45 Posterior and Transforaminal Lumbar Interbody Fusion

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Overview

Posterior lumbar interbody fusion (PLIF) after lumbar disk removal was first reported by Jaslow[1] in 1946, and Cloward[2] presented his first 100 cases at the Harvey Cushing Society meeting in 1947. More recently, Steffe,[3] Brantigan,[4] and Ray[5] have reported on the use of posterior segmental instrumentation or cage implants for PLIF, a surgical technique that allows fusion across two adjacent vertebrae by inserting grafts, titanium-threaded cages, bone dowels, or carbon-fiber spacers filled with bone graft into the disk space. All PLIF techniques require removal of the disk material from within the disk space; bone grafts and spacing devices are then used to create a bony "bridge" that will fuse the two adjacent vertebral bodies.

PLIF is a valuable way of achieving a spinal fusion. If spinal instability is present (i.e., spondylolisthesis or slippage of the vertebrae), PLIF should be performed with spinal stabilizing instruments, such as pedicle screws or hooks and rods to immobilize the loose vertebrae. The many advantages in instrumented PLIFs, or 360-degree fusions, include a decrease in pain and an increase in functional activities.[6] Compared with anterior-posterior (AP) fusions,[7] instrumented PLIFs also have equal patient satisfaction, much lower costs, and faster return to work and other activities. Furthermore, a recent biomechanical study by Bennett and associates[7] found that PLIFs double the spinal stiffness produced by transpedicular fixation following laminectomy and facetectomy. Other theoretical advantages of PLIF are technical and include the fact that a much larger area of bone surface exists for the fusion, with the fusion at the center of motion and at the site of maximum compression loading. The disk space is maintained in a distracted position without the collapse that is often seen in transverse-process fusion using transpedicular fixation. In addition, the blood supply is better at the decorticated end plate than at the transverse process.

Perhaps the greatest concern with a standard PLIF is the amount of neural retraction needed. An inappropriate amount could potentially lead to nerve root injury, cauda equina injury, dural laceration, and epidural fibrosis.[5,8] Consequently, the unilateral posterior transforaminal lumbar interbody fusion (TLIF) was developed to address some of these problems. The concept of a unilateral approach to the anterior column was refined and popularized by Harms.[9] The purpose of this approach was to obtain the same goals as a PLIF without the potential risks and complications.

The TLIF technique allows clearance of the entire intervertebral disk compartment by opening the neural foramen on one side. After appropriate clearance, it is possible to achieve further enlargement of the cleared intervertebral compartment by posterior transpedicular distraction. This enables definitive anterior column support and certain fusion by transforaminally introduced bone material and support structures. After the introduction of these anterior fusional elements, segment stability is restored by converting the distraction force into compression force.[10] The TLIF approach helps to avoid damage to important anatomic structures, such as the nerve roots, dura, ligamentum flavum, and interspinous ligament.

Preservation of the ligamentous structures is of great importance to restoring biomechanical stability of the segment and its adjacent counterparts. The advantages of unilateral TLIF over the standard PLIF include the ability to provide bilateral anterior column support through a single posterolateral approach of the disk space. The transforaminal approach preserves the anterior and most of the posterior longitudinal ligamentous (PLL) complex, which provides a tension band for compression of the graft and prevents retropulsion of the graft. It avoids excessive soft-tissue dissection, which may help prevent scarring, instability of adjacent segments, and injury to the exiting nerve root. Epidural bleeding is less of a problem than with the standard bilateral PLIF because of the unilateral transforaminal approach, and with experience, proper cage placement within the disk space is consistently achieved.[8,11]

Indications and Contraindications

INDICATIONS

- Broad-based herniations
- Totally degenerated disks with marked instability (spondylolisthesis, some cases of scoliosis)
- Recurrent disk herniation
- Pseudarthrosis of transverse process fusion (as an alternative to anterior lumbar fusion) in the absence of epidural scarring
- Back pain as a result of symptomatic spondylosis and/or symptomatic degenerative disk disease

CONTRAINDICATIONS

- Conjoined nerve root precluding access to the disk space
- Osteoporotic patients
- Active infection
- Previous anterior lumbar interbody fusion

Operative Technique

EQUIPMENT

- Radiograph-compatible operating table
- Jackson table, Wilson frame, or chest rolls
- Fluoroscopy
- Headlight system
- Pneumatic compression stockings or antiembolic stockings for both legs
- Lumbar laminectomy set
- Steinmann pins
- Bone graft source
- Lumbar pedicle screw system

POSTERIOR LUMBAR INTERBODY FUSION PROCEDURE

Laminectomy

- Patient is placed in prone position with chest rolls, on a Wilson frame, or using the Jackson table.
- A midline longitudinal skin incision is made.
- Subperiosteal dissection extends laterally beyond the border of the articular facet joints.
- Laminectomy and complete decompression of nerve roots are performed in the desired level. Total or subtotal laminectomy is easier than the partial laminectomy to handle the thecal sac and nerve roots (Fig. 45-1).
- Medial facetectomy is recommended for preservation of posterior column function.

Traditional Diskectomy

- After gently retracting the nerve roots and thecal sac, the epidural space is identified, and epidural vessels are coagulated (Fig. 45-2).
- Carefully retracting the nerve root at risk, a No. 15 scalpel is used to incise the annulus widely. A large rectangle of annulus and available disk is removed (Fig. 45-3).
- Traditional bilateral diskectomy requires removal of as much disk as possible to ensure that none bunches up to the midline, compressing the dural sac, when bone grafts or cages are placed laterally (Fig. 45-4).
- An up-biting pituitary forceps is used to remove disk beneath the thecal sac without manipulating it.
- Ring curettes are often used to further empty the disk space.
- Backward-angled curettes are carefully placed between the dural sac and the annulus to push down any bulging disk or osteophyte near the midline.

End Plate Preparation

- A vertebral spreader is used to widen the disk space.
- The size of the reamer-distractor varies from 8 to 12 mm practically. Once the reamer-distractor is attempted within the disk space, it is turned 90 degrees to distract the space (Fig. 45-5). The next larger sized reamer-distractor is then tried, and this is repeated using progressively larger reamer-distractors until the ideal disk height is achieved. The final dilator is left within the disk space in the distracted position.
- A Penfield dissector or ruler is placed into the disk space, and images are obtained.
- The osteotome should not be placed more than 50% to 60% through the AP diameter of the vertebral body.

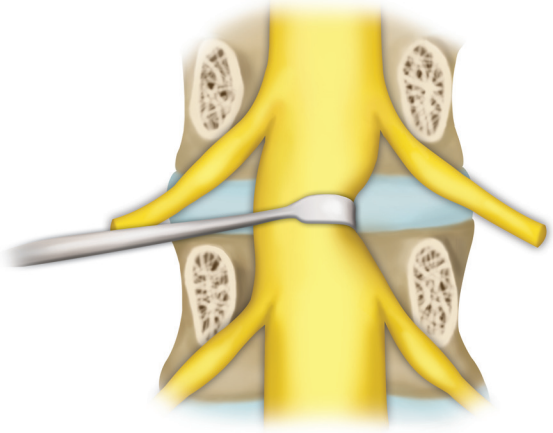

Figure 45-2 Careful retraction of the nerve roots and thecal sac.

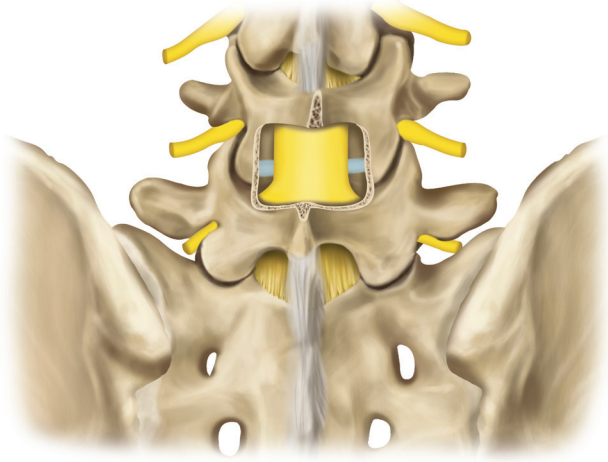

Figure 45-1 L4 subtotal laminectomy.

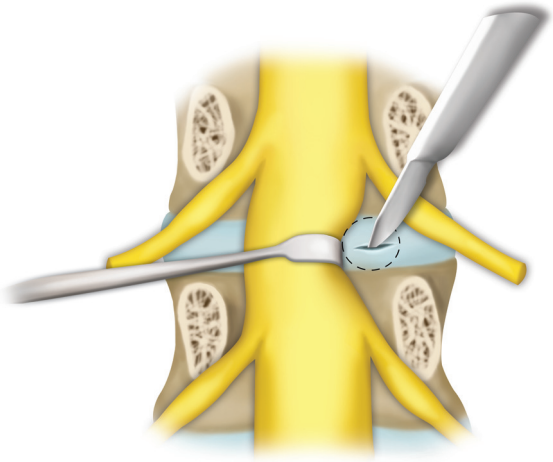

Figure 45-3 Removal of the annulus with a No. 15 scalpel.

- Osteotomes are placed parallel to the end plates at both the superior and inferior aspects of the disk space and then are placed medial and lateral.

Bone Graft Preparation

- Separate the skin incision on the posterior superior iliac crest.
- Remove the long tricortical iliac bone.
- Shape the bone as three pieces of bone graft material, with the height measuring the distracted disk space near the vertebral spreader (Fig. 45-6).
- Donor site bleeding control is achieved with bone wax and closure.

Bone Graft Placement

- The nerve root and dural sac should be very carefully protected with handheld retractors that are regularly released.
- The prepared tricortical grafts or cage filled with autograft are then tapped into the widened disk space.
- A bleeding cancellous bone surface should then be available on the cephalad and caudal edges of the space and possibly laterally as well.

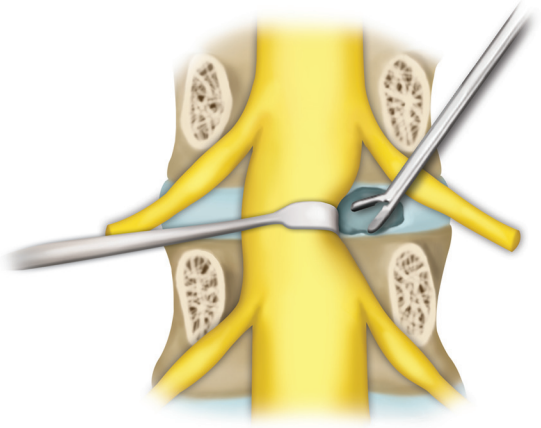

Figure 45-4 Traditional diskectomy before end plate removal.

- We generally prefer to place the more medial bone grafts first, to minimize total mobilization of the dural sac (Fig. 45-7).
- Others place the grafts laterally and then push them toward the midline.
- The superior edge of the graft should be at least 5 mm ventral to the floor of the spinal canal.
- Two to three pieces of tricortical graft material (Fig. 45-8) or cage filled with autograft (Fig. 45-9) can safely be placed on each side of the thecal sac.
- After placing the grafts, be certain that the dural sac and nerve roots are not being compressed.

Closure and Postoperative Care

- Control bleeding of the disk space, epidural space, and paraspinal muscles.
- Place a drain for 24 hours, and close the wound in layers.
- Patients are mobilized on the day of surgery and usually go home in an orthosis 1 or 2 days later.

TRANSFORAMINAL LUMBAR INTERBODY FUSION PROCEDURE

Patient Positioning and Pedicle Screw Placement

- After endotracheal anesthesia, the patient is placed in a prone position with avoidance of epidural venous distension from abdominal compression.
- Posterior spinal elements are exposed through a midline longitudinal incision.
- A subperiosteal dissection of the paraspinous muscles is completed to the transverse processes.
- To minimize blood loss, pedicle screws are sized and inserted under C-arm fluoroscopy guidance before decompression and distraction (Fig. 45-10).

Unilateral Facetectomy and Contralateral Distraction

- If radiculopathy is present, the spinal canal is entered through a unilateral laminectomy and inferior facetectomy on the side of the radicular pain. If no radiculopathy is present, the side is chosen arbitrarily.

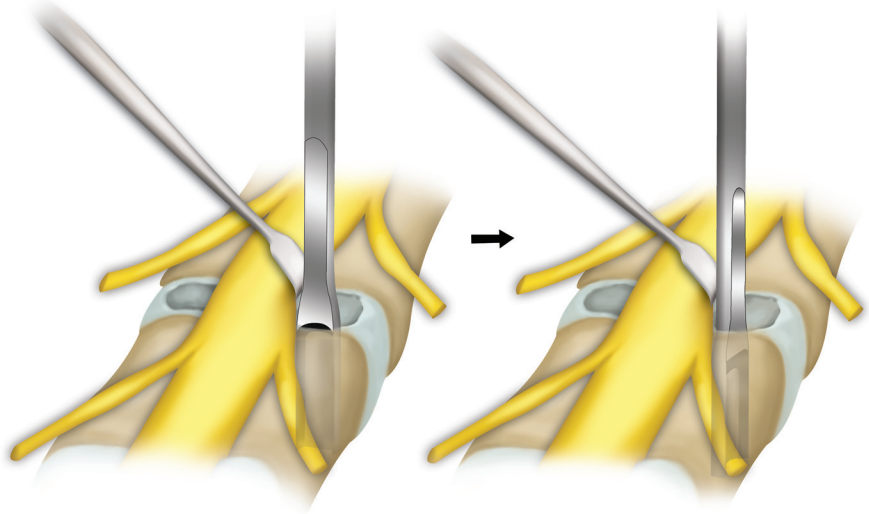

Figure 45-5 Reamer-distractors of progressively increasing size are inserted to widen the disk space, until optimal distraction is achieved.

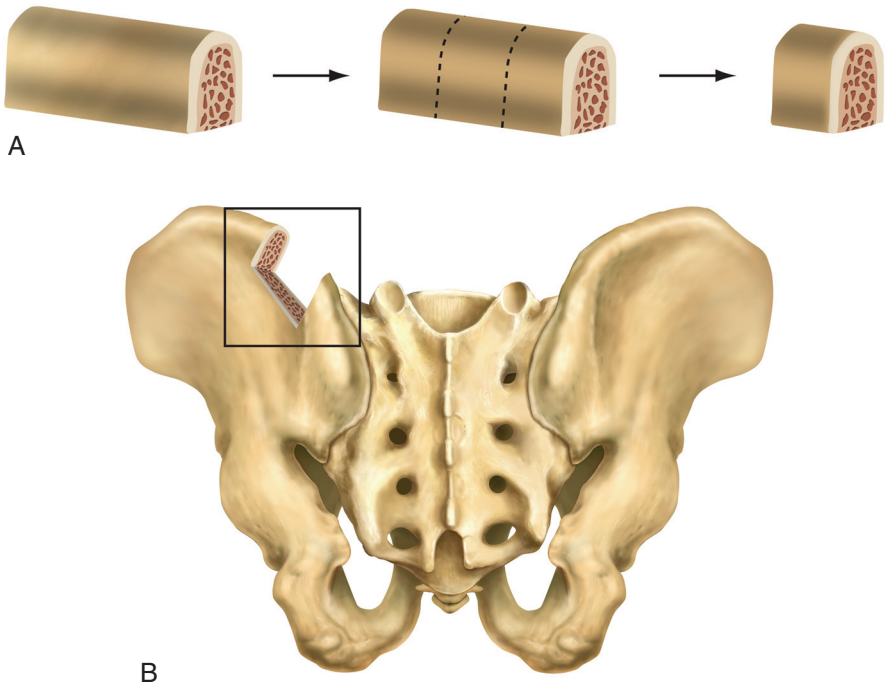

Figure 45-6 Iliac bone harvesting. **A,** Graft harvest. **B,** Location of graft harvesting from the iliac crest.

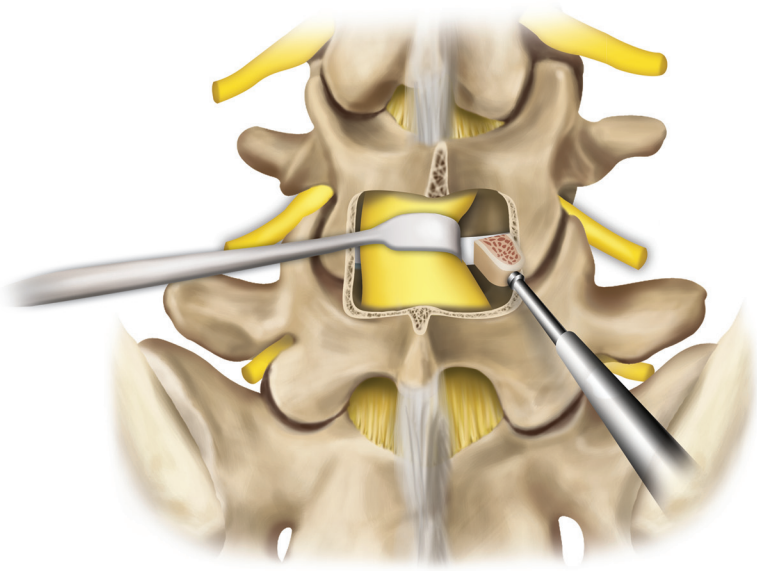

Figure 45-7 Bone graft placement.

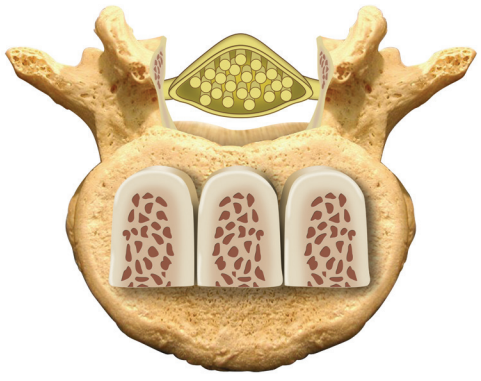

Figure 45-8 Three bone grafts are placed.

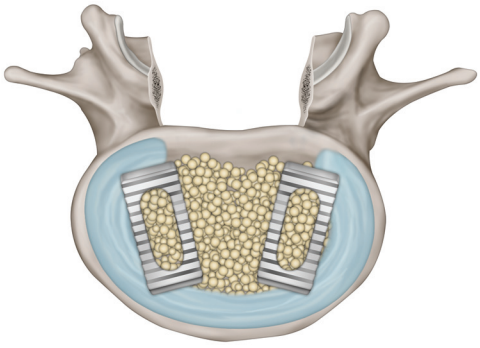

Figure 45-9 Cage filled with autografts is placed.

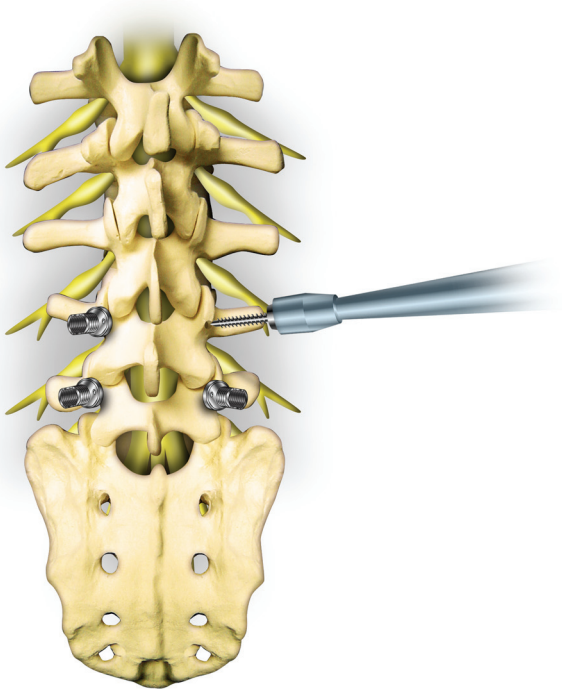

Figure 45-10 After the subperiosteal dissection, pedicle screws are sized and inserted before decompression.

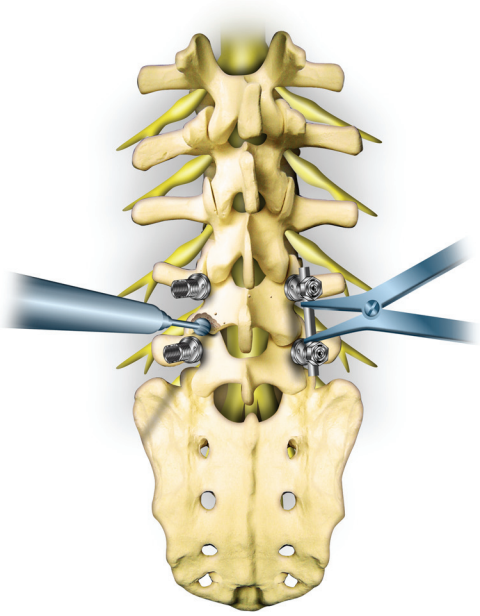

Figure 45-12 The inferior articular process of the cranial vertebra is thinned out with the use of a burr, while distraction forces are applied to the contralateral side.

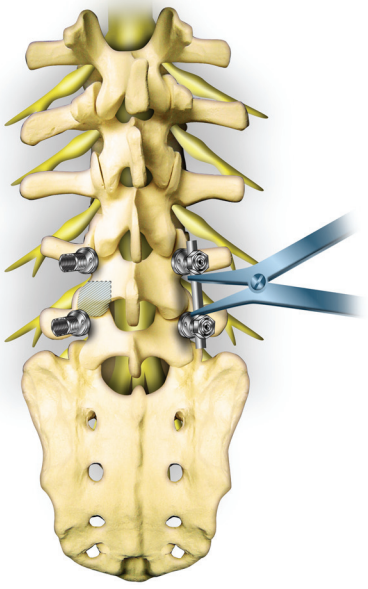

Figure 45-11 Apply the rod system at the nonradiculopathic side, and distract the disk space. A facetectomy will be done at the radiculopathic side.

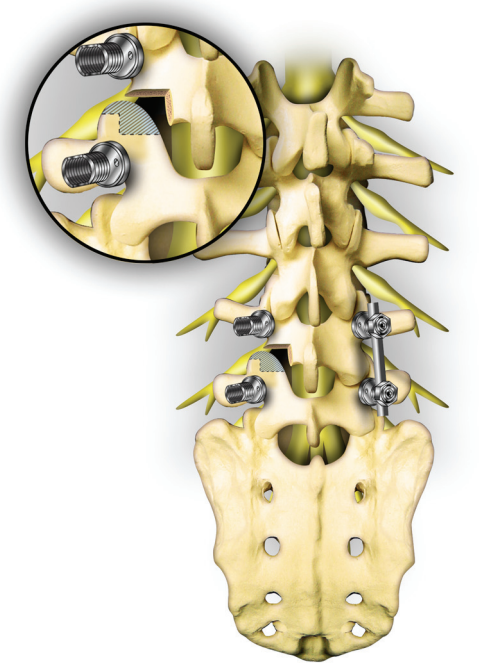

Figure 45-13 After thinning by using a drill, resect the inferior articular process of the cranial vertebral body with a chisel or bone cutter, thereby uncovering the neural foramen. The degree of bone to be resected from the superior facet of the inferior vertebra is indicated.

- Apply the rod system at the contralateral side, and distract the disk space (Fig. 45-11). The interspinous ligament, as well as the ligamentum flavum on the opposite side, is left intact. The degree of bone resection necessary for this unilateral TLIF technique is indicated in Figure 45-11.
- The next step is to gain access to the disk at L4–L5 via the transforaminal approach. The inferior articular process of the cranial vertebra is now thinned out with the use of a burr, while distraction forces are applied to the contralateral side (Fig. 45-12).
- Once thinned, resect the inferior articular process of the cranial vertebral body with a chisel or bone cutter to uncover the next stage in the approach to the neural foramen. The degree of bone to be resected from the superior facet of the inferior vertebra is indicated in Figure 45-13.

- The capsular part of the ligamentum flavum is now visible and can be resected. To avoid damage to the nervous structures, it is necessary to cut around the superior articular facet of the caudal vertebral body. Care must be taken to ensure that the lateral delimitation of the ligamentum flavum is largely preserved.
- Only in exceptional cases is resection of the lateral part of the ligamentum flavum necessary (Fig. 45-14). Tactile exploration of the neural foramen is recommended with palpatory identification of the cranial nerve root and the position and breadth of the pedicle of the caudal vertebral body.
- Resect the superior facet of the inferior vertebra as the final step in gaining access to the disk at L4–L5, the posterolateral parts of the annulus fibrosus, and the longitudinal ligament (Fig. 45-15).
- The entire neural foramen is identified after resection of the upper medial parts of the superior articular facet of the lower vertebral body. The upper nerve root that passes around the pedicle of the upper vertebral body and the lateral part of the intervertebral disk can be identified. The nerve root can be identified merely by palpation in its course within the foramen, especially where it crosses over the lateral parts of the intervertebral space (Fig. 45-16). The origin of the next nerve root in the caudal direction and the dural sac in the medial border can also be identified. After identification of these nervous structures, meticulous coagulation of the epidural veins in the neural foramen is carried out.

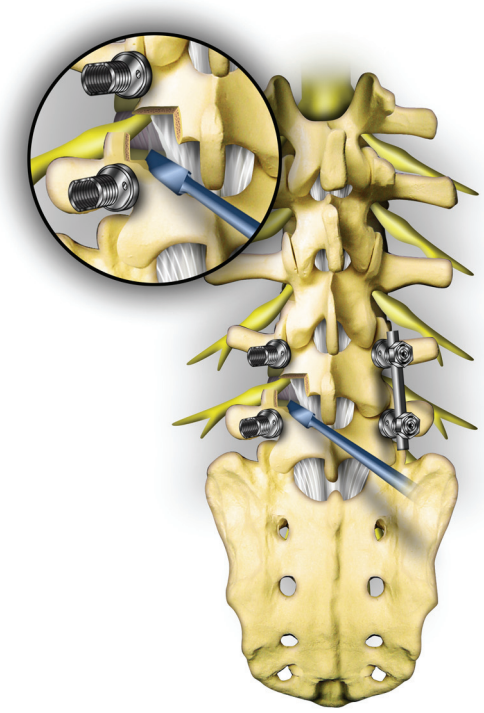

Figure 45-15 Resect the superior facet of the inferior vertebra. This is the final step in gaining access to the disk at L4–L5, the posterolateral parts of the annulus fibrosus, and the longitudinal ligament.

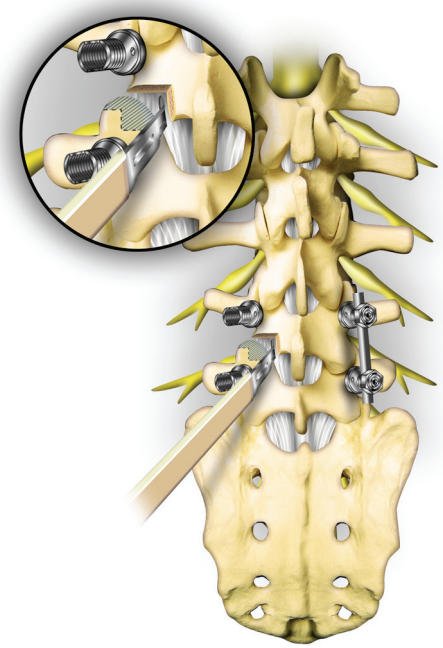

Figure 45-14 Ligamentum flavum removal. Care must be taken to ensure that the lateral delimitation of the ligamentum flavum is largely preserved. The exiting nerve root is identified and is protected from surgical trauma. Tactile exploration of the neural foramen is recommended with palpatory identification of the upper nerve root and the position and breadth of the pedicle of the caudal vertebral body.

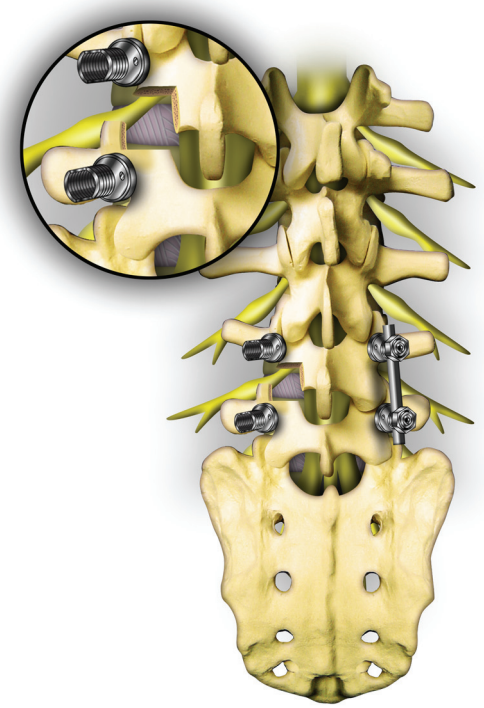

Figure 45-16 After resection of the upper medial parts of the superior articular facet, the neural foramen is opened. The upper nerve root and the lateral part of the intervertebral disk can now be identified.

Total Diskectomy through a Unilateral Approach

- The thecal sac is gently retracted medially if necessary.
- A diskectomy is performed through this unilateral approach (Fig. 45-17).
- The intervertebral disk compartment partially cleared using various rongeurs. Curettes can be used to remove the intervertebral disk remnants adhering to the upper plates. With the curettes, the cartilaginous coats of the end plates can be removed at the same time without destroying the osseous structure of the end plates.

End Plate Preparation

- After the initial diskectomy, gradual distraction is applied to the pedicle screws on the opposite side.
- An osteotome is used to remove the posterior lateral lip of concave bone to achieve a flat end plate surface. This is important because the upper plates of the lumbar vertebral bodies always have a pronounced concave shape.
- By a marginal resection of the dorsal edges of the end plates, a parallel plane between the adjacent vertebral bodies can be established. This is for the introduction of the structural graft. The dorsal lips of the vertebral body should be resected to form a uniform aperture (Fig. 45-18).
- Carefully curette the remaining cartilaginous parts of the end plates. A chisel is not indicated, because it will destroy the cortical structure of the end plates.
- It is necessary to remove the anterior one third or one quarter of the opposing end plates to enable definitive osseous fusion.[12] By this resection with angular chisels, the cancellous bone structure of the vertebral body is exposed, guaranteeing rapid osteointegration. Only the anterior one third or one quarter is resected. The remaining part of the osseous end plate must be carefully preserved to accommodate the supporting structural graft, which will be inserted later. In the process of chiseling, the anterior longitudinal ligament (ALL) must not be damaged because this can result in vascular injury (Fig. 45-19). A surgeon who is inexperienced in this procedure should initially use an image intensifier or fluoroscopy when completing this step.

Cancellous Bone and Strut Bone or Cage Graft

- The previously harvested cancellous bone is introduced into the retracted intervertebral disk compartment and is brought to the ALL. The cancellous bone is then impacted with straight and angled impactors. This procedure can attain a definite bone layer in the anterior one third of the intervertebral space. Also, this impacted cancellous bone prevents the structural graft from being positioned too far anteriorly (Fig. 45-20).
- Cut the structural graft to the appropriate height and insert it. A cage of the proper height packed with cancellous bone is inserted into the disk space. For biomechanical reasons, the graft should be situated in the middle or posterior half of the intervertebral space. Insert the first graft transforaminally into the disk space; place it primarily close to the posterior wall, and slide it anteriorly to the contralateral side (Fig. 45-21).
- Bring the first graft over the midline to the opposite side in a rolling movement. The graft is supported on the

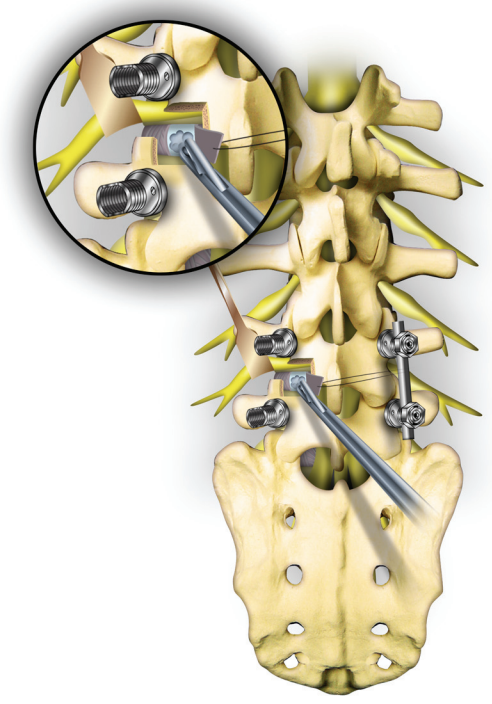

Figure 45-17 The thecal sac is gently retracted medially, if necessary. The diskectomy is performed through this unilateral approach.

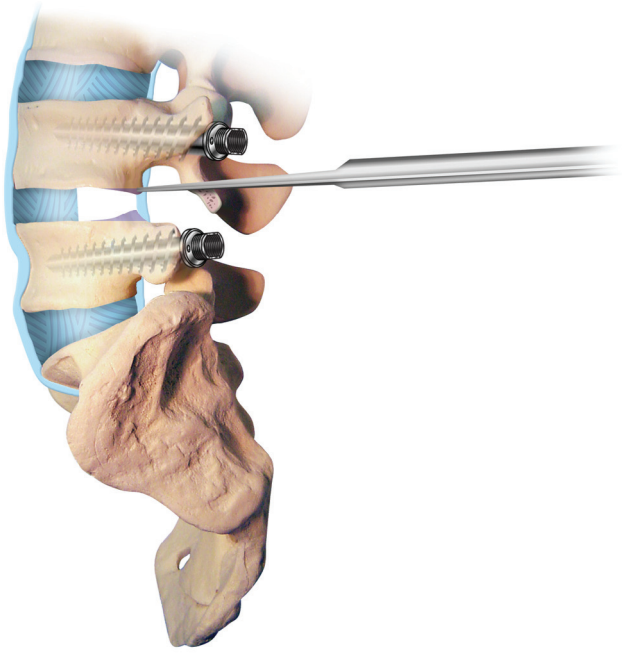

Figure 45-18 Clear the intervertebral disk compartment by using various rongeurs and curettes. An osteotome is used to remove the posterior lateral lip of concave bone to achieve a flat end plate surface. The dorsal lips of the vertebral body should be resected to form a uniform aperture.

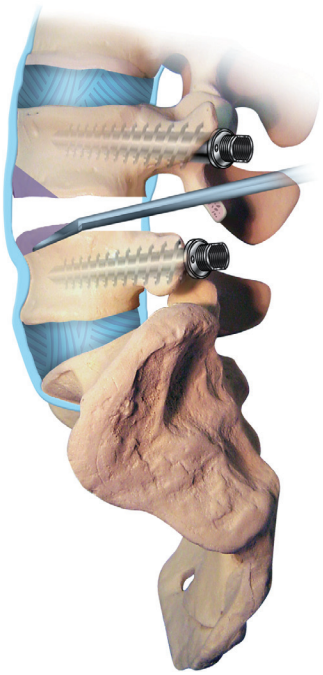

Figure 45-19 Remove the anterior one third or one quarter of the end plates to enable osseous fusion. The remaining part of the osseous end plate must be carefully preserved to accommodate the supporting structural graft. The anterior longitudinal ligament must be preserved to prevent vascular injury.

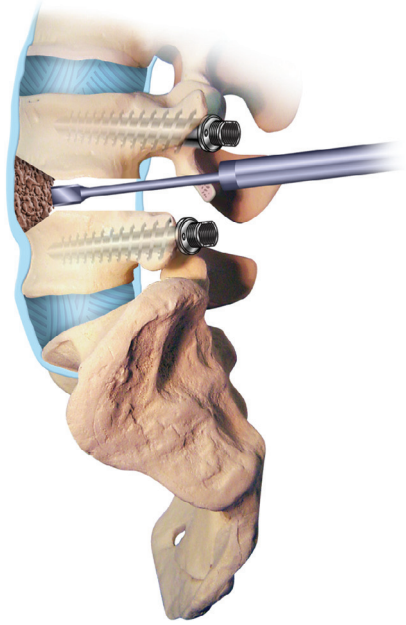

Figure 45-20 Cancellous bone is introduced into the intervertebral disk space and is brought to the anterior longitudinal ligament. This is necessary to attain a definite bone layer in the anterior one third of the intervertebral space. At the same time, this impacted cancellous bone prevents the structural graft from being positioned too far anteriorly.

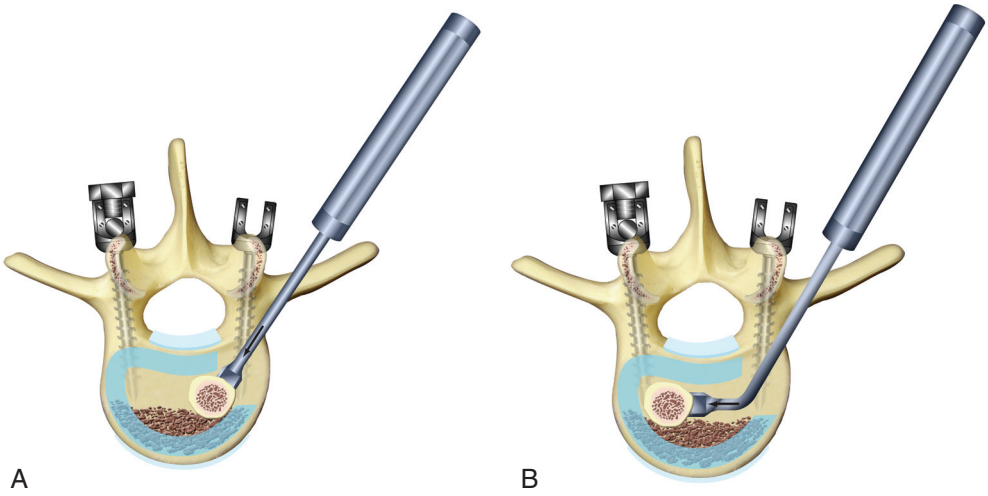

Figure 45-21 Insert the first graft transforaminally into the disk space. Place it primarily close to the posterior wall, then slide it anteriorly to the contralateral side.

ventrally introduced autologous bone chips, which prevents it from becoming positioned too far ventrally.

- A second graft is seated next to the first one to line them up to the left and to the right of the midline, respectively. In this way, a good broad area of support from the adjacent vertebral bodies is attained (Fig. 45-22).
- After insertion of the bilateral strut graft or cages from a unilateral approach, the final position is checked visually and radiologically. Then the disk space distraction is released.

Final Assembly of a Rod-and-Screw System and Closure

- The construct is compressed to establish an optimal graft-bone interface and to reestablish lumbar lordosis at the operated segments (Fig. 45-23).
- The rod-and-screw system is tightened and cross-linked.
- Perform a posterolateral fusion with cancellous iliac bone graft over the transverse processes after adequate decortication on both sides (Fig. 45-24).

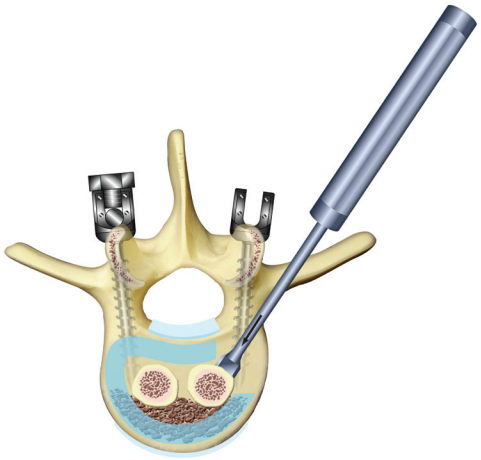

Figure 45-22 A second graft is seated next to the first one to line these up to the left and to the right of the midline, respectively. In this way, a good broad area of support from the adjacent vertebral bodies is attained.

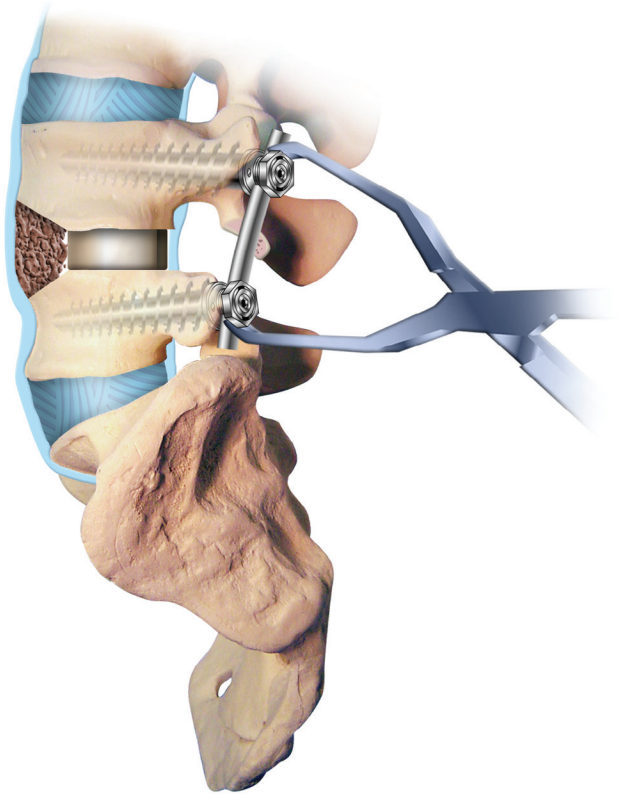

Figure 45-23 After insertion of the bilateral cages from a unilateral approach, the final position of the structural graft is checked visually and radiologically. Then the disk space distraction is released. The construct is compressed to establish an optimum graft-bone interface and to reestablish lumbar lordosis at the operated segments.

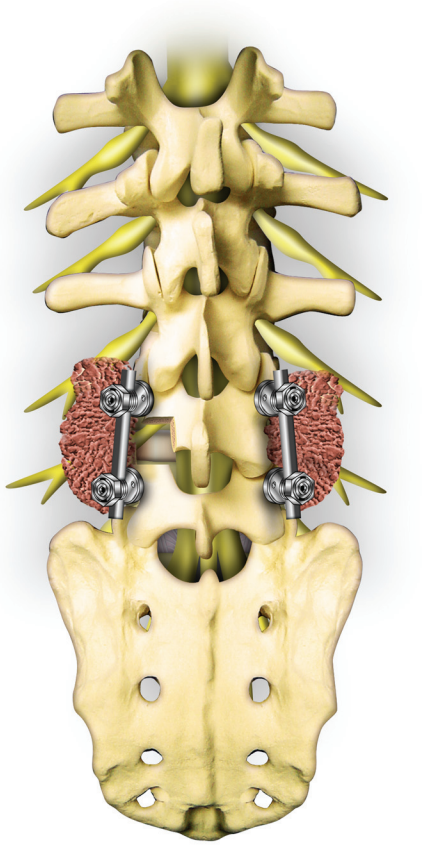

Figure 45-24 After tightening and crosslinking of the rod-and-screw system, perform a posterolateral fusion with bone graft over the transverse processes.

- Insert drains and carry out the muscle closure, followed by fascia suture, subcutaneous suture, and finally by skin closure.

Postoperative Care

- All wound drains are removed 24 to 48 hours after surgery.
- Patients with a single-level lumbar fusion do not need external orthosis.
- Weight-bearing standing radiographs are obtained before hospital discharge to ensure the implants have not shifted (Fig. 45-25).
- Patients are mobilized on postoperative day 1.
- Physical therapy for rehabilitation is then provided.
- Patients are usually discharged from the hospital 2 to 3 days after operation if there are no complications.

Complications

- Pseudarthrosis
- Excessive hemorrhage
- Dural tear
- Infection

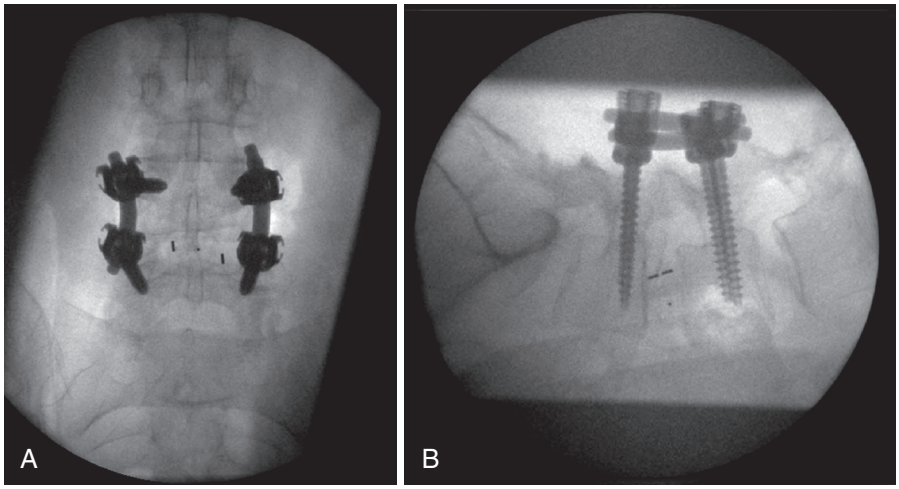

Figure 45-25 Postoperative radiographs of a transforminal lumbar interbody fusion.

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