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Anterior Lumbar Interbody Fusion

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Overview

Anterior lumbar interbody fusion (ALIF) has evolved as one of the predominant surgical techniques for the treatment of diskogenic back pain. Through an anterior retroperitoneal approach, the entire ventral surface of the disk is exposed, making complete discectomy and subsequent placement of a large intradisk implant straightforward.

Although various surgical techniques have been developed to access the anterior lumbar spine—open retroperitoneal, transperitoneal, endoscopic, and balloon-assisted endoscopic—the mini-open retroperitoneal approach has become the most widely accepted. Mini-open access allows wide exposure of up to three disk spaces from L3–L4 to L5–S1. Furthermore, standard open techniques and instrumentation can be used, allowing for direct manipulation of vascular structures. Surgeon disorientation is also kept to a minimum.

Advantages of an Anterior Approach

Lumbar interbody fusion can be approached from a number of different access corridors: anterior, anterolateral, extreme lateral, transforaminal, and posterior. The anterior retroperitoneal corridor provides the most direct and complete exposure of the disk space. Through this approach, the view is centered in the midline with lateral exposure to either side of the vertebral bodies. This extensive lateral exposure allows for the most extensive disk removal and permits placement of a single-unit implant that nearly matches the vertebral end plate in surface area. The implant enables coverage of a large vertebral body surface area and allows for low nonunion rates, and it minimizes the risk of interbody subsidence. Likewise, restoration of disk height allows for indirect neurologic decompression through expansion of the neural foramen and results in reduction of ligamentous buckling. Although direct neurologic decompression is not routinely performed with ALIF techniques, posterior disk herniations and posterior longitudinal ligament (PLL) removal are also possible.

Another major advantage of ALIF is that the technique spares both the posterior spinal musculature and the anterolateral psoas musculature. This results in a reduction of the postoperative pain and disability that frequently accompanies posterior spinal fusions and has also been reported following transpsoas extreme lateral interbody

fusions. In addition, because ALIF avoids the extensive stripping of the dorsal soft tissues, the muscle denervation and atrophy implicated in abnormal biomechanics and failed back surgery syndrome are avoided. Likewise, because the psoas muscle is not traversed by the surgical approach, the lumbar plexus is not at risk of injury during the approach or by the retractors. As a result, the ALIF technique can be safely used at levels that may pose increased neurologic risk during an extreme lateral approach (L4–L5) and those that may not be accessible by a lateral approach (L5–S1).

Patient Selection

The surgical treatment of diskogenic back pain remains controversial. Although the intervertebral disk undoubtedly contains nociceptive receptors, the relationship between symptoms of back pain, diagnostic studies, and surgical outcomes remains unclear. Because of the ubiquity of back discomfort and the high incidence of disk abnormalities on magnetic resonance imaging (MRI), strict criteria in selecting patients for surgery remains critical.

Several factors do appear to be predictive of pain relief following lumbar interbody fusion: 1) the history should be consistent with mechanical symptoms of axial pain aggravated by spinal loading and motion; 2) radiographic studies should demonstrate severe disk degeneration localized to discrete levels; 3) provocative diskography should produce concordant pain only at the affected levels and should demonstrate an abnormal nuclear distribution; and 4) abnormal excessive motion on dynamic studies or sagittal deformity are highly predictive of postoperative improvement.

Indications and Contraindications

INDICATIONS

- Diskogenic disease at the level of L3–L4, L4–L5, and/or L5–S1
- Revision of a failed posterior fusion at the level of L3–L4, L4–L5, and/or L5–S1

RELATIVE CONTRAINDICATIONS

- Severe medical comorbidities
- Morbid obesity
- Retroperitoneal scarring from previous surgery
- Aortic aneurysm

- Severe peripheral vascular disease
- Solitary kidney on the side of the exposure because of the risk of ureteral injury (without stenting)
- Severe osteoporosis with a high risk of interbody graft settling
- Spinal infection
- High-grade spondylolisthesis in the absence of a posterior fusion

Operative Technique (Mini-Open Approach)

EQUIPMENT

- Table-mounted abdominal retractor system
- Lateral fluoroscopy or flat-film radiographs
- Vascular clips and ligature suture
- Long curettes
- Long Kerrison punches
- Laminar spreader or interbody distractor
- Tamp
- Long-handled osteotomes (for vertebrectomy)
- High-speed drill (for vertebrectomy)
- Interbody spacers
- Bicortical iliac crest autograft
- Femoral ring allograft
- Cylindrical threaded allograft bone dowels
- Cylindrical threaded titanium cages
- Titanium mesh cage
- Alternate material cages (carbon fiber, resorbable polylactic acid, polyetheretherketone [PEEK] polymer)
- Osteoconductive/osteoinductive substances to fill interbody spacers
- Vertebral autograft
- Cancellous iliac crest autograft
- Cortical or cancellous allograft chips
- Demineralized bone matrix
- Bone morphogenetic protein
- Anterior thoracolumbar plating system (optional)

PATIENT POSITIONING

- The patient is positioned supine on a standard operating table with the arms abducted at 90 degrees.
- Careful attention should be paid to the degree of lumbar lordosis following positioning, and an inflatable bladder should be placed under the patient's back to elevate the midlumbar spine. This not only opens the anterior disk space to assist in the discectomy, it also allows for easier placement of lordotic implants.
- Abduction of the arms permits placement of the table-mounted abdominal retractor closer to the patient's torso without the risk of an upper extremity compressive neuropathy.
- If autograft is to be harvested, the anterior abdomen and iliac crest are prepped.

EXPOSURE

- A 12-cm skin incision is made to the left of the midline over the appropriate disk space (Fig. 46-1).

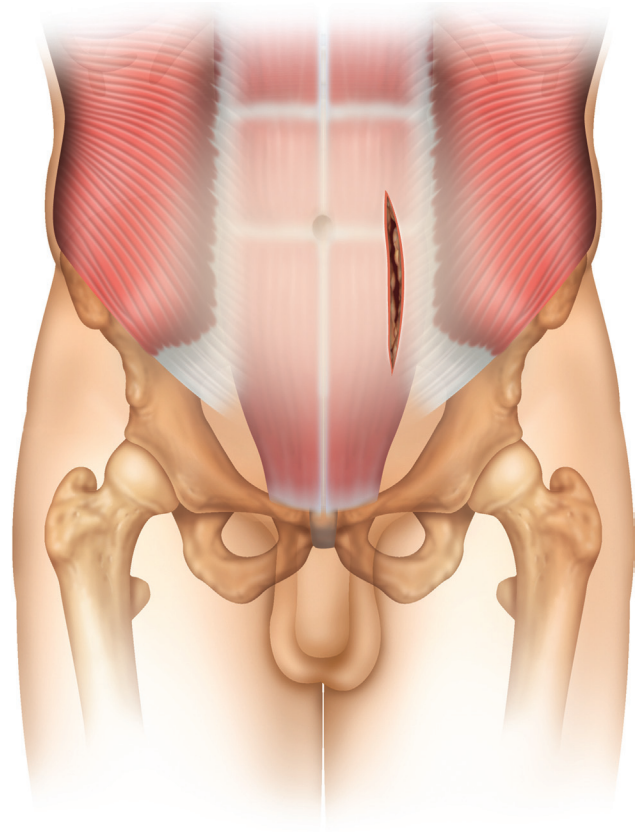


Figure 46-1 Incision along the left lateral aspect of the rectus abdominis.

- Blunt finger dissection is used to mobilize the skin and soft tissues off of the left anterior rectus sheath (Fig. 46-2).
- The anterior rectus sheath is divided longitudinally near the midline.
- The medial border of the intrafascial muscle belly is mobilized over a cranial-to-caudal distance of 12 cm.
- The muscle is then mobilized laterally to expose the underlying arcuate line. Alternatively, a lateral incision can be made in the anterior sheath, with the muscle mobilized medially (Fig. 46-3).
- Blunt dissection under the arcuate ligament—which marks the most caudal aspect of the incomplete posterior rectus sheath, superficial to the exposed peritoneum—allows access to the retroperitoneal space (Fig. 46-4).
- Inserting the fingers and then the entire hand into the retroperitoneal space allows the surgeon to sweep the intraperitoneal contents superiorly, inferiorly, and medially to reveal the spinal column in the midline (Fig. 46-5). Because this technique relies on palpation and not visualization, the surgeon must be familiar with the relevant anatomy. Palpation of the great vessels helps to avoid vascular injury, and care should be exercised to avoid tears in the peritoneal lining. These can be either repaired primarily or opened to prevent bowel strangulation.
- The ureter must be identified to prevent inadvertent injury, and it is typically found on the peritoneal side of the exposure.

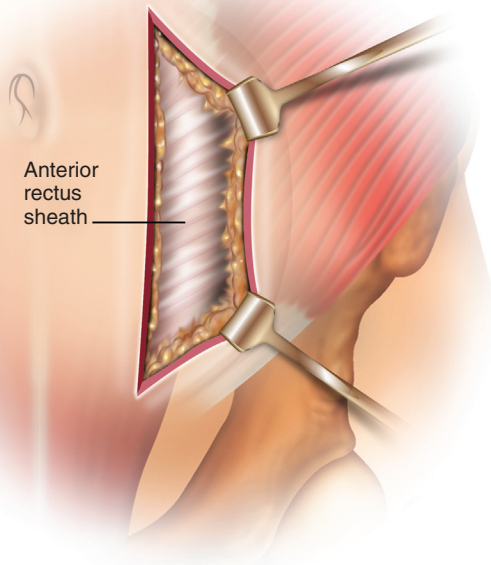


Figure 46-2 Blunt dissection and retraction of the superficial soft tissues expose the anterior rectus sheath.

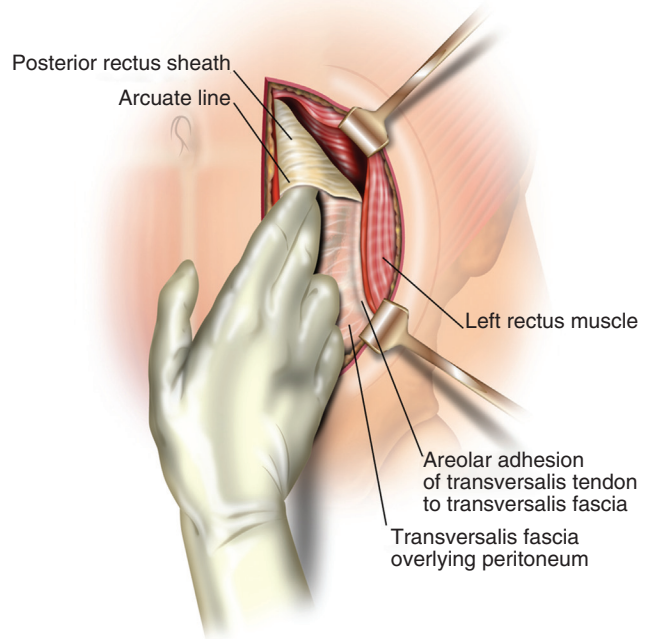


Figure 46-4 Identification of the retroperitoneal layer is accomplished with blunt finger dissection under the arcuate line between the posterior rectus sheath and the peritoneum.

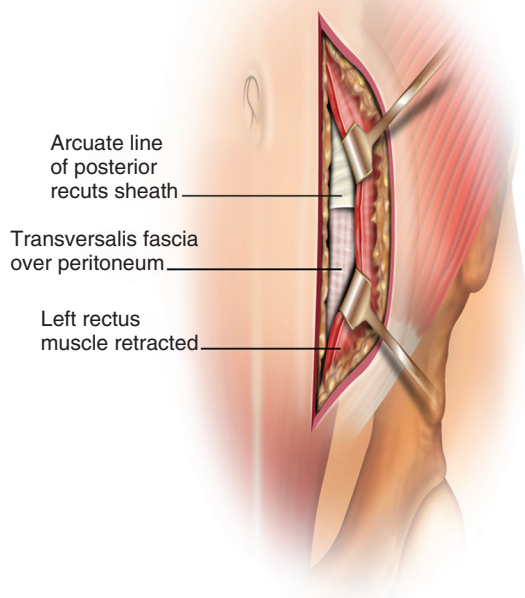


Figure 46-3 Blunt dissection along the fibers of the rectus abdominis muscle medially expose the posterior sheath. The arcuate line marks the transition at the lower end of the incomplete posterior rectus sheath to peritoneum.

- Deep, self-retaining abdominal retractors can then be placed and attached to the table-mounted frame to maintain a midline corridor to the spine (Fig. 46-6).
- Proper localization is confirmed with lateral radiography.

VASCULAR DISSECTION

- The aorta and vena cava are then identified. For exposure of the L5–S1 interspace, the disk can typically be accessed below the bifurcation of the great vessels (the interiliac corridor). At the L3–L4 and L4–L5 levels, the aorta and vena cava will have to be retracted to the left, from their midline position (the left latero-aortic route). Alternatively, an anterolateral approach may be used at these levels that involves performing the discectomy lateral to the aorta and vena cava.
- In the absence of scarring, blunt dissection with a sponge stick is very effective for mobilizing the vessels. Segmental arteries traversing the disk space or tethering the aorta need to be ligated securely. Iliolumbar veins can also be a troublesome source of bleeding. Any nearby iliolumbar veins should be prophylactically ligated, because inadvertent tearing of these vessels can be difficult to control and can lead to substantial blood loss (Fig. 46-7).
- The middle sacral artery and vein may need to be ligated for access below the bifurcations.
- The vascular anatomy of this region can be quite variable (Fig. 46-8).
- If the iliac vessels are medially located, an assistant should retract them laterally with handheld retractors to expose the disk space widely.

DISCECTOMY

- Excessive electrocautery along the anterior longitudinal ligament (ALL) should be avoided to prevent injury to the hypogastric plexus, which may result in retrograde

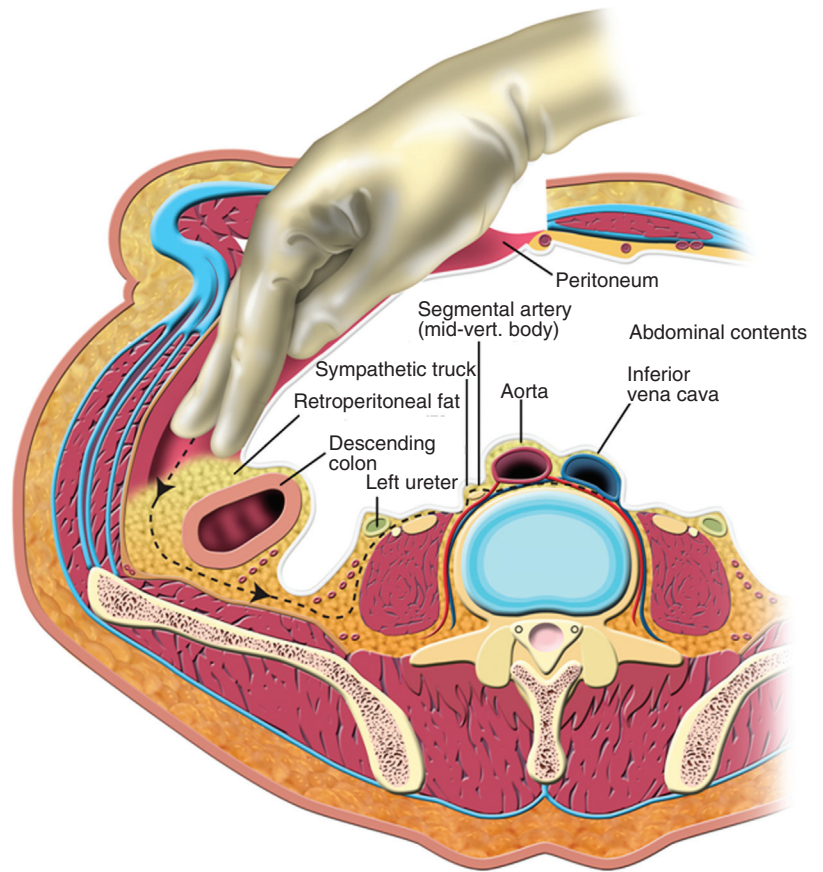


Figure 46-5 Axial section showing the approach of the blunt finger dissection used to reach the anterior aspect of the lumbar spine.

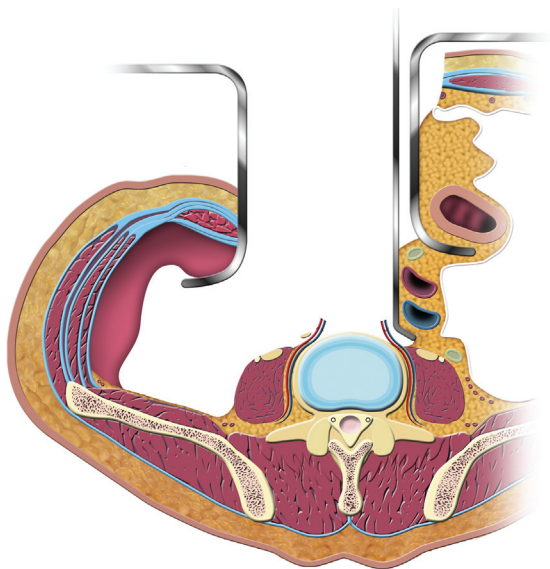


Figure 46-6 Deep retractor placement allows for a centered midline anterior approach to the spinal column.

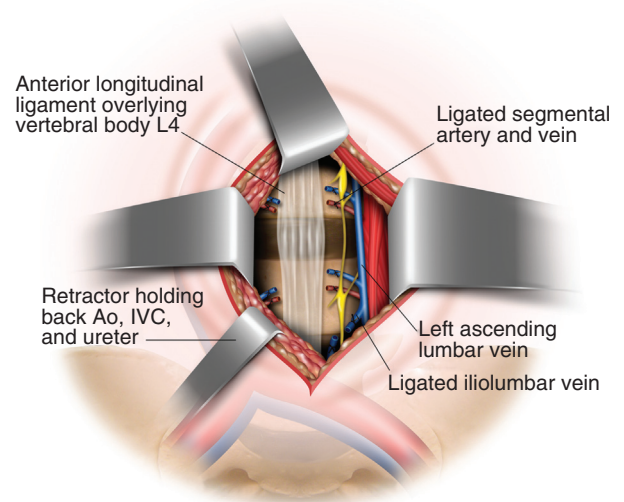


Figure 46-7 Intraoperative view of the anterior longitudinal ligament with neighboring segmental arteries and the iliolumbar vein. Ao, aorta; IVC, inferior vena cava.

ejaculation (Fig. 46-9). Instead, blunt dissection should be used to sweep the plexus from left to right.

- After determining the midline, the ALL is incised with a No. 10 scalpel blade on a long handle.
- Complete disk removal is then accomplished with curettes and rongeurs.

- The cartilaginous end plates should be completely removed, and vertebral body surfaces should be decorticated to prepare the graft recipient site.
- In select cases, the intervertebral space will then need to be increased through serial dilation of the disk space before implant insertion.

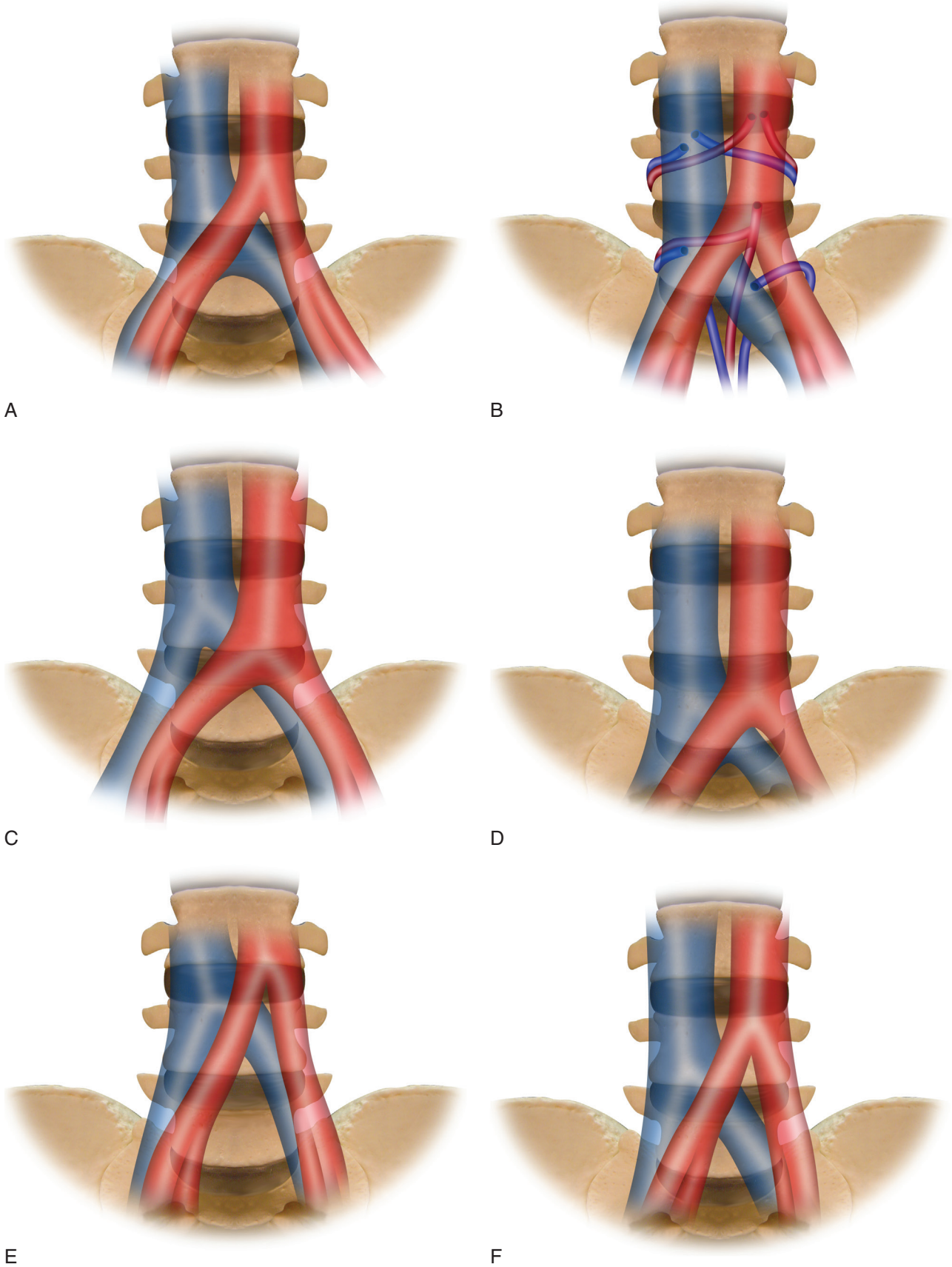


Figure 46-8 Various relationships between the aortic and vena cava bifurcations to the L5-S1 disk space.

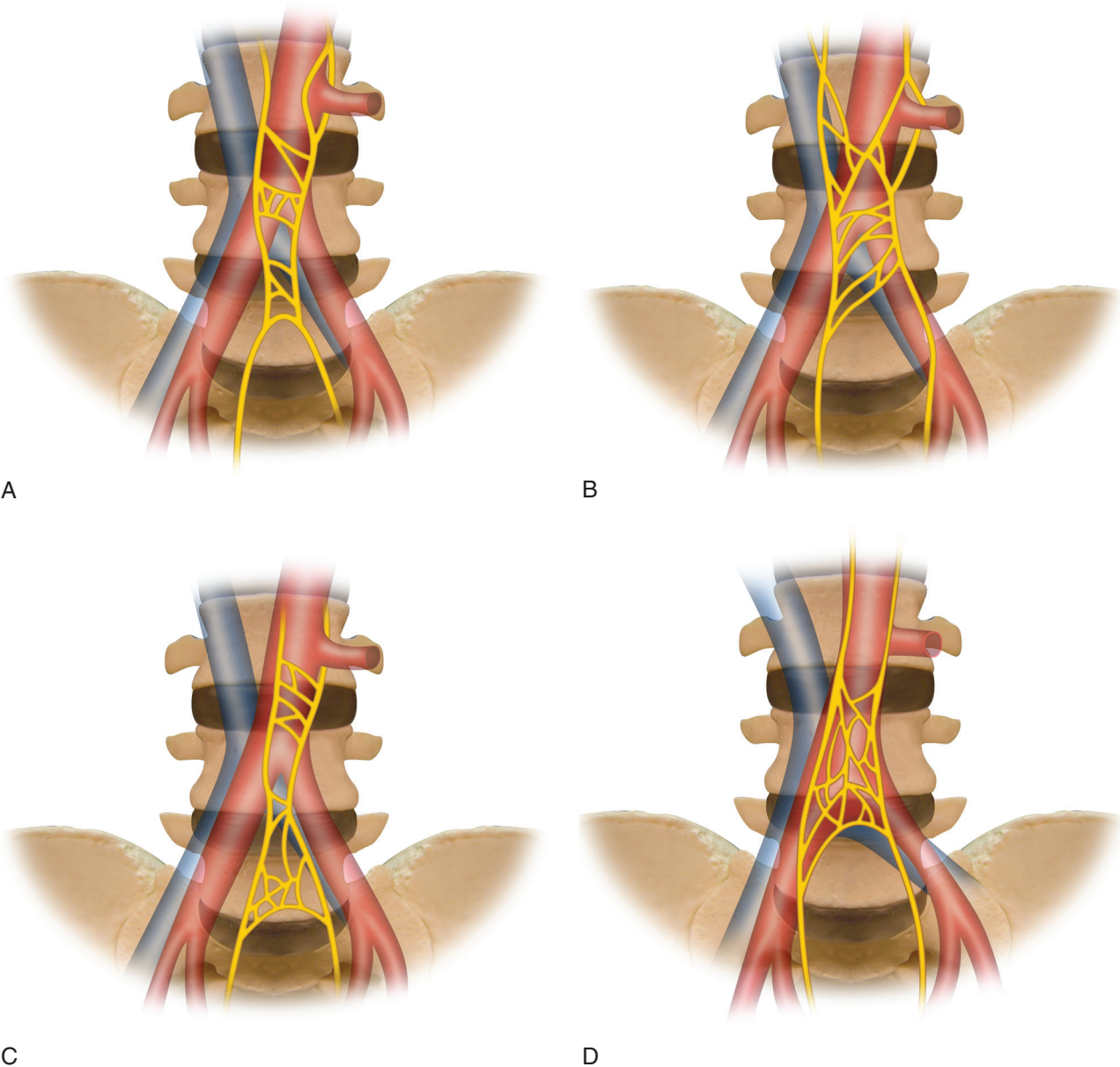


Figure 46-9 Variations in the arrangement of the superior hypogastric plexus.

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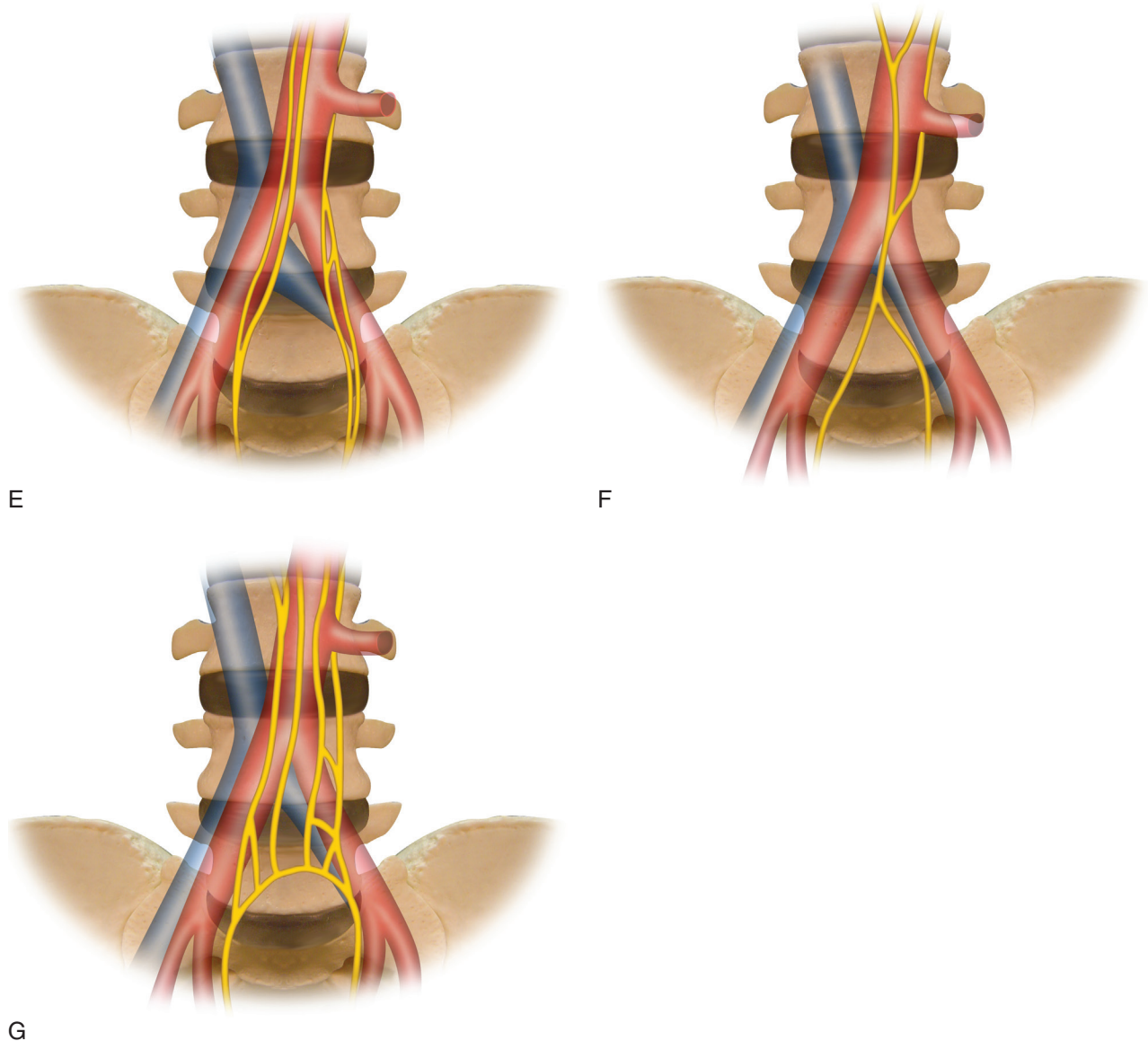


Figure 46-9, cont'd

- Distraction between vertebral bodies can increase the foraminal height and effect an indirect neural decompression.

INTERBODY IMPLANTS

- A variety of interbody spacers can then be placed to maintain disk height and promote interbody fusion.
- Bicortical iliac crest autograft can be inserted with the ridge of the crest placed anteriorly. In this position, cortical bone supports the interspace, maximizing contact between cancellous autograft and vertebral end plates.
- Rings of femur or humerus allograft bone can be cut to size to fit into the disk space. The cylindrical geometry of these long bones matches the vertebral end plates nicely, because the strongest vertebral end plate is at the periphery. The allograft should be cut for an appropriate

lordosis. The central canal should be packed with osteoconductive/osteoinductive materials, as is the case with all implants except autograft bone. Commercially, precision-machined allograft rings are also readily available.

- Precision-machined, cylindrical, threaded allograft bone dowels have the advantages of an allograft but a reduced risk of backout because of their threaded contact with host bone.
- Titanium-threaded fusion cages have been purported to provide superior stabilization when compared with impacted spacers (Fig. 46-10). This presumably decreases the need for supplemental posterior fixation.
- Titanium mesh cages have a long track record of safety and efficacy and remain a versatile option.
- Impacted cages composed of alternate materials—such as carbon fiber, resorbable polylactic acid, and PEEK polymer—are widely available.

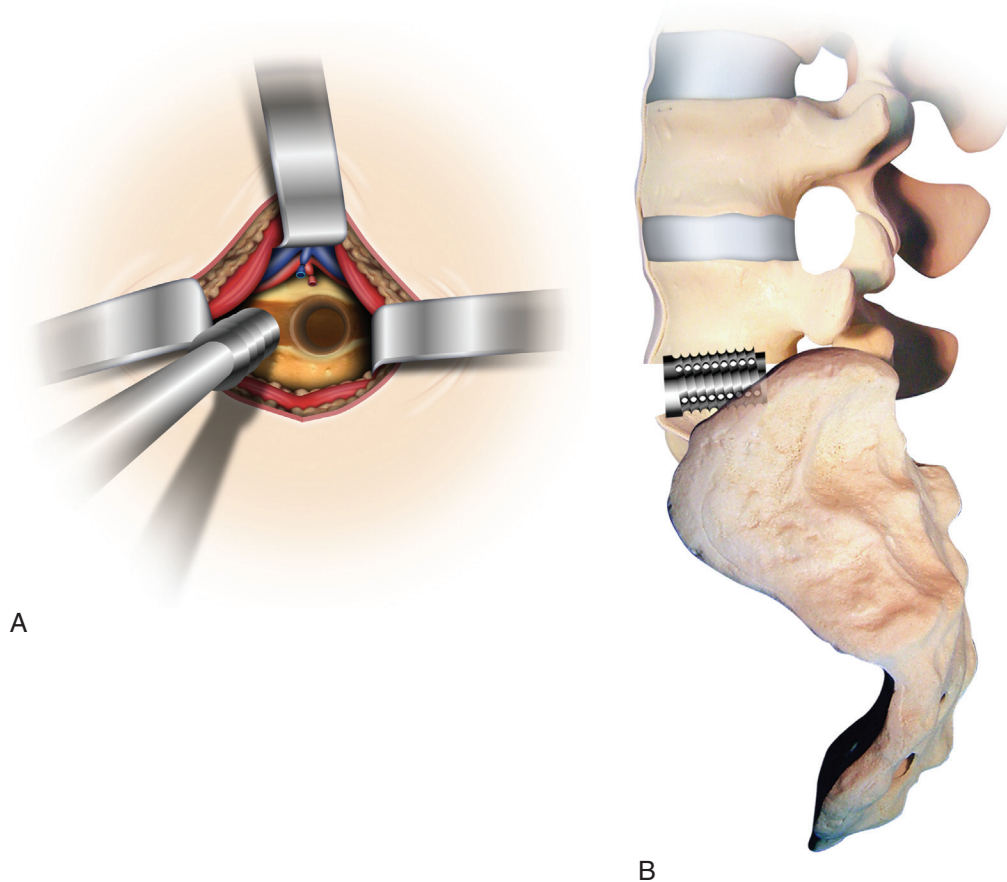


Figure 46-10 Placement of titanium-threaded fusion cages into the disk space. **A**, Intraoperative view. **B**, Sagittal view.

PLATING (OPTIONAL)

- Plating of the anterior lumbar spine enhances the rigidity of the construct and decreases the risk of interbody spacer migration (Fig. 46-11).
- Additional options include the use of buttress plates attached to only the superior or inferior vertebral body.
- Newly developed cages are available that contain an integrated, zero-profile anterior plate (SynFix-LR; Synthes, Solothurn, Switzerland) or allow for implantation of screwless plating devices (ROI-A; LDR Medical, Austin, TX). These novel cage designs allow for improved cage stability that may approach levels previously only achieved by supplementation with posterior pedicle screw instrumentation (Fig. 46-12).

BIOLOGICS (OPTIONAL)

- Recombinant human bone morphogenetic protein (BMP) 2 (Infuse; Medtronic, Memphis, TN) has been approved by the Food and Drug Administration (FDA) for use in ALIF to promote bony fusion.
- Fusion rates using BMP for ALIF have been reported to approach 100%. However, complications have been associated with use that include increased rates of retrograde ejaculation and increased graft resorption.

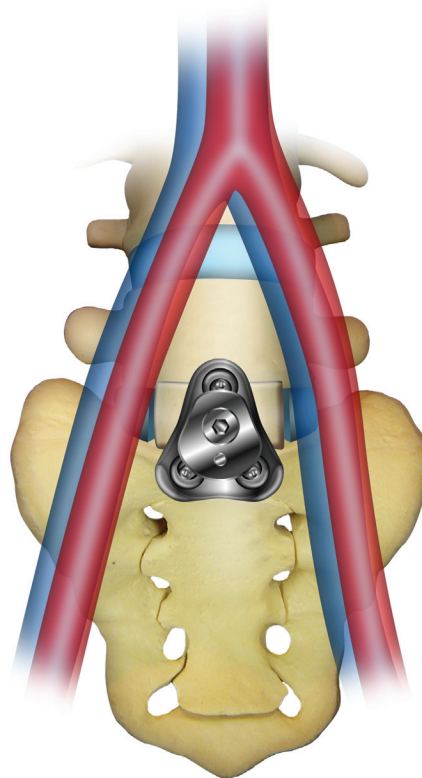


Figure 46-11 Anterior plating at the L5-S1 level.

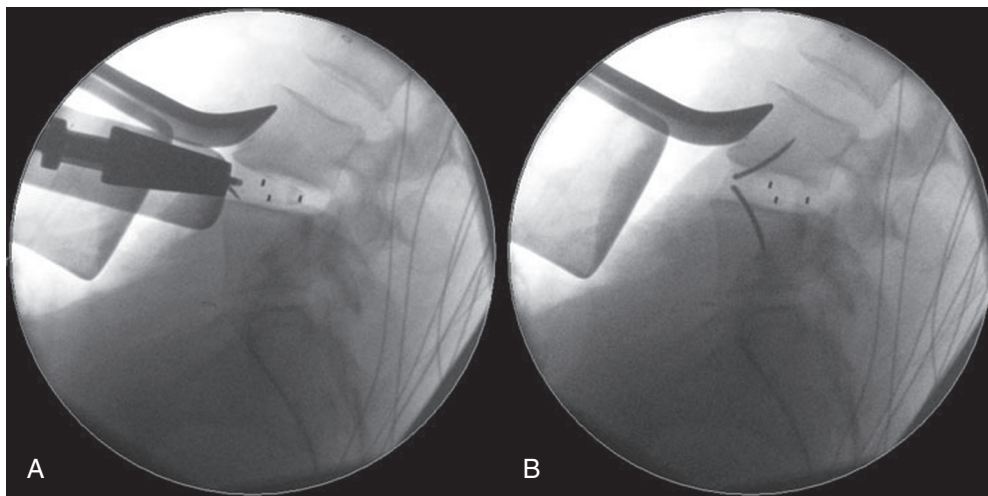


Figure 46-12 Intraoperative radiographs of the ROI-A cage with incorporated plating devices. **A**, Insertion of the device at L4–L5. **B**, After deployment of the screwless plating devices.

CLOSURE

- The wound is irrigated, and all cottonoids and retractors are removed.
- A final radiograph is taken to confirm implant location and to check for retained sponges.
- The wound is inspected for any bleeding, and all vasculature ligatures are checked.
- The peritoneal lining and ureter are inspected. Small tears in the peritoneum should be either repaired primarily or opened widely to prevent bowel strangulation.
- The rectus sheath is reapproximated with resorbable suture.
- The skin is closed with a running subcuticular stitch.

Postoperative Care

- Patient-controlled analgesia is appropriate for pain control.
- The patient is mobilized the day after surgery.
- A liquid diet is begun as soon as the patient has bowel sounds.
- Depending on the number of levels treated, a 1- to 3-day hospital stay is typical.
- Weight-bearing standing radiographs are obtained before hospital discharge to ensure that the implants have not shifted.
- For multilevel fusions, the patient should wear a rigid orthosis, such as a thoracolumbar sacral orthosis with thigh extension for L5–S1, for 3 months postoperatively.
- For multilevel fusions, posterior supplemental instrumentation may be necessary. This can be performed under the same anesthetic or in a delayed fashion.

Complications

- Injury to the alimentary tract can be avoided by packing the peritoneum away from the operative corridor.

Postoperative ileus is uncommon and should be treated with intravenous hydration, minimization of narcotic doses, and restricted oral intake.

- Damage to the ureter is uncommon and can be avoided by its proper identification.
- Careful manipulation of the numerous vessels encountered during ALIF will minimize the risk of vascular complications, and nearby arteries and veins should be prophylactically ligated.
- Retraction or electrocautery of the hypogastric plexus should be avoided to minimize the possibility of retrograde ejaculation. Male patients are offered the opportunity to bank their sperm before surgery.
- Proper graft sizing and shaping is critical. Undersized grafts can lead to fusion in a kyphotic attitude. Grafts with a small surface area are prone to settling. Ideally, the interbody spacer should maintain vertebral height and physiologic lordosis with distraction across the neuroforamina.
- Telescoping of the graft into adjacent end plates can be minimized by preserving the vertebral end plates and using a graft with the maximal cross-sectional contact area.
- Pseudarthrosis rates can be minimized by proper recipient site preparation, incorporation of osteoinductive substances, supplemental posterior stabilization, proper nutrition, and postoperative immobilization. Patients addicted to tobacco are strongly encouraged to refrain from or to minimize use in the perioperative period.
- Abdominal wall weakness from partial denervation of the rectus abdominis muscle may result in injury to the superficial segmental nerves during exposure.

Conclusion

ALIF is a highly effective method for fusing the lower lumbar spine in carefully selected patients with back pain from degenerative disk disease.