the paucity of reports in the current literature, we undertook a review of our own series of patients who underwent minimally invasive lateral interbody fusion in the thoracolumbar spine with supplemental lateral plate instrumentation in an effort to better evaluate the incidence of lateral plate hardware-associated complications. We also discuss potential mechanisms and complication avoidance strategies.

Abbreviation used in this paper: VB = vertebral body.
Methods

This study is an institutional review board–approved, retrospective review of a prospectively collected database. Between November 2007 and December 2010, 101 consecutive patients underwent minimally invasive lateral interbody fusion using the XLIF system (NuVasive, Inc.) with the use of XLP (NuVasive, Inc.) lateral plate(s) and were included in this study. This lateral plate is approved by the FDA for single-level fixation. The patients underwent surgery that was performed by 1 of 4 spine neurosurgeons at an academic, tertiary hospital.

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Surgical indications could include trauma, adult degenerative scoliosis, degenerative disc disease, spondylitis with instability, lumbar stenosis, spondylolisthesis, and adjacent-segment failure. Patients were included if they underwent interbody fusion through a minimally invasive, lateral approach in the thoracic or lumbar spine with supplemental lateral plate instrumentation. Patients were excluded if they underwent stand-alone fusion, interbody fusion with posterior supplemental instrumentation only, or disc arthroplasty. All patients had T-scores of −2.5 or greater.

This minimally invasive lateral interbody fusion procedure was performed as previously described. Polyetheretherketone interbody cages (CoRoent XL, NuVasive, Inc.) with 10° of lordosis were used. In 95 (94.1%) of the 101 patients, the cages were filled with allograft (1.05–2.10 mg recombinant human bone morphogenetic protein–2 [INFUSE, Medtronic] mixed with bone extender hydroxyapatite and tricalcium phosphate per level [Formagraft, NuVasive, Inc.]), and in the remaining 6 patients (5.9%), the cages were filled with 5 ml of cadaveric cancellous bone mixed with mesenchymal stem cells (Osteocel, NuVasive, Inc.).

Once the 50-, 55-, or 60-mm-long cages were placed spanning the entire width of the endplates, the retractor blades were expanded to accommodate placement of the lateral plate construct hardware. A rigid lateral plate sizing trial was placed in a rostral-caudal orientation, and the correct positioning and size were fluoroscopically confirmed. The lateral plate was positioned such that the rostral and caudal entry points cleared each corresponding endplate and ipsilateral segmental artery. An awl and manual drill were then used to create the screw tract. A 5.5-mm screw was then placed with the goal of placing the screws parallel to the corresponding endplate and obtaining a bicortical purchase. A bicortical purchase may not be feasible, however, in instances in which only an oblique trajectory is possible or when the screw tip is aimed at the center of the contralateral VB wall, as this puts the contralateral segmental artery at risk for injury. Once the screws were placed, the sizing trial was removed and the lateral plate was then seated over the screw heads, ensuring that both screw heads were properly exposed above the lateral plate for lock nut placement. This was confirmed by direct visualization. Once satisfactory, the lock nuts were secured in place.

Postoperative upright radiographs taken at the routine 6- and 12-week, and 6-, 12-, 18-, and 24-month follow-up visits were reviewed to evaluate for any hardware-associated complications. Preoperative and postoperative quadruple visual analog scale scores were compared when available. When a complication was identified, patient demographics and clinic notes recorded during the patient’s physical examination were noted as well as the type of complication and subsequent management.

Results

The average age at the time of surgery was 57.2 years. The male/female ratio was 46:55. The mean follow-up time
was 14.3 months; 2 patients were lost to follow-up. There were 56, 27, 15, and 3 patients who had undergone 1-, 2-, 3-, and 4-level minimally invasive lateral interbody fusion procedures, respectively. The mean preoperative and postoperative quadruple visual analog scale scores were 7.3 and 4.3, respectively. Eighteen patients reported postoperative transient ipsilateral thigh numbness, 2 reported ipsilateral iliopsoas weakness, and 2 reported paresthesias/radiculopathy.

Six complications in 101 cases (5.9%) were identified and are presented in Table 1. In these cases, the cages were packed with bone extenders in addition to recombinant human bone morphogenetic protein–2. One case was a single-level operation for adjacent-segment disease. The remaining cases consisted of one 2-level, one 3-level, and three 4-level minimally invasive lateral interbody fusion procedures. Brief summaries will be described here.

Three cases involved a dislodged lock nut and lateral plate. The patient in Case 1 was lost to initial follow-up, but he presented 1 year later after several months of recurrent low-back pain and radiculopathy. Imaging studies demonstrated hardware failure involving a dislodged L2–3 lateral plate from an initial L2–5 minimally invasive lateral interbody fusion, as well as canal and foraminal stenoses. Treatment options were discussed with the patient, and it was decided to remove the hardware in addition to performing an L1–5 laminectomy and foraminotomies followed by L1–3 posterolateral fusion. The patient in Case 2 presented at the 10-week follow-up with recurrent back pain, and the failed L4–5 lateral plate was discovered. The patient opted for nonoperative management. Finally, the patient in Case 3 had an incidentally found hardware failure at a 4-month follow-up, which was managed nonoperatively (Fig. 2).

Three VB fractures were identified as well. The patient in Case 4 presented at her 6-week follow-up appointment with recurrent back pain, and the radiographs demonstrated a right-sided L-2 fracture (Fig. 3). Her symptoms were successfully managed nonoperatively with analgesics. Two patients presented with recurrent back pain and an L-3 coronal plane fracture (Fig. 4). Both required reoperations for hardware removal, decompression, and pedicle screw instrumentation.

**Discussion**

Traditional open operations for lumbar interbody fusion include anterior lumbar interbody fusion, posterior lumbar interbody fusion, and transforaminal lumbar interbody fusion. Anterior lumbar interbody fusion provides for a large interbody graft for disc space reexpansion, restoration of lumbar lordosis, and elimination of discogenic pain. However, an access surgeon may be needed, and complications can include a risk of vascular injury and also rare iatrogenic retrograde ejaculation in males postoperatively. The transforaminal lumbar interbody fusion was developed as a modification of the posterior lumbar interbody fusion to decrease the degree of nerve root and thecal sac manipulation, and it allows for interbody fusion, concurrent posterior segmental instrumentation, and circumferential fusion. However, the graft size is typically smaller than that of the anterior lumbar interbody fusion.

The minimally invasive lateral interbody fusion through a retroperitoneal transpsoas approach is a safe and effective alternative to traditional anterior or posterior approaches for lumbar fusion. Advantages include indirect neurological decompression with less tissue trauma, minimal blood loss, shorter operation times, fewer wound infections, placement of a larger cage, and earlier patient mobilization. In addition, normal stabilizing ligaments are not sacrificed, as can happen with other traditional interbody techniques.

A lateral plate can be used to supplement the large interbody cage to increase the construct rigidity and promote arthrodesis. This increased biomechanical advantage is limited primarily to lateral bending, however, as studies by Bess and colleagues and Cappuccino and colleagues have demonstrated. These studies demonstrated that lateral plates compared very favorably with bilateral pedicle screws, as bilateral pedicle screws offered only slightly more rigidity in lateral bending, with reported ranges of motion of 15.9%–24.2% and 14.4%–16.1%, for lateral plates and bilateral pedicle screws, respectively.

Dua and colleagues recently reported 2 lateral plate hardware complications following minimally invasive lateral interbody fusion. These cases consisted of 2 atraumatic coronal plane fractures at L4–5 in the first 6 weeks.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Case No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>age (yrs), sex</td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>initial presentation</td>
<td>72, M</td>
</tr>
<tr>
<td>diagnosis</td>
<td>lumbar spondylosis</td>
</tr>
<tr>
<td>op performed</td>
<td>L2–5 minimally invasive LIF</td>
</tr>
<tr>
<td>initial presenting FU interval</td>
<td>12 mos (lost to FU during the initial period)</td>
</tr>
<tr>
<td>FU presentation</td>
<td>recurrent intractable LBP, radiculopathy</td>
</tr>
<tr>
<td>imaging type &amp; findings</td>
<td>XR &amp; CT; dislodged L2–3 lat plate &amp; both lock nuts, canal &amp; foraminal stenoses</td>
</tr>
<tr>
<td>management</td>
<td>removal of hardware at L2–3 &amp; L1–5, laminectomy &amp; foraminotomies, L1–3 PSs, posterolateral fusion</td>
</tr>
<tr>
<td>latest FU &amp; current condition</td>
<td>1 yr; symptoms improved</td>
</tr>
</tbody>
</table>

* DDD = degenerative disc disease; FU = follow-up; LBP = low-back pain; LE = lower extremity; LIF = lateral interbody fusion; PRN = as needed; PS = pedicle screw; XR = radiography.
of the postoperative period. Their reported incidence was 15% based on a small series of 13 patients.

We report 6 complications associated with the lateral plate after a review of 101 consecutive cases, giving an overall incidence of 5.9%. Three hardware failures and 3 VB fractures were identified. All cases were atraumatic. All patients presented with recurrent back pain except for one in whom the complication was identified incidentally. All hardware failures involved a dislodged lateral plate and lock nut(s). Both coronal plane fractures resulted in collapse of the VB and loss of lordosis radiographically. The other VB fracture was a right-sided lateral VB fracture that resulted in a coronal plane deformity and collapse of the disc space at that level.

Two potential mechanisms have been proposed that could explain how a coronal plane fracture may occur. One mechanism involves subsidence of the cage and the consequences of having a fixed-angle screw to the lateral plate. As the cage subsides onto the screw, no settling or toggling is possible, so the screws would then cut through the VBs in the coronal plane. Another mechanism may involve a stress riser in the area of stress concentration, since the interbody fusion cages concentrate stress at the interface between the cage and the adjacent endplates.

Although not entirely clear, there are possible mechanisms that may explain these complications. The 3 cases of hardware failure are most likely related to cross-threading intraoperatively, leading to a weakened construct, although the failure of a correctly placed lock nut is still possible, especially in the setting of subsidence. Mechanisms for the VB fractures are not quite as clear. The lateral VB fracture may have been a consequence of screw placement. Review of the intraoperative and immediate postoperative radiographs indicated that the entry point of the inferior L-2 screw was immediately adjacent to the inferior endplate. This introduces the potential for endplate disruption and subsequent weakening of the periphery, where the endplate is strongest, leading to subsidence and fracture laterally.

Causes of subsidence are multifactorial. They can be related to technique, implant material, and patient bone quality. Our group recently found a 20% overall subsidence rate for all minimally invasive lateral interbody fusion cases in the lumbar spine with the use of a lateral plate in the construct, either alone or in addition to other supplemental instrumentation (unpublished data). The current study evaluating lateral plate use with or without other types of supplementation found a comparable rate of 17.8% (18 of 101 patients).

Complication avoidance is a key component to any operation, and there are some key points that can be gleaned from these cases. First, as with any procedure, meticulous attention to detail will help to avoid unnecessary complications such as cases of dislodged hardware.

Regarding the surgical technique, a goal should be to stay as parallel to the endplate as possible to place a bicortical screw. Staying close to the subchondral bone takes advantage of greater bone density and potentially greater purchase. An additional advantage of using a parallel trajectory is the ability to minimize retractor opening, thereby reducing the chance of injuries related to muscle and nerve retraction.

Anatomical limitations may obviate the need to take a more oblique trajectory than desired, however. This is especially true when placing a lateral plate at L4–5, where the iliac crest may affect the L-5 screw placement. An oblique trajectory can lead to a “windshield wiper” effect, which can lead to additional stress on the plate interface and bone. Also, as the risk of neurological deficits is greater at this level, any expansion of the retractor blades should be very brief and should be as minimal as possible for hardware placement. If the oblique angle forces a trajectory that is toward the contralateral mid VB, a bicortical screw could then risk injuring the contralateral segmental artery, which would not be easily controlled from the contralateral side. Placement of the lateral plate may even be precluded in cases in which the neuromonitoring devices indicate a critical proximity of the operative field, particularly the retractor apparatus, to the lumbosacral plexus.

Of course, patient selection prior to surgery will also aid in complication avoidance. Patients with osteoporosis have a lower failure load of the vertebrae that leads to a greater risk for complications. All but one of the complications occurred in multilevel cases. Thus, multilevel fusions using a lateral plate may also increase the risk of complications, and this should be an important consideration if lateral plates are used.

Patients must also be free of any gross instability, as bilateral pedicle screws provide a much more rigid construct in comparison with lateral plates, as mentioned earlier. For similar reasons, lateral plates may not be optimal for defor-
Minimally invasive lateral transpsoas approach

Lateral plates are used in minimally invasive lateral interbody fusion for thoracolumbar fusions to provide additional stiffness to the overall construct, with their greatest advantage in lateral bending. Caution should be used when considering multilevel fusions or deformity correction using a minimally invasive lateral interbody fusion technique. We report 3 cases of failed hardware and 3 cases of VB fractures related to lateral plate use in minimally invasive lateral interbody fusion that highlight the importance of meticulous attention to detail at every stage of an operation.

Conclusions

Lateral plates are used in minimally invasive lateral interbody fusion for thoracolumbar fusions to provide additional stiffness to the overall construct, with their greatest advantage in lateral bending. Caution should be used when considering multilevel fusions or deformity correction using a minimally invasive lateral interbody fusion technique. We report 3 cases of failed hardware and 3 cases of VB fractures related to lateral plate use in minimally invasive lateral interbody fusion that highlight the importance of meticulous attention to detail at every stage of an operation.

Disclosure

Dr. Uribe is a paid consultant and receives research grants from NuVasive, LLC (San Diego, CA).

Author contributions to the study and manuscript preparation include the following. Conception and design: Le, Uribe. Acquisition of data: Le. Analysis and interpretation of data: Le. Drafting the article: Le. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Le. Administrative/technical/material support: Smith, Greenberg, Dakwar, Bajaj. Study supervision: Uribe.

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