14 Anterior Cervical Diskectomy and Fusion

JAY RHEE and JEAN-MARC VOYADZIS

Overview

Cervical spondylosis and disk degeneration can lead to radiculopathy and myelopathy from progressive foraminal or central stenosis. A 14 year epidemiologic study from Rochester, Minnesota, found the incidence of cervical radiculopathy to be 83.2 per 100,000 population.[1] The majority of the cases were secondary to chronic degenerative arthropathy of the cervical spine. Although the majority of patients suffering from symptomatic cervical spondylosis or intervertebral disk herniation will improve with conservative therapy, many will have persistent or worsening symptoms that require surgery.[1,2]

The anterior approach provides a safe and effective corridor to the subaxial cervical spine in cases of instability or anterior pathology. First described by Robinson and Cloward, the anterior cervical diskectomy and fusion (ACDF; Fig. 14-1) has become an established and commonly performed operation.[3,4] Once a decompression of the intervertebral disk and neural foramen is performed, an intervertebral graft is inserted to maintain disk space height and enhance fusion. The choice of graft material will be dictated by surgeon preference, and multiple pathologic levels may be treated in the same operation. Upon placement of an autograft or allograft, an anterior cervical plate may be placed to span the most rostral to the most caudal vertebral bodies included in the diskectomies. Although the efficacy of anterior cervical plating for single-level operations remains controversial, plating for multilevel fusions has been shown to decrease pseudarthrosis rates.[5] Furthermore, studies suggest that instrumentation maintains sagittal balance through the segments within the construct, even in single-level fusions.[6,7]

Indications

- Intractable or progressive cervical radiculopathy or myelopathy refractory to conservative management with evidence of spondylosis or disk herniation causing foraminal or central stenosis at corresponding level on imaging
- Cervical diskitis
- Drainage of anterior cervical epidural abscess
- Diskogenic cervical headaches[8]
- Anterior cervical tumor
- Degenerative or traumatic cervical subluxation
- Traumatic cervical instability

Contraindications

- No absolute contraindications
- Prior neck irradiation
- Prior anterior neck surgery
- Tracheostomy
- Primary posterior pathology (hypertrophied ligamentum flavum)
- Ossification of the posterior longitudinal ligament (may require corpectomy or posterior decompression)
- Severe osteoporosis

Operative Technique

EQUIPMENT

- Radiolucent operating table
- Intraoperative fluoroscopy
- Optical loupes
- Headlights
- Operative microscope
- Radiolucent self-retaining cervical retractor
- Monopolar and bipolar electrocautery
- Metzenbaum scissors
- Kittner swabs
- Cloward handheld retractors
- Caspar pins with left- or right-sided retractor, depending on the side of approach
- Pneumatic drill
- Kerrison rongeurs, sizes 1 through 3
- Pituitary rongeur
- Straight and curved curettes
- 18-gauge spinal needle
- Intervertebral graft material (autograft, allograft)
- Plate-and-screw system (optional)
- Jackson-Pratt drain (optional)

PATIENT POSITIONING

- The patient is placed supine on the radiolucent operating table with the head toward anesthesia.
- Upon induction of general anesthesia, the patient is intubated. If significant central stenosis or myelopathic symptoms are present, care is taken to avoid extension of the neck. This may require fiberoptic intubation.
- The patient's head is placed on a horseshoe or padded donut.

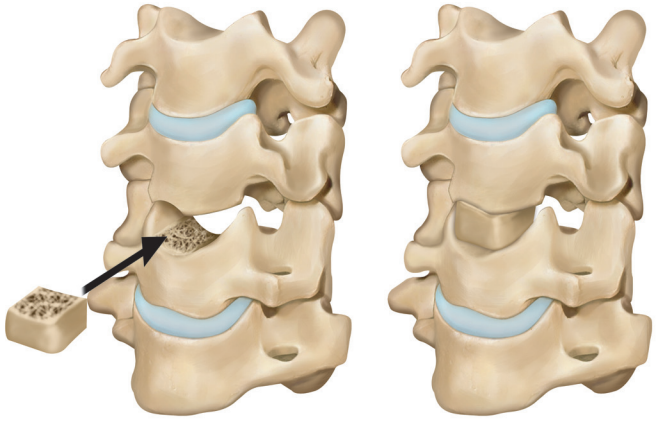

Figure 14-1 Illustration of the Smith-Robinson technique. A rectangular diskectomy is performed, allowing both central and foraminal decompression followed by insertion of an intervertebral graft.

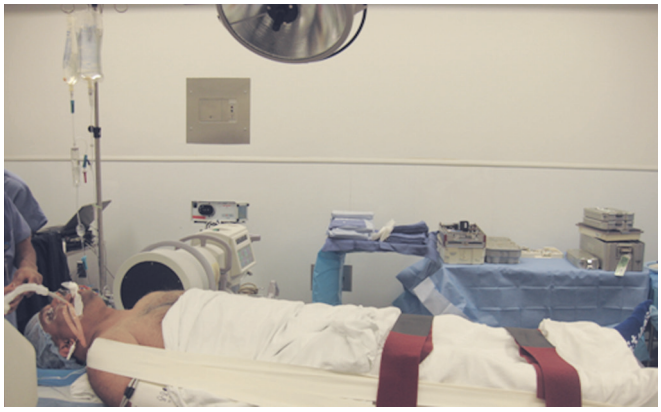

Figure 14-2 The final operative position has the patient secured supine in mild neck extension with a small roll placed transversely across both shoulders. The head is toward anesthesia; the fluoroscopy machine is positioned transversely at the level of the cervical spine in preparation for localization. The shoulders are gently retracted caudally and are taped in place for better radiographic exposure of lower cervical levels.

- A small roll is placed under the shoulders transversely to facilitate cervical lordosis.
- The elbows and wrists are padded to prevent compression neuropathy, and the arms are tucked to the patient's sides.
- Intraoperative fluoroscopy is placed at the level of the cervical spine transversely in preparation for a lateral view.
- When the patient's shoulders obscure imaging of the operative levels, they may be retracted caudally with tape (Fig. 14-2).
- If planning an iliac crest autograft, the ipsilateral crest is elevated and rotated contralaterally by placing one pillow beneath the ipsilateral buttock.

MARKING THE INCISION

- The side of approach is based on surgeon preference. Despite the more lateral location of the right recurrent laryngeal nerve, studies reveal no increase in risk of nerve injury between left- and right-sided approaches.[8-10]

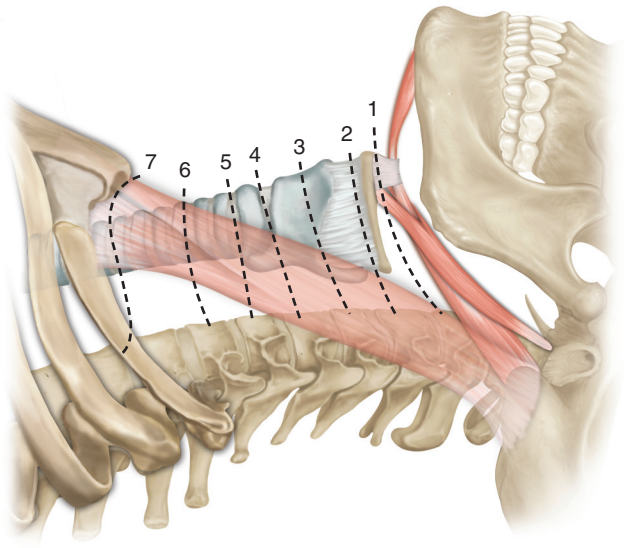

Figure 14-3 Anatomic landmarks for marking incisions.

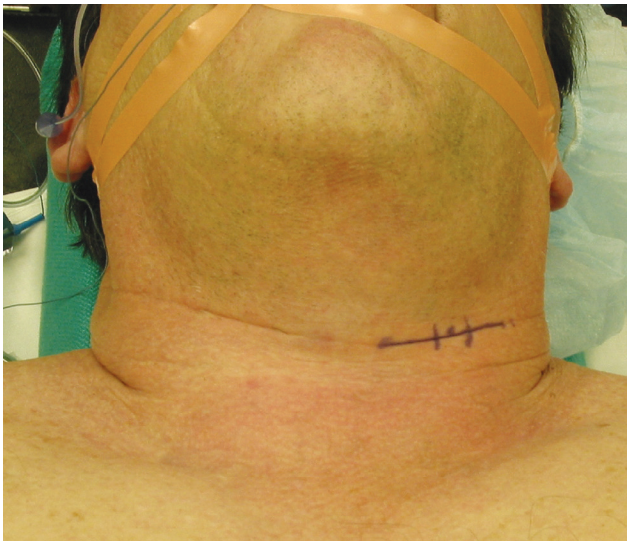

Figure 14-4 Left paramedian incision along a natural skin crease in preparation for a C5–C6 anterior cervical diskectomy and fusion.

The sagittal orientation of the cervical intervertebral disks is approximately 15 degrees rostral; therefore positioning the patient lying on the right side for a right-handed surgeon—or conversely, lying on the left side for a left-handed surgeon—will facilitate diskectomy.

- A transverse incision is marked out from the midline to the lateral border of the sternocleidomastoid (SCM) muscle. The marking should be placed along a natural skin crease or along the Langer line for improved cosmesis. The level of the target disk(s) dictates the rostral or caudal location of the incision (Figs. 14-3 and 14-4).
- For C1–C2 and C2–C3, the incision is placed 1 cm below the angle of the mandible. A mandibular osteotomy may be required for access to vertebrae in a patient with a short neck.
- For C3–C4, the incision is placed just caudal to the level of the hyoid bone.

- For C4–C5, the incision is placed at the level of the thyroid cartilage.
- For C5–C6 and C6–C7, the incision is placed at the level of the cricoid cartilage.
- C7–T1 may be accessible in certain patients with longer necks. In these cases, the incision is placed as low as possible, just above the clavicle.
- These guidelines for the marking of incisions should be confirmed with lateral fluoroscopy.
- To obtain an iliac bone autograft, an 8-cm oblique line is marked 6 cm lateral to the anterior superior iliac spine.

PREPARATION AND DRAPING

- Once the incision is marked, the operative field is isolated with circumferential 10 × 10 cm adhesive drapes.
- The skin is sterilized in standard fashion.
- The iliac incision is prepared if autograft harvesting is planned (see the section on autograft harvesting).
- Both cervical and iliac incisions are isolated with sterile towels. A clamp is placed over the iliac incision for localization through the sterile drapes, and a thyroid drape is placed over the cervical incision.
- The base of the intraoperative fluoroscopy machine is placed opposite the surgeon; it is draped carefully to avoid contamination of the sterile field and is moved rostrally toward anesthesia. The operative microscope is placed behind the primary surgeon opposite the fluoroscopy machine.

INCISION AND SOFT TISSUE DISSECTION

- Local anesthetic is injected into the incision site.
- The skin is incised transversely along the marking with a scalpel to expose the subcutaneous layer, which in turn is dissected until the longitudinal fibers of the platysma are visible (Fig. 14-5).
- The platysma is cut transversely with electrocautery in the same plane as the skin incision (Fig. 14-6).
- The external jugular vein or its branches may be encountered; these may be dissected, retracted, or ligated if necessary.

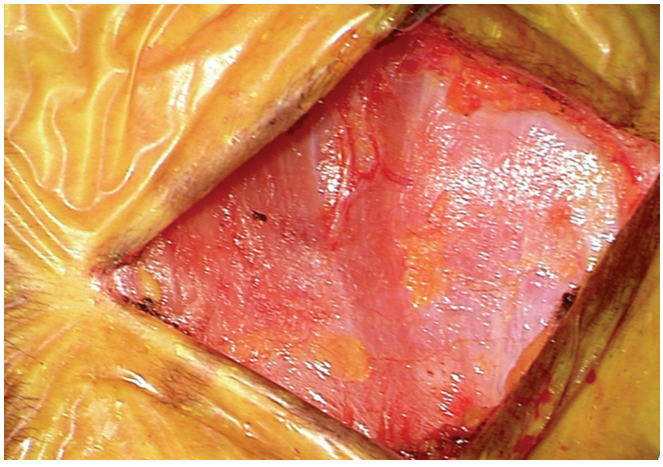

Figure 14-5 A left-sided transverse skin incision is made, exposing the longitudinal fibers of the platysma muscle.

- The subplatysmal areolar layer is undermined both rostrally and caudally to facilitate exposure and retraction.
- The SCM muscle is identified, and the anterior cervical fascia on its medial border is incised (Fig. 14-7).
- Deep to the anterior cervical fascia lies a loose areolar layer, between the SCM and infrahyoid (omohyoid and sternothyroid) muscles. This plane is exposed using blunt and sharp dissection.

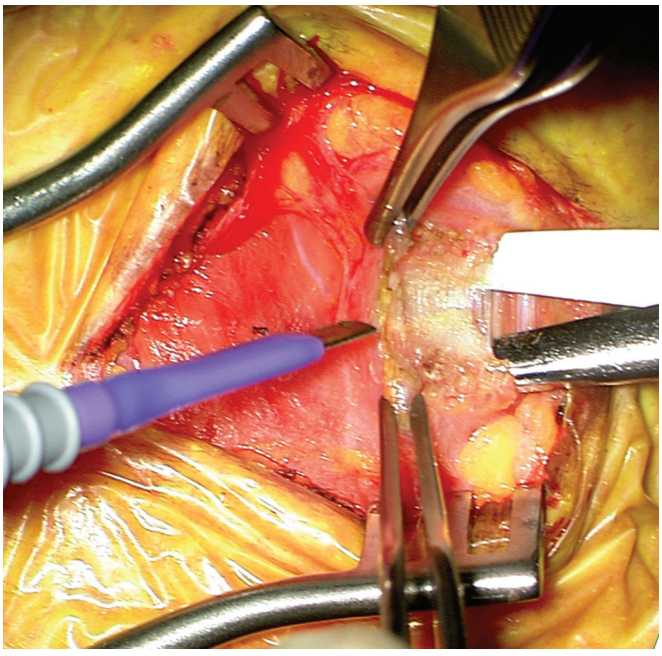

Figure 14-6 The platysma is bluntly dissected and elevated from underlying structures with Metzenbaum scissors, then incised transversely with monopolar electrocautery.

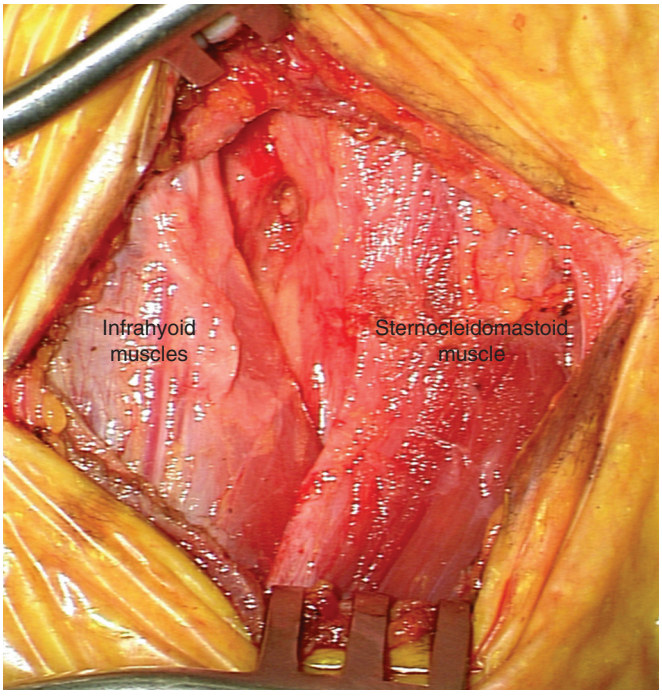

Figure 14-7 Anterior cervical fascia on the medial border of the sternocleidomastoid muscle has been incised to reveal a natural plane.

- The transverse belly of the omohyoid muscle may obscure access to this corridor, especially if the procedure involves C5 to C6. If medial retraction proves inadequate, the omohyoid may be transected.
- The carotid artery is palpated and retracted laterally with a Cloward handheld retractor.
- Another Cloward retractor protects the infrahyoid muscles, trachea, and esophagus medially. The anterior vertebral column may be palpated at this stage.
- The middle cervical fascia immediately deep to the retractors is held under tension. This layer is dissected bluntly with Kittner swabs to expose the prevertebral fascia (Fig. 14-8).

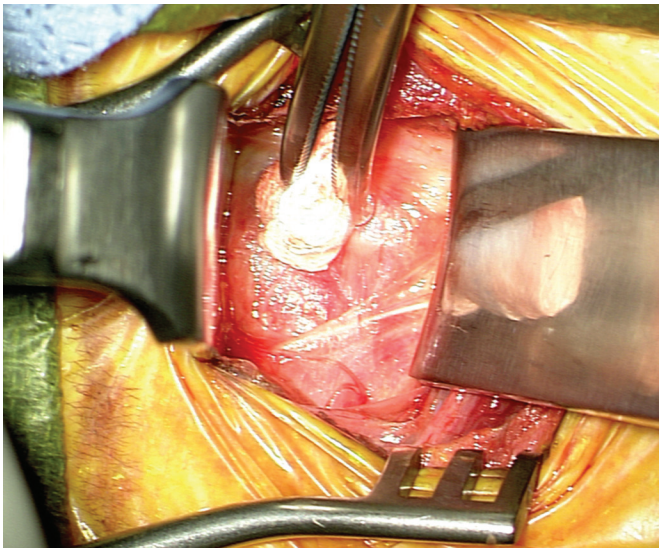

Figure 14-8 Using Cloward handheld retractors, the infrahyoid muscles, trachea, and esophagus are retracted medially; the sternocleidomastoid muscle and carotid sheath are retracted laterally. This places the middle cervical fascia under tension; the fascia is dissected bluntly with Kittner swabs.

EXPOSURE OF THE VERTEBRA

- The prevertebral fascia is dissected in similar fashion, until the vertebral column and bilateral longus colli muscles are visible.
- An 18-gauge needle is inserted into the disk space of interest. The tip of the needle is bent twice to prevent inadvertent placement of the needle into the spinal canal (Fig. 14-9).
- A lateral fluoroscopic image is taken to confirm the correct disk space.
- The longus colli muscles and the anterior longitudinal ligament are dissected subperiosteally with monopolar cautery up to the uncovertebral joints bilaterally (Fig. 14-10). When operating at the C3–C4 and C4–C5 levels, the surgeon may encounter the inferior thyroid vein and artery; these vessels may be ligated if necessary. The superior laryngeal nerve may extend from the vagus nerve in the carotid sheath toward the thyroid cartilage, and care must be taken to avoid injury to this nerve.
- Once the longus colli muscles are sufficiently mobilized, a depth gauge is inserted up to the anterior vertebral surface. Self-retaining retractors are chosen based on the depth measurement, and the blades are placed beneath the longus colli muscles bilaterally. The blades are distracted until the uncovertebral joints are visualized. Care must be taken to identify the midline.
- A second self-retaining retractor may be placed in the cephalocaudal direction to facilitate exposure. This step is often unnecessary in single-level procedures but is helpful when exposing multiple disk levels (Fig. 14-11).
- 12- to 14-mm Caspar pins may be hand drilled into the vertebral bodies immediately rostral and caudal to the target intervertebral disk to provide distraction.

DISKECTOMY AND FORAMENOTOMY

- Any overhanging anterior osteophytes are removed with rongeurs to fully expose the disk space.

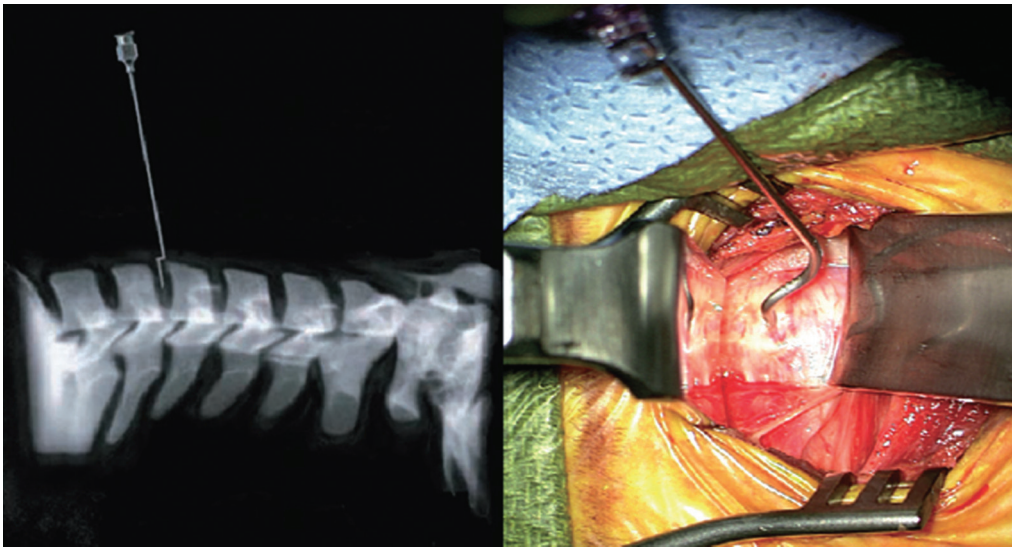

Figure 14-9 A bent 18-gauge spinal needle is used to correctly localize the C5–C6 intervertebral disk space. A lateral fluoroscopic image and an intraoperative image are shown.

- A 15 blade scalpel is used to incise a 10- to 12-mm rectangular opening in the annulus. The lateral extent of this incision should not extend past the most medial portion of the uncinate process bilaterally (Fig. 14-12).
- The incised portion of the annulus is removed with a pituitary rongeur. The remaining portion of the intervertebral disk and cartilaginous end plates are removed carefully with 2- to 3-mm curettes, 1- to 3-mm Kerrison rongeurs, and a pituitary rongeur (Fig. 14-13).
- The operative microscope may be utilized for the remainder of the diskectomy and foraminal decompression. The microscope must be placed so that the view is midline and perpendicular to the vertebral column. An oblique view of the operative field may predispose the surgeon to skive unilaterally toward a vertebral artery.
- A pneumatic drill is used to remove posterior osteophytes and prepare the disk space for graft placement (Fig. 14-14). The osseous end plates must be preserved, because these will prevent subsidence of the graft into the vertebral bodies. The intervertebral disk space is typically oriented rostrally 10 to 20 degrees, which requires angling of the microscope in similar fashion.
- With completion of the diskectomy, the posterior longitudinal ligament is exposed and subsequently removed with a #1 or #2 Kerrison rongeur (Fig. 14-15).
- Osteophytes and portions of the uncinate process that extend into the neural foramen in cases of foraminal stenosis can be removed with Kerrison rongeurs. The microscope may be tilted to enhance the lateral view of the neural foramen.
- A blunt hook is gently inserted to the neural foramen and central canal to ensure adequate decompression.
- Epidural bleeding is managed with bipolar electrocautery and thrombin-soaked Gelfoam.

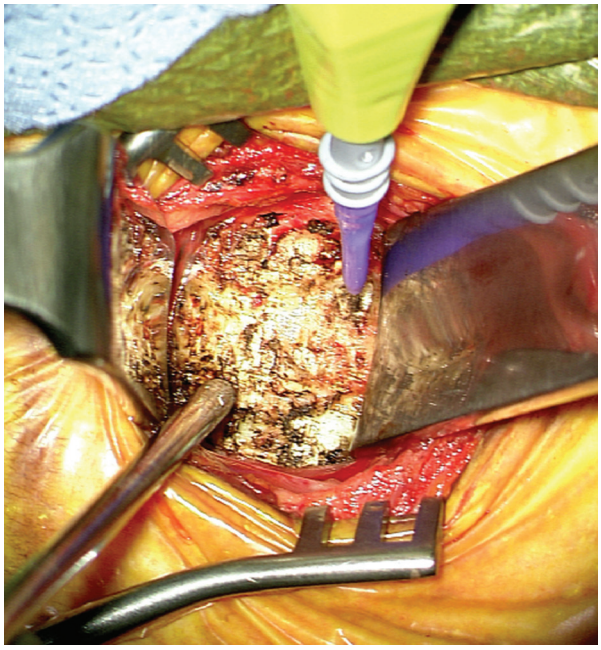

Figure 14-10 Exposure of the anterior vertebral surface and disk space. The anterior longitudinal ligament and longus colli muscles are dissected subperiosteally.

INTERVERTEBRAL GRAFT

- The disk space height is measured with a series of temporary sizing spacers inserted sequentially, starting with the smallest, until one fits tightly into the disk space. A graft of the same size is selected and gently tamped in place, until the graft is flush with the anterior border of the vertebra (Fig. 14-16). Available graft materials include autologous iliac crest, titanium, carbon fiber, and polyetheretherketone (PEEK).
- A typical cervical intervertebral graft measures 12 mm transversely, 8 to 12 mm in the anterior–posterior (AP) dimension, and 6 to 10 mm vertically.
- Once the graft is placed, the Caspar distractor and pins are removed. A bone wax cone on the end of a Kittner swab is used to immediately plug the pin site holes as they are removed.
- A lateral radiograph is taken to confirm proper placement.

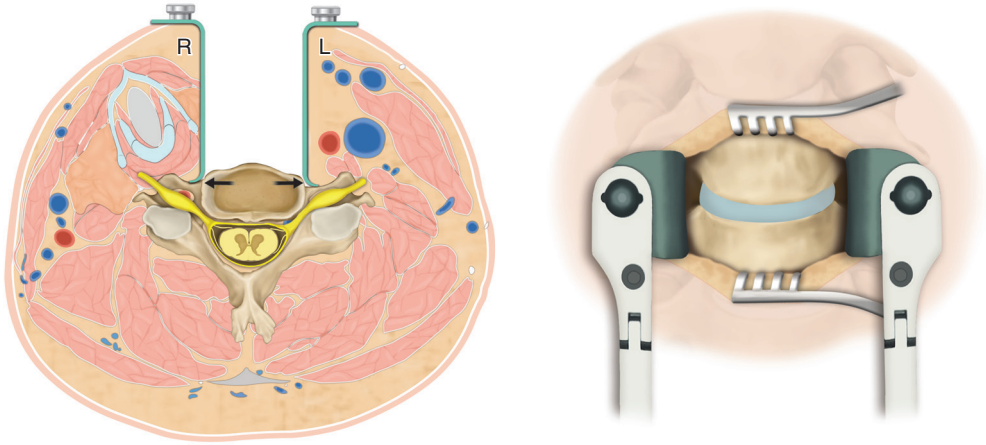

Figure 14-11 Cross-sectional (*left*) and anterior (*right*) images of the final position of the self-retaining retractors. The teeth of the laterally oriented blades are tucked beneath the longus colli muscles (*arrows*). Identification of the midline will prevent lateral deviation and vertebral artery injury during diskectomy.

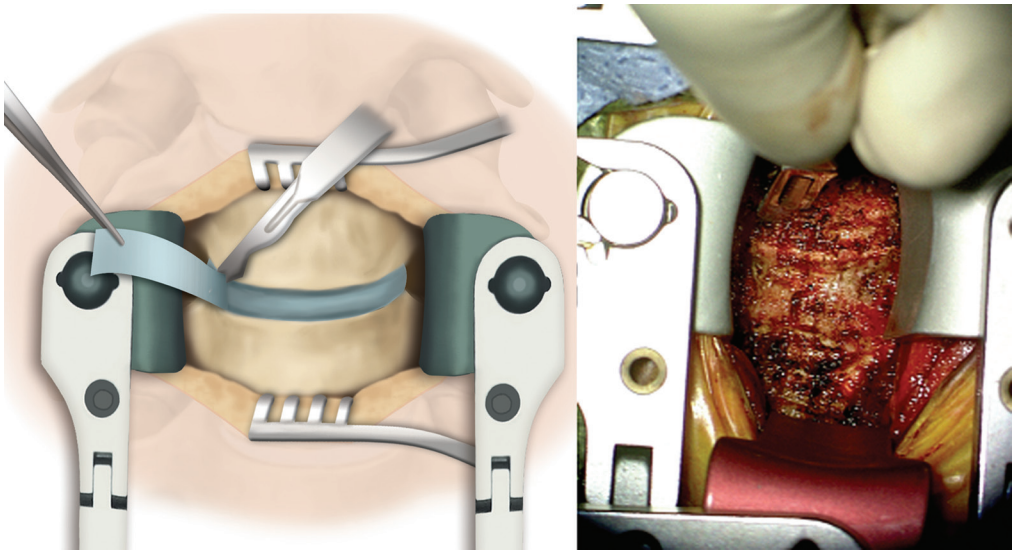

Figure 14-12 Schematic (*left*) and intraoperative (*right*) views demonstrate incision through the anterior annulus.

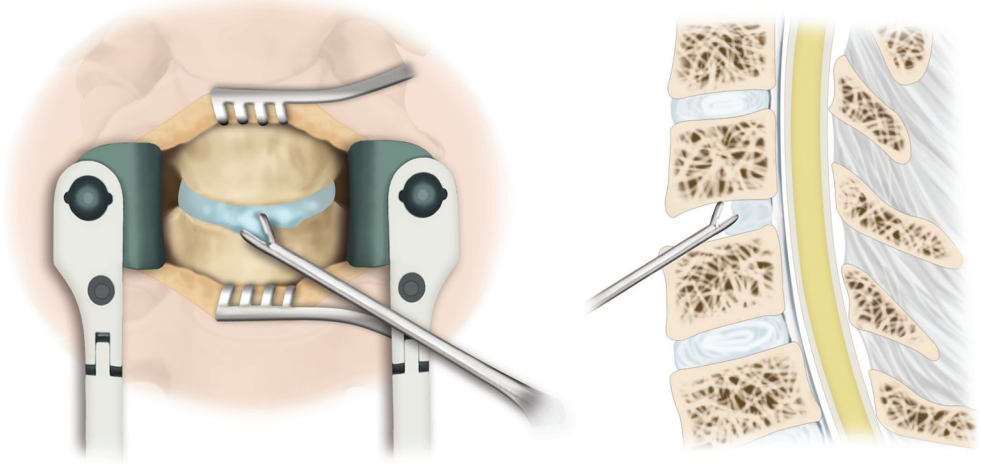

Figure 14-13 Pituitary rongeurs, Kerrison rongeurs, and curettes are used to remove disk space material.

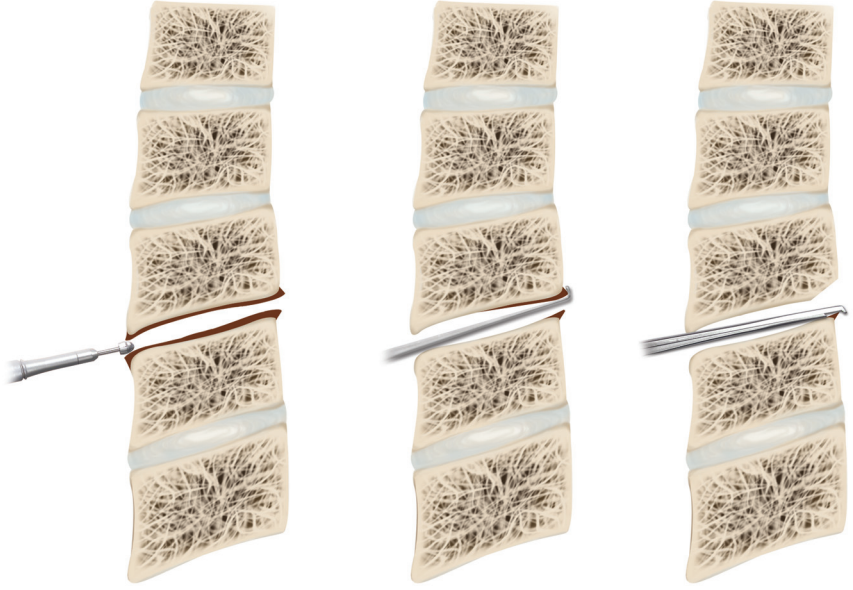

Figure 14-14 The cartilaginous end plates and osteophytes are carefully drilled and removed with curettes and Kerrison rongeurs to create a rectangular bed for placement of an intervertebral graft.

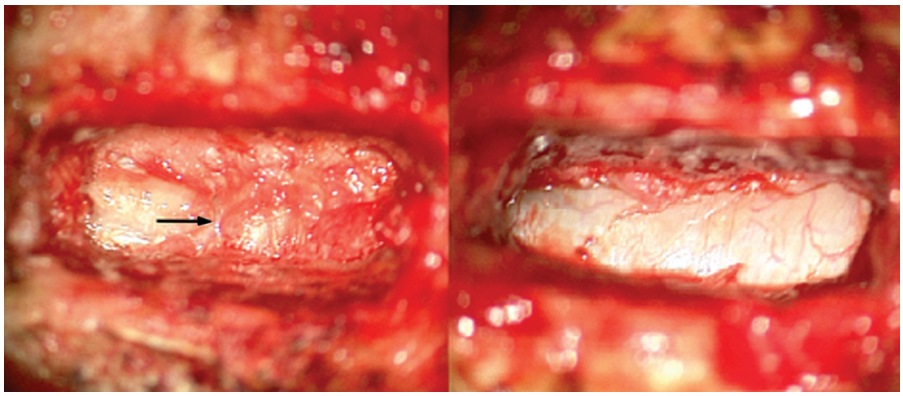

Figure 14-15 *Left,* The posterior longitudinal ligament is exposed with a small rent (*arrow*) to reveal the dura posteriorly. *Right,* The posterior longitudinal ligament is removed with Kerrison rongeurs to ensure complete decompression of the spinal canal.

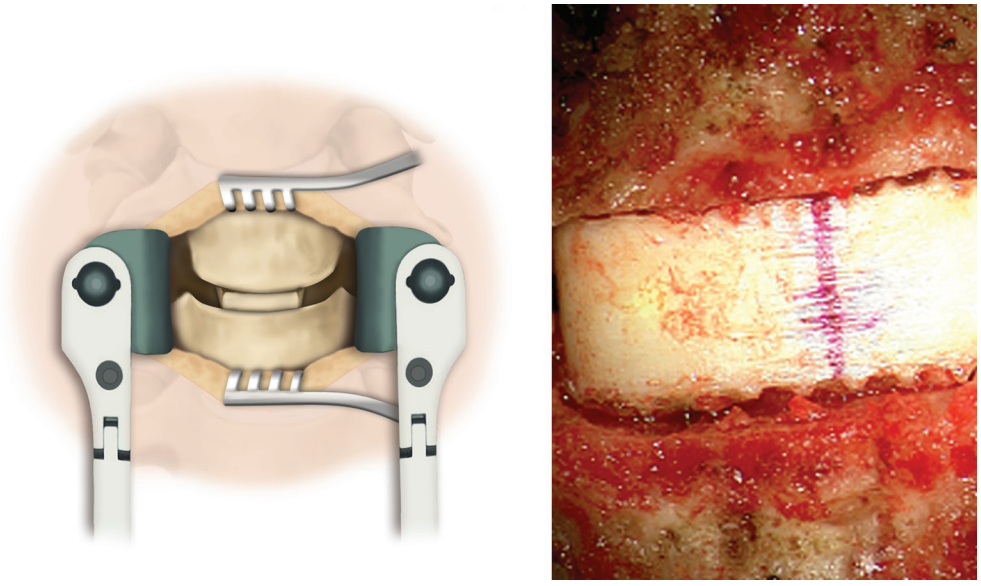

Figure 14-16 The intervertebral graft is inserted flush to the anterior vertebral surface and the superior and inferior end plates. The graft is mildly oversized to prevent graft migration and promote fusion.

CERVICAL PLATING

- The anterior vertebral margins are flattened.
- An appropriately sized plate is chosen and affixed to the rostral and caudal vertebral bodies with screws (Fig. 14-17).
- Lateral and AP radiographs may be taken to ensure proper placement of all instrumentation.

AUTOGRAFT HARVESTING

- The prepared disk space is measured.
- An 8-cm incision is made 6 cm lateral to the anterior superior iliac spine.
- The fascia lata is incised, and the muscle is dissected subperiosteally.
- Once the soft tissue is removed and sufficient iliac crest is exposed, two parallel cuts separated by the height of the prepared disk space are made perpendicular to the iliac crest. The distance between these cuts should be greater than 2 mm from the disk space to allow distraction and final tailoring. An oscillating saw is preferred over osteotomes, because the latter may cause microfractures that can compromise the load-bearing capacity of the graft.
- A third cut along the base is made with the oscillating saw to free the graft.
- The graft is measured and tailored for the disk space.
- This process is repeated for multilevel procedures.

CLOSURE

- The soft tissues are inspected, and hemostasis is achieved with cautery.
- If persistent bleeding is present, a drain may be placed in the subplatysmal layer.
- The platysma is closed with interrupted 3-0 absorbable suture.
- The skin is closed with subcuticular absorbable suture.
- The incision is cleaned and dressed in standard fashion.

Postoperative Care

- Following extubation, the patient is monitored for airway obstruction and neurologic compromise.

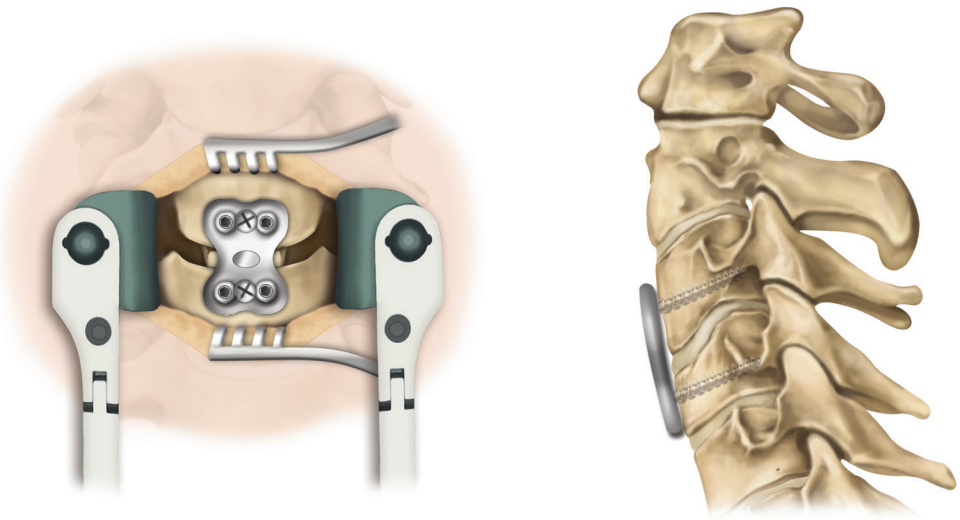

Figure 14-17 The cervical plate is in midposition, spanning the disk space evenly. The sagittal view (*left*) shows the plate is flush with the anterior vertebral surface.

- The patient may be placed in a soft or hard collar.
- A liquid diet is ordered and advanced as tolerated. Esophageal edema from retraction may require a liquid or soft diet for the first 1 to 2 days after surgery.
- Early ambulation is encouraged.
- Transient posterior cervical and shoulder pain may develop as a result of stretching of the facet capsule from the intervertebral graft.
- An oral narcotic is prescribed along with an intravenous breakthrough medication if needed. A muscle relaxant may be helpful for spasmodic discomfort.
- Patients are typically discharged the day following surgery.
- Postoperative radiographs are typically taken before discharge.

Complications

- Neurologic decompensation or new deficit may result from intraoperative cord or nerve root injury, graft migration, or epidural hematoma formation. If this is discovered, an immediate radiograph, CT scan, or MRI should be obtained to rule out a treatable etiology.
- Neurologic deficit or airway obstruction from a wound hematoma typically develops within the first 12 hours postoperatively. If a hematoma is palpable or tracheal deviation is appreciated in the setting of dyspnea, the incision should be opened immediately.
- In susceptible patients, stroke may result from carotid retraction. Proper preoperative workup should include evaluation of carotid atherosclerotic disease in select patients.
- The patient should be instructed to inspect the incision regularly for signs of wound infection.
- Delayed neurologic deterioration may indicate epidural abscess, graft dislocation, subluxation, and intervertebral collapse, which would require urgent surgical treatment.
- Postoperative fluid collection may indicate a cerebrospinal fluid (CSF) leak or esophageal injury, which would require immediate reexploration.
- Delayed swallowing difficulty may result from anterior plate dislodgment, causing esophageal obstruction.
- Hoarseness typically results from intraoperative recurrent laryngeal nerve injury. The majority of cases are transient secondary to retraction, and patients should recover within 3 to 6 months. Persistent hoarseness necessitates laryngoscopy for visualization of the vocal cords and further evaluation by an otolaryngologist.

References

1. Radhakrishnan K, Litchey WJ, O'Fallon WM, et al: Epidemiology of cervical radiculopathy: a population-based study from Rochester, Minnesota, 1976 through 1990. *Brain* 117:325–335, 1994.
2. Gore DR, Sepic SB, Gardner GM, et al: Neck pain: a long-term follow-up of 205 patients. *Spine* 12:1–5, 1987.
3. Cloward RB: The anterior surgical approach for removal of ruptured cervical discs. *J Neurosurg* 15:602–617, 1958.
4. Smith AW, Robinson RA: The treatment of certain spine disorders by anterior removal of the intervertebral disc and interbody fusion. *J Bone Joint Surg Am* 40:607–624, 1958.
5. Wang JC, McDonough PW, Endow KK, et al: Increased fusion rates with cervical plating for two-level anterior cervical discectomy and fusion. *Spine* 25:41–45, 2000.
6. Troyanovich SJ, Stroink AR, Kattner KA, et al: Does anterior plating maintain cervical lordosis versus conventional fusion techniques? A retrospective analysis of patients receiving single-level fusions. *J Spinal Disord Tech* 15:69–74, 2002.
7. Katsuura A, Hukuda S, Imanaka T, et al: Anterior cervical plate used in degenerative disease can maintain cervical lordosis. *J Spinal Disord* 9:470–476, 1996.
8. Ebraheim NA, Lu J, Skie M, et al: Vulnerability of the recurrent laryngeal nerve in the anterior approach to the lower cervical spine. *Spine* 22:2664–2667, 1997.
9. Kilburg C, Sullivan HG, Mathiason MA: Effect of approach side during anterior cervical discectomy and fusion on the incidence of recurrent laryngeal nerve injury. *J Neurosurg Spine* 4:273–277, 2006.
10. Beutler WJ, Sweeney CA, Connolly PJ: Recurrent laryngeal nerve injury with anterior cervical spine surgery: risk with laterality of surgical approach. *Spine* 26:1337–1342, 2001.