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Pre-psoas (Oblique) Lateral Interbody Fusion at L5-S1

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Introduction

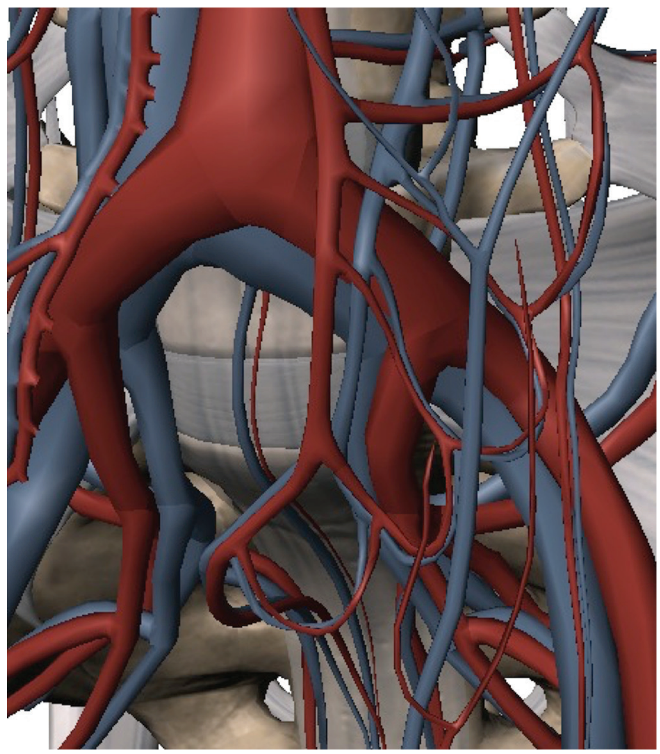
The pre-psoas oblique lateral approach to the lumbar spine was first described by Mayer et al. in 1997.[1] At that time, the approach was described only for the L2-5 disk spaces and the authors recommended an anterior transabdominal approach to the L5-S1 disk space owing to the anatomic considerations surrounding its access. The aortic bifurcation and iliocaval junction typically occur at or just below the L4 vertebral body[2] and, as the iliac vessels course inferolaterally from their origin, they commonly overlie the anterolateral aspect of the L5-S1 disk space (Fig. 13.1).

After the initial description of oblique lateral interbody fusion (OLIF) by Mayer, there were only scattered reports of OLIF in the literature while alternative interbody fusion techniques (transforaminal lumbar interbody fusion [TLIF], anterior lumbar interbody fusion [ALIF], posterior lumbar interbody fusion [PLIF]) were predominantly used to access the L5-S1 interspace. This was true until 2012, when a retrospective study of 179 patients who underwent OLIF was published.[3] This study included six patients who had two-level interbody fusions from L4-S1. The authors also introduced a "sliding window" mini-open technique to access multiple disk levels through one small incision. To our knowledge, this is the first reported L5-S1 OLIF procedure in the literature, although the specific technique has since been modified by other authors to facilitate easier access to the L5-S1 level.[3]

In 2014, another group[4] performed a cadaveric study attempting to access L2-S1 disks from a lateral decubitus position. They found that in all of their 20 specimens they were able to access the L5-S1 disk space medial to the iliac vessels, elucidating the surgical corridor used for modern L5-S1 OLIF. The authors noted that an advantage of this technique is in being able to access all levels from L2-S1 while keeping the patient in a lateral decubitus position without a break in the table. It has only been since the publication of this study and the discovery of this corridor that reports of isolated L5-S1 OLIFs have begun to appear in the literature. In addition, at least one company (Medtronic Inc., Memphis, TN) has begun producing and marketing a retractor and instrumentation system designed specifically for this procedure.

One case report described two OLIFs performed at L5-S1 accompanied by posterior fixation and reported good results without complications. In their discussion, the authors supported the concept of being able to access disks at multiple levels and perform fusion from L1-S1 with the patient in the lateral decubitus position.[5] Another case report presented OLIFs performed at L2-3, 3-4, 4-5, and 5-1 in a single procedure with good results. The authors also commented on the benefit of being able to perform the L5-S1 interbody work through the same incision as the other levels.[6]

From an anatomic standpoint, a recent retrospective magnetic resonance imaging study[2] explored the oblique access to L5-S1, which the authors defined transversely from the midsagittal line of the inferior endplate of L5 to the medial border of



• **Fig. 13.1** Three-dimensional rendering of a lumbar spine showing the bifurcation of the abdominal aortic *(red)* and the anastomoses of the common iliac veins *(blue)* overlying the superior aspect of the L5 vertebral body. The L5-S1 disk can be seen immediately below with the internal iliac arteries and veins overlying the anterolateral margins of the disk space. (Reprinted with the permission of Medtronic, Inc., Memphis, TN, USA © 2016.)

the left common iliac vessel and vertically to the first vascular structure that crossed midline. They found sufficient anatomic access to the L5-S1 interspace in 69% of patients analyzed and observed that the lower the iliocaval junction was, the less probable it was that sufficient access was present. This study failed to take into account the additional space gained by intraoperative mobilization and retraction of the iliac vessels, but interestingly, they found that in 13% of patients with no anterior access to the L5-S1 disk, an oblique corridor could be delineated between the psoas and the iliac vessels similar to that previously described by Silvestre et al.[3]

The benefits of L5-S1 OLIF may be largely in contrast to other procedures. Some authors discuss the benefits of OLIF's oblique pre-psoas approach in contrast to a lateral transpsoas approach (lateral lumbar interbody fusion [LLIF] eXtreme LIF [XLIF]/DLIF), as OLIF does not require dissection or splitting of the psoas muscle. This may theoretically decrease postoperative pain and avoid injury to the psoas and lumbar plexus, which may obviate the need for intraoperative neuromonitoring.[2] Specifically, in regards to the L5-S1 level, a nonoblique lateral approach can be extremely difficult or impossible owing to obstruction by the iliac crests.[7]

In contrast to a traditional PLIF, OLIF avoids dissection of the paraspinal muscles, reduces the risk of incidental durotomies, and eliminates the need for nerve root retraction.[8] It also may have some benefit over a direct ALIF, which can lead to injury to abdominal viscera, retrograde ejaculation, and prolonged ileus,[8] while still potentially offering the similar benefits in sagittal balance and restoration of disk height associated with these other interbody approaches.

Surgical Indications

The L5-S1 OLIF has similar indications as other interbody fusion techniques. These include a number of symptomatic pathologies including, but not limited to, degenerative disk disease with disk collapse, spondylolisthesis, discitis, and scoliosis. OLIF at other levels has been reported in the literature for revision of a pseudoarthrosis[9] because it affords good disk space visualization. It may be chosen over other approaches to the L5-S1 disk space for reasons previously discussed, including the ability to access multiple levels through one incision without having to reposition the patient.

Limitations

A number of potential limitations of L5-S1 OLIF exist. Vascular anatomy may in some cases make L5-S1 access a challenge, if not impossible. As previously discussed, a low-lying iliocaval junction may prohibit access to the L5-S1 interspace and can be evaluated with preoperative imaging at the surgeon's discretion. In trauma patients with substantial pelvic injuries, a lateral decubitus position may be prohibited. A posterior approach which avoids peritoneal manipulation may be preferred in patients with an ostomy or significant abdominal or retroperitoneal pathology. Similarly, an alternative approach that avoids iliac vessel retraction may be preferred in vasculopathic patients with lower extremity arterial insufficiency.

The surgeon may have difficulty using this approach in a morbidly obese patient if the retractor system is not long enough to accommodate the extra depth from the skin to the spine. However, it may also be argued that access and exposure for this approach is often easier in the morbidly obese patient than a traditional posterior approach, or a direct anterior transabdominal approach, owing to the tendency of the abdominal pannus to "fall away" anteriorly when the patient is placed in the lateral position. In the authors' experience, this has been the case in the moderately and morbidly obese, but begins to lose its advantage in the supermorbidly obese (BMI >50). We recommend measuring along the planned approach trajectory on the preoperative imaging, and comparing the expected depth with the retractor system's available lengths to minimize the chance of access problems. Accommodation should be made, in a "best guess" manner, for expected shifting of the tissues between intraoperative positioning and the typical supine position in which preoperative imaging is obtained.

Although one might reasonably assume that all aspects of the surgery would be easier in very thin patients, the more extreme end of this spectrum can pose some challenge in the sense that the normal retroperitoneal fat planes used to help proceed with the exposure may be more difficult to identify and stay safely within, potentially increasing the risk of inadvertent entry into the peritoneum or injury to other retroperitoneal structures.

Although spondylolisthesis is an approved indication for the OLIF procedure, surgeon discretion should be used in selecting appropriate cases for OLIF, especially in the early part of the surgeon's learning curve. The authors advise against attempting to treat Meyerding grade III or higher spondylolisthesis with this technique. Additionally, when approaching L5-S1, we suggest that a dysplastic/congenital spondylolisthesis, with associated anatomic variations (such as domed or rounded S1 superior endplate) should be avoided unless the surgeon has both significant experience treating these types of spondylolisthesis with other techniques and significant experience with OLIF in more conventional cases.

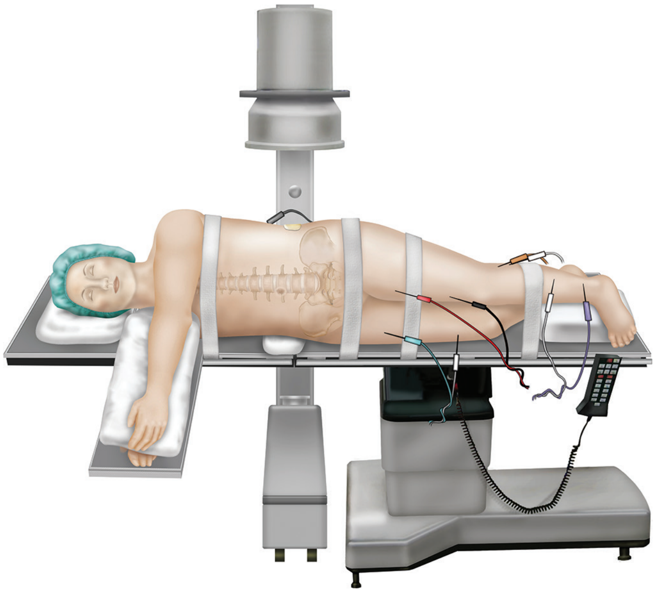
As discussed previously, OLIF may offer the opportunity to complete interbody fusions at multiple levels through a single incision. However, if supplemental fixation beyond what can be achieved through an anterior approach is necessary, then additional incisions, possibly requiring repositioning of the patient, may still be necessary.

Surgeons more familiar with a direct anterior and/or direct lateral approach may find that working in the disk space from an oblique angle can be disorienting. The use of intraoperative image guidance and/or extensive fluoroscopy may be necessary, particularly early in the learning curve, to avoid inadvertent entry into the spinal canal. However, both image guidance and extensive use of fluoroscopy carry well documented risks and costs associated with them.

Another prohibitive factor may be the cost of the procedure or availability of necessary equipment. A specialized retractor system is only available at this time through one device manufacturer and may have limited availability or be expensive to purchase or lease for individual cases. Similarly, if anterior plating systems or specialized cages are desired they present the same challenges.

Surgical Technique (Videos 13.1 and 13.2)

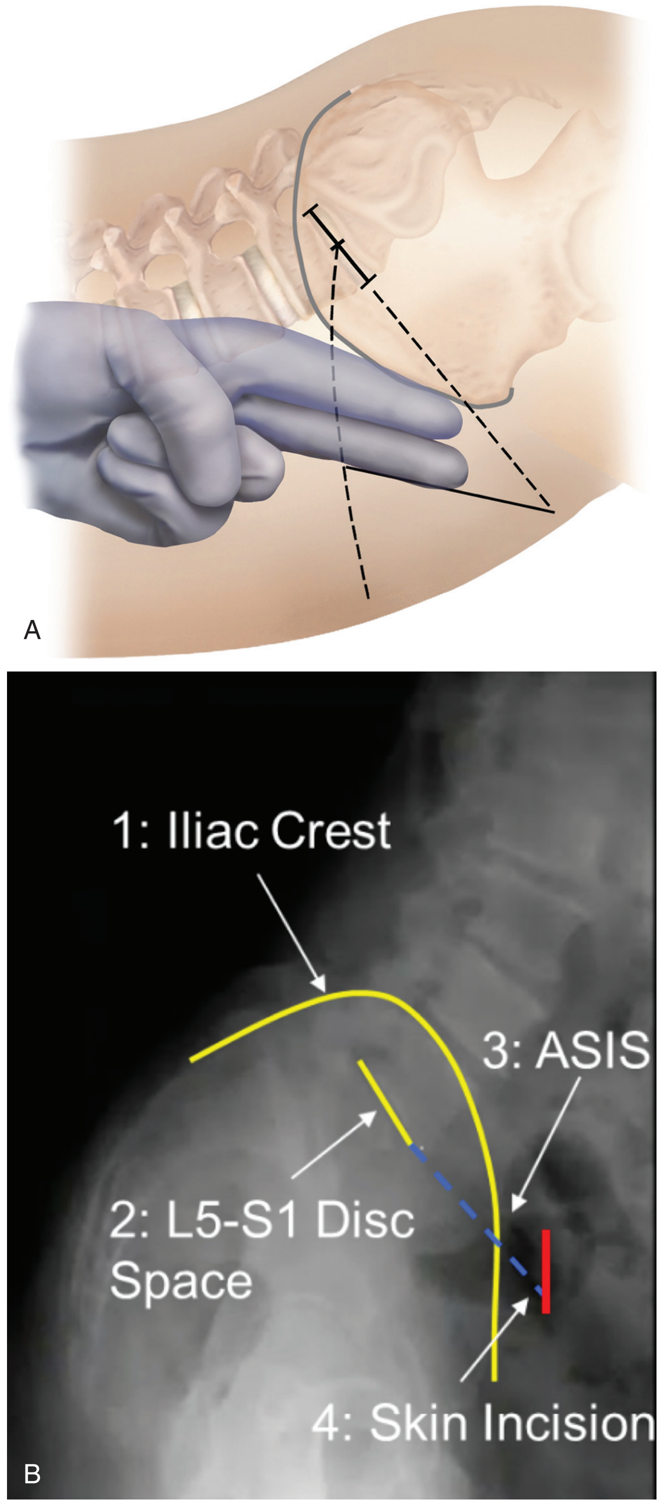
- Place the patient in the right lateral decubitus (left side up) position. The upper hip is extended to facilitate access to the L5-S1 disk space. This is in direct contradistinction to a typical transpsoas approach in which the upper hip is usually flexed to relax the psoas muscle. The patient is secured to the radiolucent



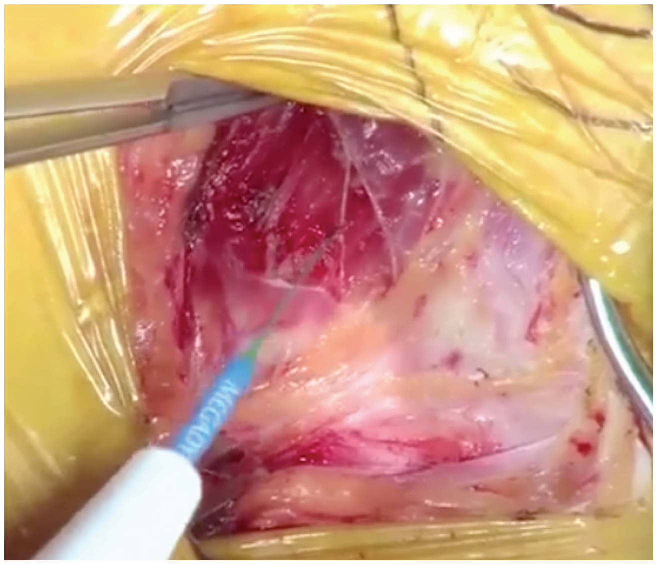
• **Fig. 13.2** Patient positioned in a right lateral decubitus position with upper hip extended. Use of neuromonitoring leads as depicted is optional. (Reprinted with the permission of Medtronic, Inc. © 2016.)

operating table and padded appropriately (Fig. 13.2). The surgeon should approach the patient from the abdominal side with the base of the fluoroscopy unit behind the patient. It has been noted, however, that when rotating the C-arm into the anteroposterior (AP) projection, the radiation source in this configuration will be on the surgeon's side; we highly recommend standing away from the operative field when shooting these views owing to scatter radiation. Pulse oximeters are placed on both feet and monitored throughout the case to ensure that retraction of the iliac vessels does not result in unrecognized lower limb ischemia.

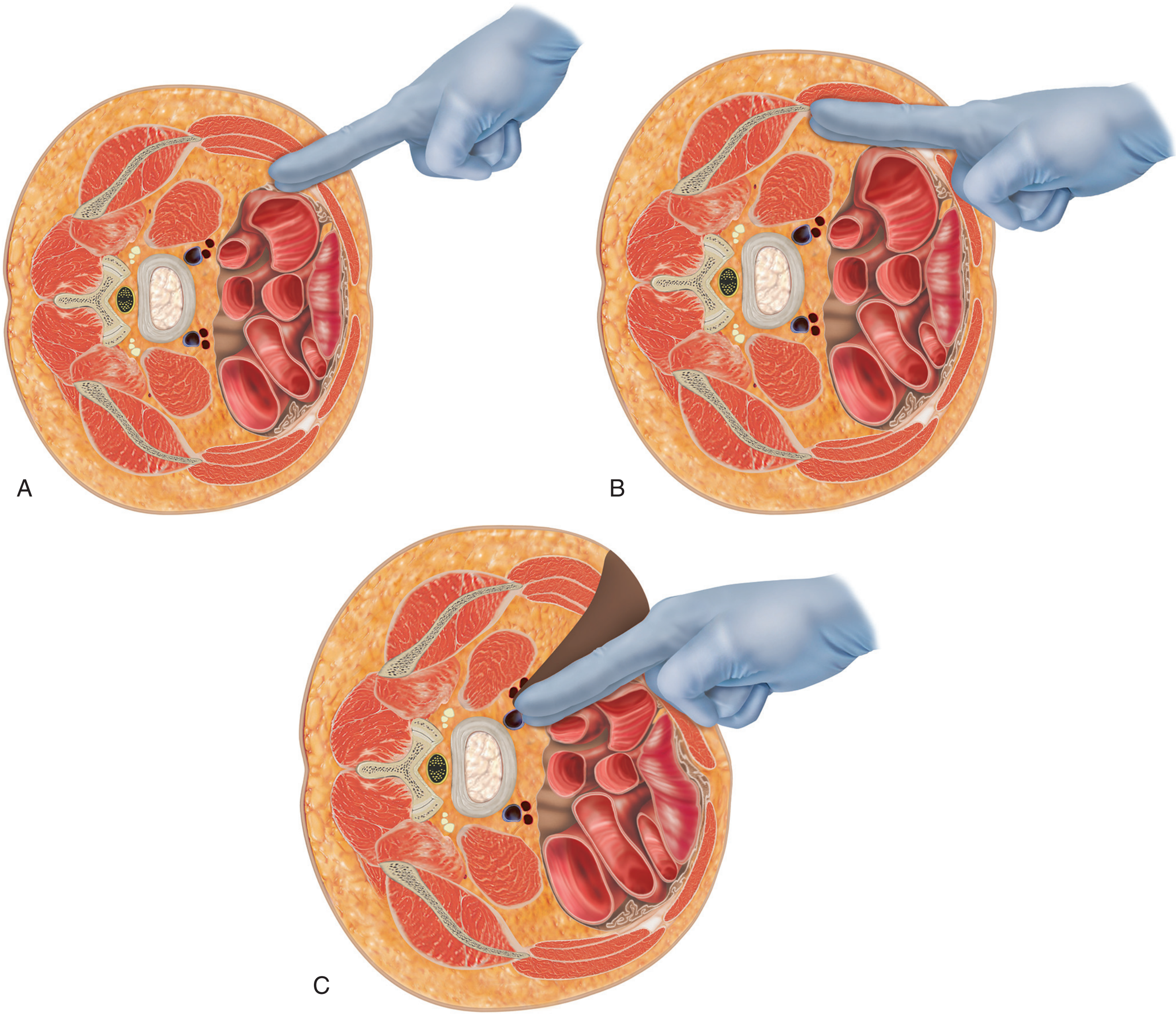
- Under fluoroscopy the L5-S1 disk is localized and a line is drawn on the patient's skin over and perpendicular to the disk space. This line is extended anteriorly onto the patient's abdomen. A 3 cm incision is then made, extending rostral from this line beginning at a point approximately 3 cm anterior to the anterior superior iliac spine (Fig. 13.3). This incision may need to be extended further rostrally if additional levels are being treated.
- The external oblique muscle (Fig. 13.4) or its fascia will be encountered, depending on patient anatomy, and is swept anteriorly with the surgeon's finger (Fig. 13.5A). After confirming that the peritoneum is released by sweeping a finger under the ASIS and iliac crest, retroperitoneal exposure is performed using blunt dissection with two fingers to facilitate exposure of a wide rostral-caudal plane (Fig. 13.5B). The ureter is attached to the posterior peritoneum and should be carefully mobilized anteriorly with the peritoneum.
- Dissection is continued anterior to the psoas while palpating the pulsations of the common iliac artery. The artery is utilized as a landmark to identify the common iliac vein, which is located immediately medial to it on the L5-S1 disk space (Fig. 13.5C).
- Once the disk space is encountered, the adventitial layer overlying it should be mobilized using gentle blunt dissection as it is adherent to the common iliac vein as well as the annulus. This



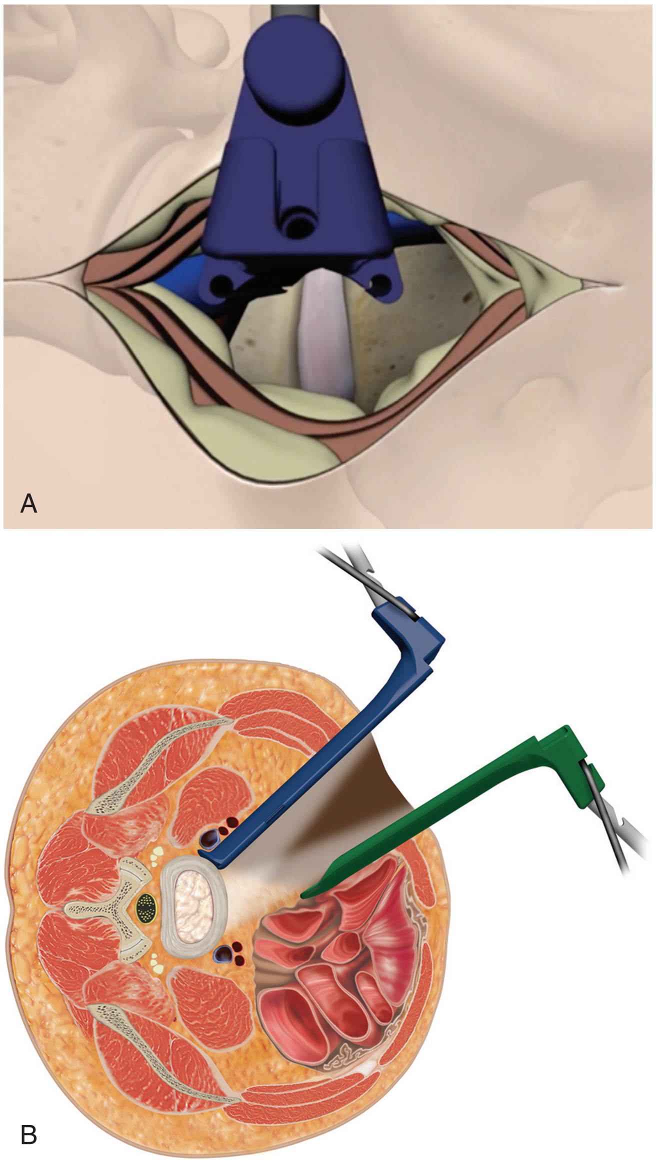
• **Fig. 13.3** **A.** Mapping and marking of the skin incision. A line is marked over the L5-S1 disk space using fluoroscopy (*solid hashed line*). The line is extended anteriorly (*dashed straight line*) onto the abdomen. The incision *(solid line)* is then marked extending rostrally from this line approximately two finger breadths anterior to the anterior superior iliac spine. **B.** The described markings superimposed over a lateral plain film of the lumbar spine. (Reprinted with the permission of Medtronic, Inc. © 2016.)



• **Fig. 13.4** Intraoperative photograph demonstrating the incision with external oblique muscle exposed. (Reprinted with the permission of Medtronic, Inc. © 2016.)



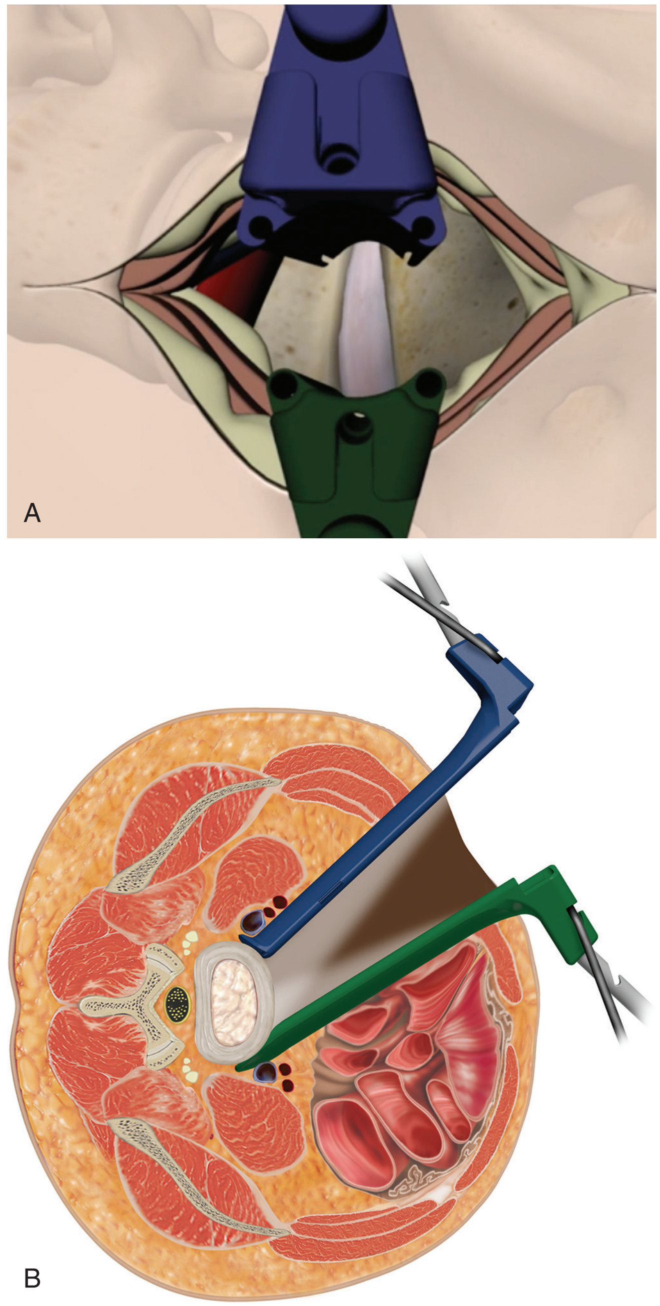
• **Fig. 13.5** Developing the retroperitoneal dissection. **A.** The plane deep to the external oblique muscle and its fascia is entered. **B.** A finger is swept under the anterior superior iliac spine to confirm that the peritoneum is released. **C.** The retroperitoneal plane is developed while palpating for the common iliac artery and vein. (Reprinted with the permission of Medtronic, Inc. © 2016.)



• **Fig. 13.6** **A.** The lateral *(blue)* retractor blade is inserted medial to the common iliac vein after release of the adventitial layer. **B.** The medial retractor blade *(green)* may be used to visualize the vessels directly during its placement. (Reprinted with the permission of Medtronic, Inc. © 2016.)

layer can also contain portions of the sympathetic chain and superior hypogastric plexus. Great care should be taken during this dissection to avoid injury to the vein, which is much more susceptible to minor trauma than the artery. Nevertheless, both vessels must be diligently protected throughout the dissection and subsequent interbody work.

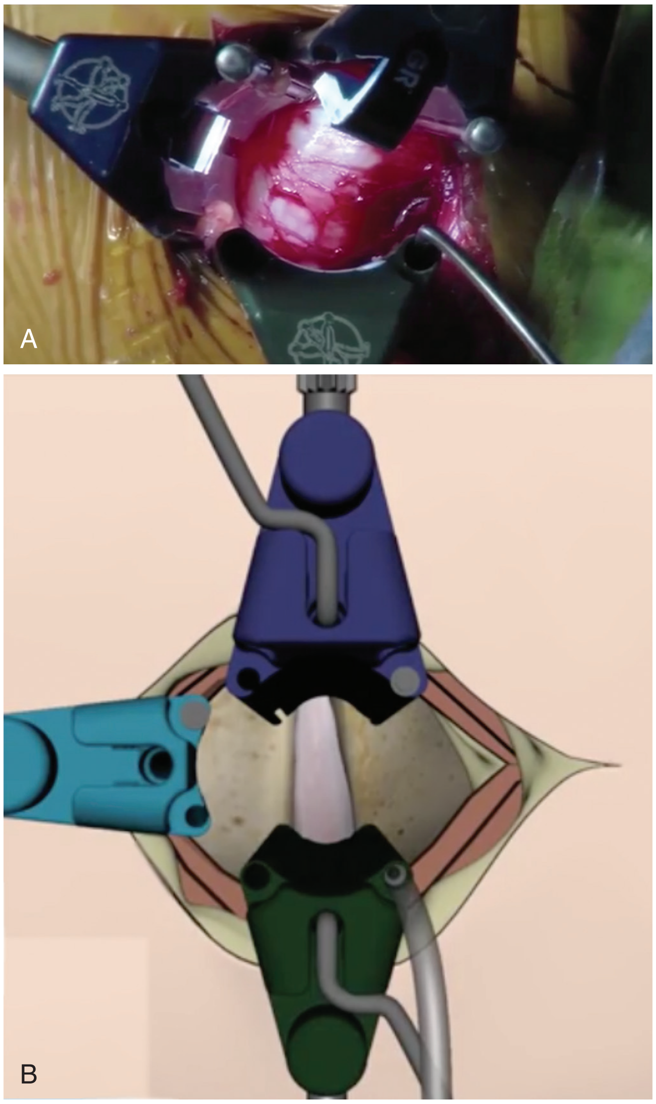
- Medial and lateral retractor blades are then inserted with the lateral blade protecting the common iliac vessels and the medial blade wrapping around to the contralateral side of the disk space (Fig. 13.6). Overzealous retraction with this medial blade can result in injury to the contralateral iliac vein and/or artery and should be avoided. Per surgeon's preference, the lateral blade can be pinned to the L5 body or sacrum to stabilize the retractor (Fig. 13.7). Finally, a third blade is placed rostrally and can be pinned to the L5 body to protect the bifurcation of the great vessels. Of particular note, this retractor blade



• **Fig. 13.7** **A** and **B.** The medial *(green)* retractor blade is positioned on the contralateral side of the disk space. The lateral *(blue)* retractor blade may be secured to the body of L5 as per the surgeon's preference. (Reprinted with the permission of Medtronic, Inc. © 2016.)

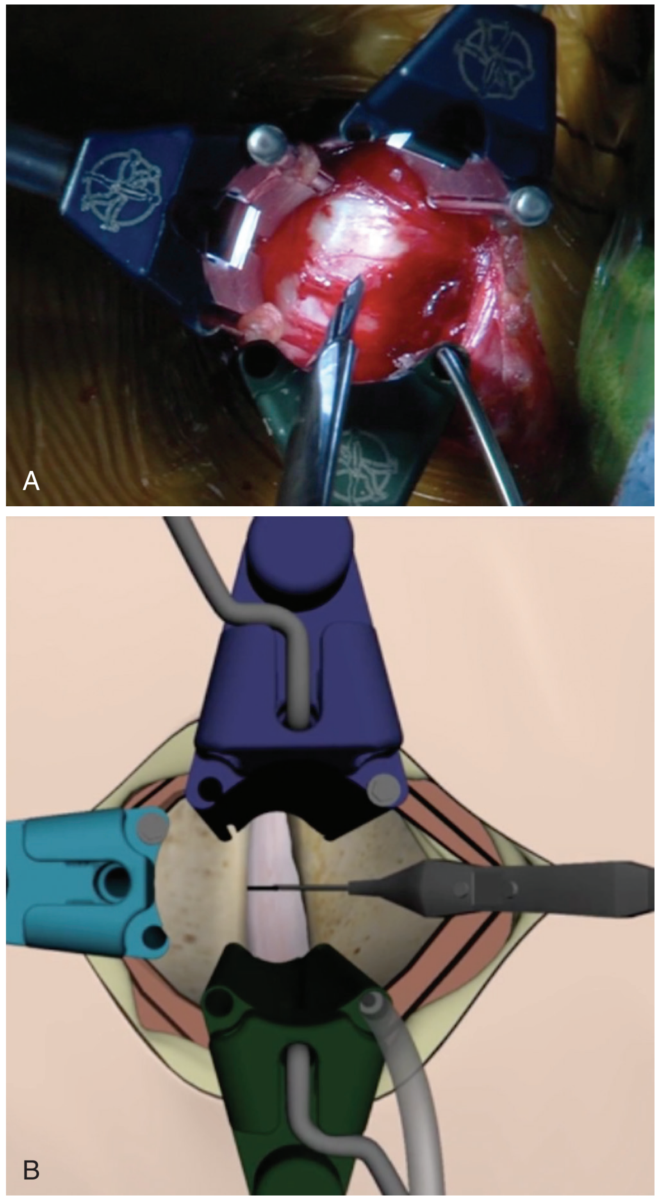
configuration is in contradistinction to the typical cranial-caudal retractor blades associated with standard lateral transpsoas and OLIF approaches above L5 where one is working entirely lateral to the vasculature.

- Once the disk is well visualized (Fig. 13.8), the midline of the disk space can be identified and marked using AP fluoroscopy to help maintain orientation. An annulotomy (Fig. 13.9) and diskectomy (Fig. 13.10) are then performed in a standard fashion with lateral fluoroscopy available to determine the depth of instruments relative to the posterior annulus and epidural space.[10]



• **Fig. 13.8** With all retractors in place, the disk space is well visualized. (A) Intraoperative photograph and (B) corresponding illustration. (Reprinted with the permission of Medtronic, Inc. © 2016.)

- Once the diskectomy is completed, the surgeon's choice of interbody device is appropriately trialed (Fig. 13.11) prior to implantation (Fig. 13.12). Choice of biologics/bone graft materials to be packed into the OLIF spacer is per surgeon's discretion, and should mirror the same considerations as that of any other interbody fusion construct, including different considerations of product cost as well as each patient's biology and risk profile for possible pseudoarthrosis. The authors typically use an allograft bone product with autologous bone marrow. In recent years we have avoided use of high-potency, off-label osteoinductive agents except in rare cases considered exceptionally high risk for pseudoarthrosis. Use of a device with self-retaining screws may avoid the need for supplemental fixation in select cases, but at the surgeon's discretion a supplemental anterior plating system may be implanted at this stage, or a variety of posterior stabilization options may be utilized after completion of the OLIF. Posterior stabilization may be performed in the lateral decubitus position or after turning the patient prone. After completing all work on the anterolateral spine, the

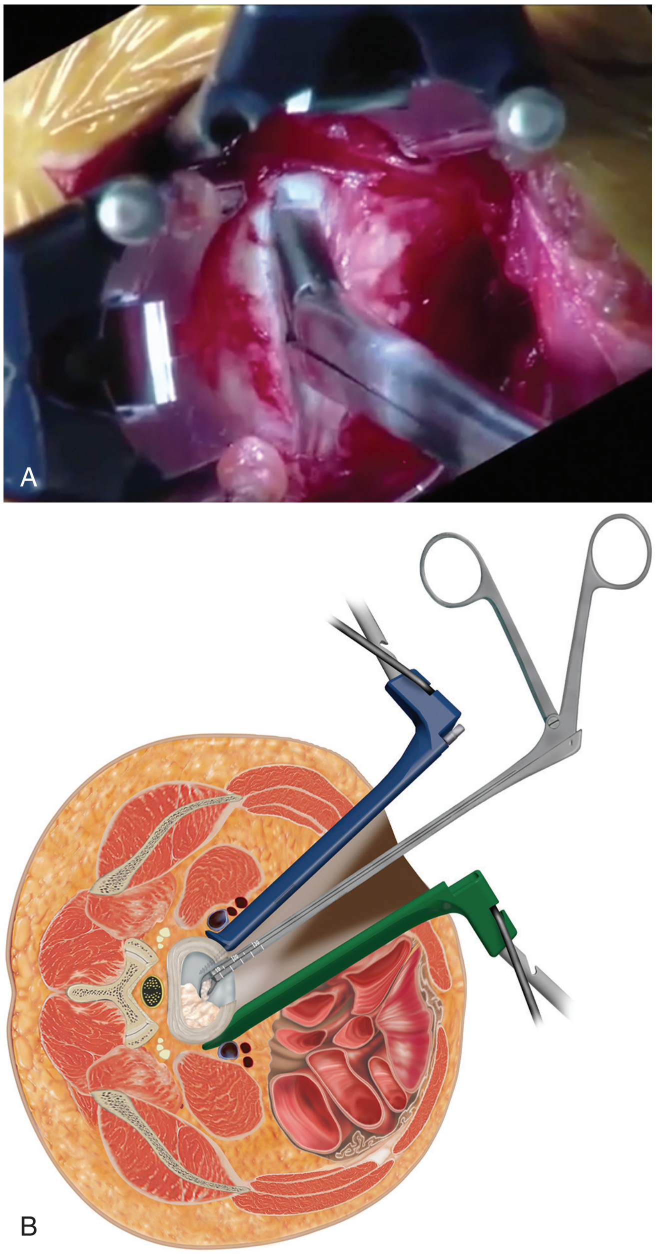


• **Fig. 13.9** After appropriately identifying the midline of the disk, an annulotomy is performed. (A) Intraoperative photograph and (B) corresponding illustration. (Reprinted with the permission of Medtronic, Inc. © 2016.)

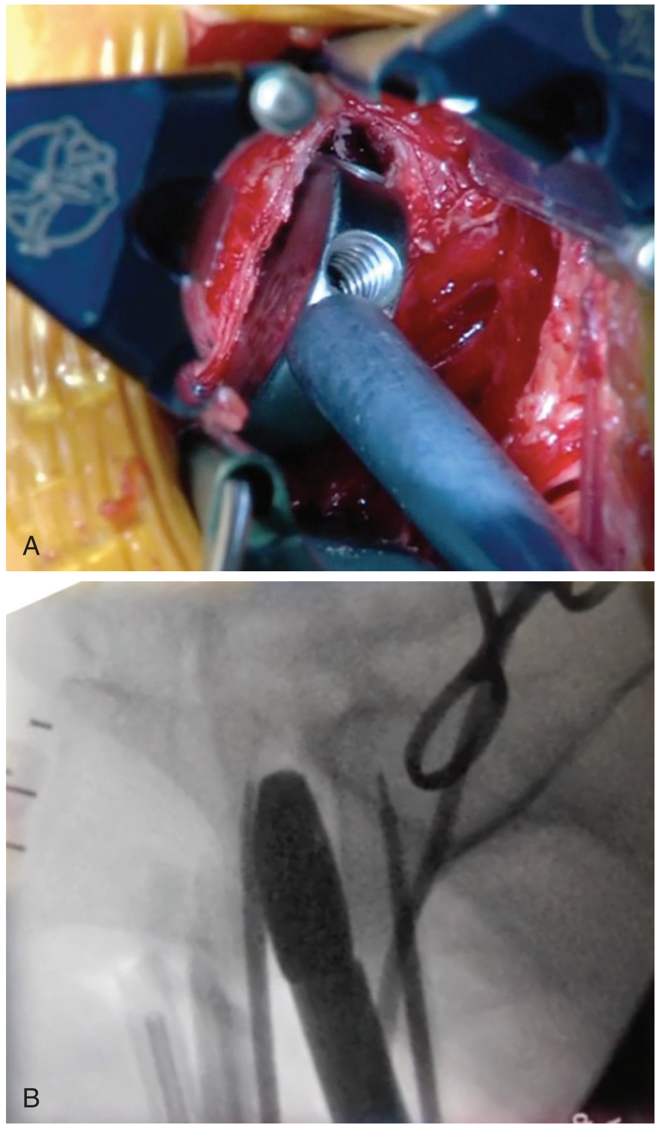
rostral blade is then cautiously removed prior to the removal of the lateral blade, followed by the medial blade in order to identify any potential bleeding.

Closure

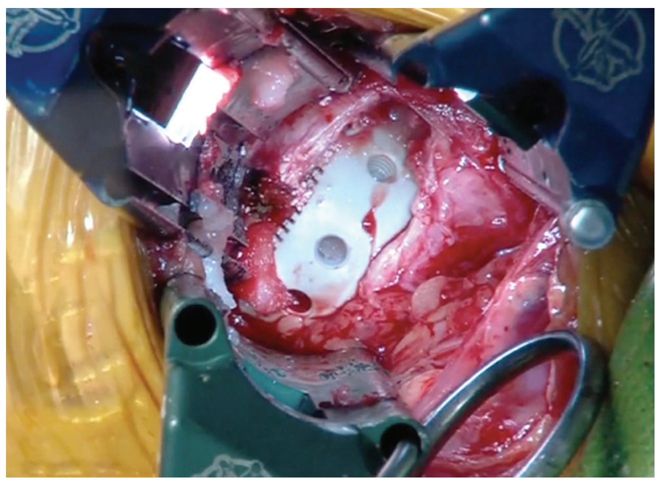
Once retractors are withdrawn and hemostasis obtained, the surgeon may proceed with wound closure. Any inadvertent entry into the peritoneum, if not already closed during the initial approach, can be repaired at this stage. We typically close the fascia of the external oblique muscle with absorbable suture. Depending on the patient's body habitus, closure of any additional dead space between the fascia and skin may be performed at the surgeon's discretion. The surgeon may then proceed to close the skin according to his/her preference. In the majority of our cases we typically utilize a subcuticular skin closure with topical skin adhesive applied over the incision.



• **Fig. 13.10** A and **B.** Annulotomy and diskectomy are performed in a standard fashion with direct visualization of the disk space facilitated by the retractor blades. (Reprinted with the permission of Medtronic, Inc. © 2016.)



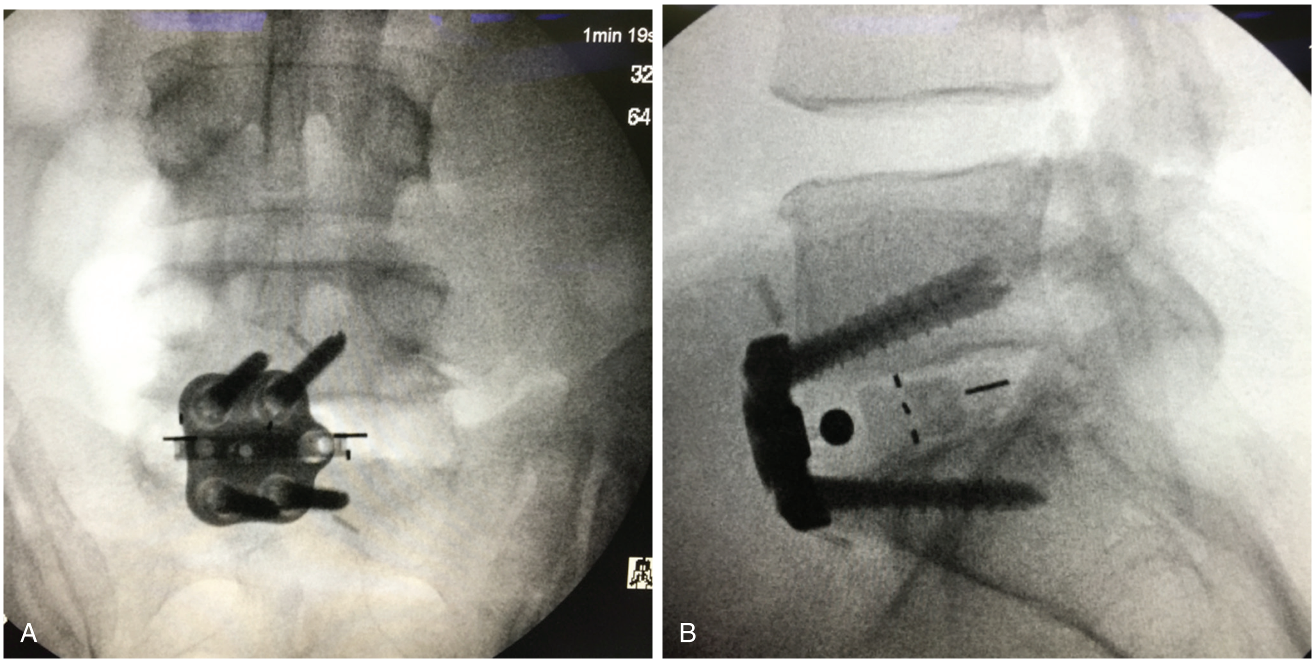
• **Fig. 13.11 A.** Intraoperative photograph demonstrating placement of a device trial for appropriate sizing. **B.** Corresponding lateral radiograph showing the same. Note the pins present in L5 and the sacrum for retaining the medial and lateral retractors. (Reprinted with the permission of Medtronic, Inc. © 2016.)



• **Fig. 13.12** Intraoperative photograph showing final placement of interbody device prior to placement of plating system. (Reprinted with the permission of Medtronic, Inc. © 2016.)

Postoperative Care

We recommend obtaining postoperative x-rays (Fig. 13.13) after surgery to serve as a baseline for future comparison. Particularly in patients with deformity (e.g., those with degenerative scoliosis), plain x-rays can be difficult to interpret as to accuracy of implant placement and we recommend considering routine postoperative computed tomography scans to better evaluate these patients. Despite the retroperitoneal approach, ileus is a common concern and patients should be maintained on bowel rest with intravenous fluids until return of bowel sounds. Owing to the mobilization and retraction of the iliac arteries, we have nursing perform bilateral lower extremity pulse checks with gradually decreasing frequency over the first



• **Fig. 13.13** Postoperative anteroposterior (A) and lateral (B) radiographs of a patient who underwent L5-S1 OLIF demonstrating final placement of the interbody device and anterior plating system. (Reprinted with the permission of Medtronic, Inc. © 2016.)

24 hours after surgery, based on a standardized vascular protocol at our institution. Complaints of excessive flank pain may be a sign of hydronephrosis from ureteral dysfunction and warrant further investigation. Sequential compression devices and early mobilization should be used as prophylaxis against deep vein thrombosis and at 24 hours postoperatively we augment them with subcutaneous heparin if not otherwise contraindicated. We require patients to meet the usual postoperative milestones prior to discharge, including independent ambulation, adequate pain control, voiding, a bowel movement, and tolerating a regular diet. If necessary, in-house physical therapy consultation may be obtained to assist with early ambulation. Unless the patient has poor bone quality or other extenuating circumstances, we do not typically prescribe a brace. As with all of our patients having fusion, we suggest light activity for 12 weeks postoperatively at which point we will obtain repeat x-rays before releasing any restrictions.

Complications/Side Effects

Many of the potential complications of OLIF at L5-S1 have yet to be reported in the literature. These include complications common to any interbody fusion procedure or spine surgery in general such as infection, excessive blood loss, pseudoarthrosis, risks of anesthesia, development of adjacent level disease, injury to neural elements, graft subsidence, and graft migration/extrusion. A number of complications that are already established in the literature for retroperitoneal surgery will likely prove to be shared with OLIF as well. Ileus may result from manipulation of the peritoneum and lumbosacral plexus. Retroperitoneal dissection or retraction may result in ureteral injury and hydronephrosis or vascular injury (with resultant deep vein thrombosis, arterial insufficiency, or retroperitoneal hematoma). Abdominal wall pseudohernia may present in a delayed fashion owing to nerve injury (most commonly the iliohypogastric nerve) of the abdominal wall. Whereas some of these complications have been reported to us through personal communication from colleagues or observed through personal experience, there have been no systematic studies in the literature regarding complication rates associated with OLIF in general, nor has there been any specific literature regarding complications associated with OLIF specifically at the L5-S1 level.

Outcomes in a Nutshell

Outcomes of the L5-S1 OLIF procedure are largely unknown owing to the recent development of the technique and the paucity of reported cases. It seems likely that outcomes will be comparable to other anterior or lateral interbody techniques with similar fusion rates, degrees of lumbar and segmental lordosis obtained, and impact on quality of life. Clinical, radiographic, and socioeconomic outcomes all remain areas ripe for future study.

Conclusion

The oblique lateral approach for interbody fusion at L5-S1 is a relatively new technique with only a handful of published cases. It appears likely to have many of the advantages of an anterior or lateral approach while potentially minimizing the complications of a transabdominal or transpsoas approach. Most notably, it may be unique among lumbar approaches in facilitating interbody fusion at multiple levels through a single incision.

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