71 Cervical Discectomy

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SUMMARY OF KEY POINTS

- Successful discectomy can be performed from an anterior or posterior approach.
- Each approach has specific risks and benefits.
- Central herniations typically require an anterior approach.
- Fusion is typically indicated following anterior discectomy.
- Fusion techniques vary, but nonunion continues to be a clinically relevant problem.
- Disc arthroplasty is a more recent alternative to reconstruct an anterior discectomy.
- Indications for disc arthroplasty are more limited than those for fusion.

An anterior cervical discectomy and fusion and a posterior foraminotomy and discectomy are among the simplest, most popular, and most effective spine operations ever invented. Despite being so common, because of all the possible permutations on the technique, it is likely that no two surgeons do these procedures in exactly the same manner. In this chapter, we describe our technique for doing both. Although we make no claims that this is the best possible technique, we have found that, in our hands, as well as those of our fellows, these techniques help to minimize complications and maximize results. Our fellows are required to memorize these steps and to perform these operations in exactly the same step-by-step manner every time. By doing so, new trainees, and even experienced spine surgeons, can become more efficient surgeons. In addition, by memorizing each step and performing the procedure in exactly the same manner every time, the scrub nurse can learn the steps and know what tools to hand to the surgeon. The surgeon can make the procedure more efficient by asking for the instrument needed for the next step while performing the current one. This gives the nurse time to find it and to get it ready to hand off to the surgeon.

INDICATIONS FOR CERVICAL DISCECTOMY

Age-related degeneration as well as trauma can lead to disc pathology requiring surgical excision. Commonly accepted indications for cervical discectomy include myelopathy and persistent radiculopathy that is unresponsive to nonsurgical measures.[1,2] Less commonly accepted indications include axial neck pain and headaches[3] that can be attributed to the disc pathology. The pathologic cervical disc can be approached ventrally and dorsally. Both approaches have been in use for over a half century[4-8] and still find utility today.

The dorsal approach is indicated for a soft, foraminal (lateral) disc herniation with radiculopathy.[1] One of the major advantages is that the posterior approach can be performed via a "keyhole" foraminotomy without creating instability at the segment. Disadvantages include the technical challenges (positioning, epidural bleeding, wound complications) and the surgeon's learning curve, as this procedure is less commonly performed in most centers than is the more versatile ventral approach. Additionally, central disc herniations, "hard" disc herniations with uncovertebral bone spurs, and myelopathy are not adequately addressed via this approach. The dorsal approach for a discectomy via a foraminotomy can be accomplished with a small traditional midline incision and a self-retaining retractor[9,10] or with a tubular retractor system.[11]

The ventral approach is familiar to most spine surgeons. In most patients, the C3-4 level down to the C7-T1 level can be approached via a standard ventrolateral approach. Advantages of the ventral approach include access for central and bilateral foraminal decompression. Although some authors have reported good results for anterior discectomy without interbody fusion, interbody fusion following discectomy has become the standard of care in most centers. Trends include the use of allograft or synthetic interbody devices along with ventral cervical plates.[12] Nonunion continues to be a clinically relevant problem that can lead to the need for re-operation.[13] Cervical disc arthroplasty devices are now available and can be used for postdiscectomy reconstruction; although the indications are more limited, excellent results have been reported in properly selected patients.[14]

ANTERIOR CERVICAL DISCECTOMY

Anterior Cervical Discectomy and Fusion Technique

Preoperative Planning

It may be appropriate in revision settings to get a preoperative otolaryngology consult to evaluate vocal cord paralysis.[15] If a vocal cord paralysis exists, the approach should be made on the ipsilateral side to avoid a potential bilateral paralysis. An approach on the right side may put the recurrent laryngeal nerve at more risk, whereas a low approach on the left side may put the thoracic duct at risk.

Preoperative Imaging

The preoperative radiographs are examined to identify unique anatomic features. The proper identification of existing instrumentation is especially important to ensure that all needed equipment will be available. Knowledge of the ventral osteophytes can help the surgeon to identify the proper levels during the approach by intraoperative palpation and visualization. The vertebrae are labeled by level, and the anterior-to-posterior distance of the vertebral body (minus the magnification factor) is measured to estimate the graft and screw size. Anatomically "short" necks where the lower cervical levels are at or below the level of the clavicle may alert the surgeon to potential difficulty accessing these lower levels during a standard approach. It may be helpful to list the patient's symptoms (especially left versus right, radiculopathy or myelopathy), surgical plan (levels of discectomy), and important comorbidities (smoker, diabetic, etc.). The axial magnetic resonance imaging (MRI) or computed tomography

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(CT) scan should be carefully reviewed for the vertebral artery position, and any anomalies should be carefully noted. The operative site is marked in the holding area.

Exposure

The anesthesiologist may administer 10 mg of intravenous Decadron to minimize ventral swelling and prophylactic antibiotics (usually cefazolin 1 g) to minimize the risk of infection.

The patient is placed supine on the operating table. Neck flexion should be minimized in moving a patient with a large cervical disc herniation and myelopathy. A folded sheet or an intravenous bag is placed underneath and across the shoulders; sometimes, two sheets will be better. The sheets under the shoulders and the foam doughnut under the head are adjusted to obtain ideal neck extension (it is important to be careful in using two sheets, which may overlordose the cervical spine). It is rare that any support other than the foam doughnut is needed under the head. Wrist restraints or an unrolled Kerlix is placed around both wrists (NYOH stockinette-style knot) and hung off the bottom of the table to allow pulling down of the arms and shoulders for intraoperative radiographs. Plastic self-adhesive drapes are placed just above the nipple line and along both sides of the neck as low as possible. The side drapes are placed dorsal to the ear and around the circumference above the chin. The upper thorax should be accessible in case of emergency (e.g., vertebral artery injury and necessity for exposure of subclavian artery for proximal control). A half sheet is placed down over the patient's body and legs to prevent accidental contamination via the surgeon's gown touching the bed or patient. Sterile towels are placed over the sterile field and moved away from the center. The inferior towel is usually at the sternal notch; the superior towel is around the chin; the ipsilateral towel is as low as possible; the contralateral towel is several centimeters lateral to midline to accommodate a midline-crossing incision.

The carotid tubercle, thyroid cartilage, and cricoid cartilage can be palpated as landmarks. The incision location can also be based on the location of the mandible and clavicle on preoperative radiographs. An incision is marked along Langer's lines, in a neck crease if possible, crossing the midline as needed. Perpendicular lines help during closure. Larger transverse incisions with less retraction (skin stretching) tend to heal better than a smaller incision with stretched skin edges. Vertical incisions leave unappealing scars and can be avoided. The incision should be located in the inferior third of the levels to be decompressed because it is easier to mobilize skin in a cephalad rather than a caudad direction and the disc spaces angle cephalad. The skin is injected with 0.25% Marcaine with epinephrine as early as possible, because the epinephrine takes time to work (ideally 10 minutes). Cut strips of adhesive barrier drape (Ioban) are used to seal the edges after the incision is marked.

A scalpel is used to incise the epidermis and dermis. Leaving an intact corner of dermis at the ends of the wound protects against stretching, thereby allowing for a more cosmetically pleasing closure. Subcutaneous bleeders can be cauterized but will often tamponade with a gently placed Weitlaner retractor that is spread gradually during exposure. Using the cut function on the electrocautery will minimize charred tissue, but small veins will often need the coagulate function. The platysma is cut transversely in line with the incision; sometimes, veins run in the platysma layer and can be dissected bluntly with Metzenbaum scissors or directly coagulated with the cautery. The platysma is undermined cranially and caudally with spreading scissors, blunt finger dissection, and cautery. When multiple segments are being exposed, the platysma should be undermined from the corner of the mandible to the clavicle along the length of the sternocleidomastoid. The interval between the sternocleidomastoid and medial strap muscles is identified. The external jugular vein may be mobilized either laterally or medially. Preserving the sternocleidomastoid fascia by starting the dissection closer to the strap muscles will minimize bleeding. Spreading scissors, blunt finger dissection, and cautery are used to dissect through the interval between the alar fascia (carotid sheath) and the visceral fascia (trachea and esophagus). The carotid pulse can be palpated and kept lateral. In the interval, the ventral cervical spine and longus colli muscles can be palpated. Blunt finger dissection can widen the defect longitudinally, although there may be less bleeding with the spreading scissors technique. Crossing nerves that should be preserved include the glossopharyngeal and hypoglossal nerves at the very top of the approach and the superior laryngeal nerve above the superior thyroid artery. The recurrent laryngeal nerve may be at the bottom of the approach, especially on the right side. It is acceptable to take the inferior, middle, and superior thyroid vessels if necessary. Larger crossing vessels may need to be tied. A wall bleeder can be difficult to stop if it represents a side-opened vessel; in this case, a bipolar technique will often slow bleeding enough to allow packing with a hemostatic agent and cottonoid patty. A handheld retractor is placed medially to pull the trachea and esophagus over the midline to see the ventral aspect of the cervical spine. The omohyoid muscle crosses the field around C6 and can be retracted caudally and medially with the trachea for upper level exposures. Caudal retraction may help protect the recurrent laryngeal nerve on the right side. Alternatively, the omohyoid can be divided with lower-level dissections with no adverse effects typically noted. The muscle can be elevated with Metzenbaum scissors underneath and then divided with electrocautery. Beginners will often find their dissections stuck in the axilla of this muscle belly, instead of lateral to it. This limits the cranial extent of the dissection and increases the force necessary to retract the soft tissues. Therefore, early identification of the muscle is necessary to prevent this from happening.

The carotid tubercle, usually at C6, and ventral osteophytes can be palpated to estimate levels. The prevertebral fascia is cleared off the discs (hills) and vertebral bodies (valleys) using scissors and forceps with a nick-and-spread technique. The handheld retractor is then replaced under this layer (Fig. 71-1).

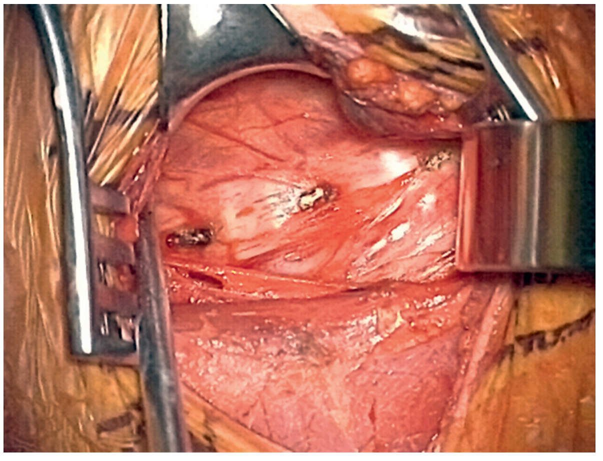

Figure 71-1. Prior to elevating the longus colli muscle, one can mark the midline with a Bovie electrocautery. This helps in keeping the decompression centralized and also helps to keep the plate straight.

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A Burlisher clamp or long hemostat is placed on the edge of the longus coli to localize the level. We prefer this to placing a needle in the disc space, as doing that in an uninvolved disc may cause injury by initiating or acceleration disc degeneration. If one is trying to localize one of the lower cervical levels in a patient with a short neck, it is preferable to place hemostats at multiple levels starting at C3-4 or C4-5 and count down to the operative level, as lower levels may not be visible. We use a spot C-arm image, which is faster than using plain radiographs. We inspect the films for three things: first, that we have the correct surgical level; second, that we have the right patient; and third, that the patient's neck alignment is not hyper- or hypolordotic. Once the level has been localized, we mark the disc space by cauterizing it until it is impossible to mistake for an unmarked level. It is surprising how a small mark can disappear once it is bathed in blood. The radiology technician is now allowed to leave the room, as no further shots will be taken until the instrumentation goes in. The sterile draped microscope is then brought into the field.

We next elevate the longus colli muscle. There are two dangers associated with this. The first is that the vertebral artery can be injured, especially if it is anomalously located anterior to the foramen transversarium. Therefore, the safe (nonanomalous) position of the vertebral artery should be confirmed on the preoperative axial MRI or CT prior to elevation of the longus. The second risk associated with elevating the longus has to do with the small arterioles that lie ventral to the longus that perforate the anterior vertebra at the medial aspect of the longus muscle. If this is cut with a monopolar electrocautery, it will sometimes retract and stop bleeding, only to open up again a few hours postoperatively, resulting in a retropharyngeal hematoma. We avoid this complication by first identifying these vessels on top of the longus and cauterizing them with bipolar electrocautery. Then we stick the bipolar under the muscle in the "valley" of the ventrolateral aspect of the vertebral body above and below the suspected disc and cauterize the segmental arterioles where they perforate into the vertebral body. We elevate the longus out to the lateral aspect of the costal process (anterior roof of the foramen transversarium) with a Penfield 2 and cauterize the periosteum. This technique helps to ensure that the segmental arterioles will not bleed postoperatively. As a final precaution, we wrap the edges of this muscle at the end the case with Surgicel. If bleeding recurs from the undersurface of the longus or out laterally, bipolar cauterization or a hemostatic agent and a large cottonoid patty can be used. At this point, the handheld appendiceal retractor is replaced with self-retaining (Shadowline or similar) retractors, which are placed underneath the elevated layer of the longus colli. Because these retractors tend to tip away from the esophageal side, we leave the retractor handle on that side while removing it from the other side. The weight of the handle helps to keep the retractor blades in place.

Smooth Off All Osteophytes. Before placing the Caspar pins, it is critical to smooth down the anterior aspect of the vertebral body with a rongeur or a bur. This is important for two reasons. First, one can size the length of screws needed for the plate by placing the screw in the disc space, and this is done more accurately if all the osteophytes have been removed. Second, if the body is not made smooth at this point, it is easy to forget to do so at the end of the case. This will cause the plate to sit proud on top of the osteophyte instead of flush with the body, increasing the risk of dysphagia. The osteophytes can be saved for local autograft.

Pin Placement. It is also important to choose an appropriate starting point, as well the directional angle of the Caspar pin. The superior post should be approximately 7 to 10 mm from the cranial level's end plate. This is because the cranial end plate is concave, and one needs to resect more of its overhang to smooth it out. If the pin is too close to the end plate, it will not be possible to adequately smooth down the end plate. Also, the threads of the pin may be encountered while burring off the end plate. On the other hand, the inferior post is placed 5 mm below the caudal level's superior end plate. This is because the caudal end plate does not require much bone removal. Further, a pin placed too caudally and not angled cranially can perforate the adjacent disc space. As far as the direction of the pins, the cranial angulation of the Caspar pins should be parallel to the disc space in the sagittal plane. It can be helpful to identify the disc space with a Bovie or #15 blade if the surgeon is unsure of the location or angle. If the localizing radiographs show that the patient is in perfect alignment, the pins are placed parallel to each other. If the patient is hypolordotic, then the Caspar pins can be inserted with the tips diverging to allow for lordosis. If they are hyperlordotic, then the pins are placed with the tips converging. Next, the pins must both be centered medial-laterally, because going off center with one post may result in vertebral twisting and scoliosis after the Caspar retractor is placed. If the posts are not placed in the center but are both off to one side, the distraction of the interspaces will be asymmetrical and lead to uneven end-plate preparation while the posts are retracting. Finally, placing the pins off to one side can compromise the fixation of the plate, as the hole for the pin may interfere with the ideal placement of the screw. Excellent visualization of the bodies before placing the posts will help to avoid errors at this step. Centering with reference to the spine, based on the uncinates, is more reliable than centering with reference to the patient's chin and sternal notch. We therefore use the electrocautery to identify the curved lateral borders of the uncinates prior to placing the pins. If the lateral border of the uncinate is still not clearly identifiable, we place a Penfield 4 lateral to the uncinate to clearly identify it. Caspar pins (usually 14 mm or 16 mm based on preoperative and localizing radiographs) are inserted by hand. Careful insertion is important if the patient is myelopathic or stenotic.

Discectomy. There are two possible dangers in cutting the disc with a blade. The first is that a blade that is placed too deep can cut the dura and spinal cord. The second is that a blade that cuts lateral to the uncinate can cut the vertebral artery. The technique described here helps to prevent both complications. A #15 blade is used to cut the width of the ventral annulus. Do not insert the blade any deeper than the length of the sharp portion of the blade, which measures exactly 11 mm. This makes it unlikely for one to inadvertently incise the dura or cord. To prevent inadvertent injury to the vertebral artery, we start with the caudal end plate as far as possible on the side contralateral to the surgeon and use an up-and-down seesaw motion to incise the disc. As the knife blade approaches the ipsilateral side, it follows the curve of the ipsilateral uncinate until it hits the superior end plate. Then, we backhand the blade, cut away from the ipsilateral uncinate, and cut approximately half of the superior end plate (Fig. 71-2A). We do not go farther, as one can inadvertently go past the uncinate and cut the vertebral artery. Instead, we withdraw the blade and start again at the original starting point at the contralateral uncinate. But this time, the blade faces the contralateral side and is used to cut along the curve of the contralateral uncinate until it hits the superior end plate. Then we cut the disc off of the superior end plate toward the surgeon until we meet the halfway point where the previous cut had been made (Fig. 71-2B). A pituitary rongeur is used to remove initial disc fragments. The Caspar retraction can be increased once the ventral annulus has been excised. A

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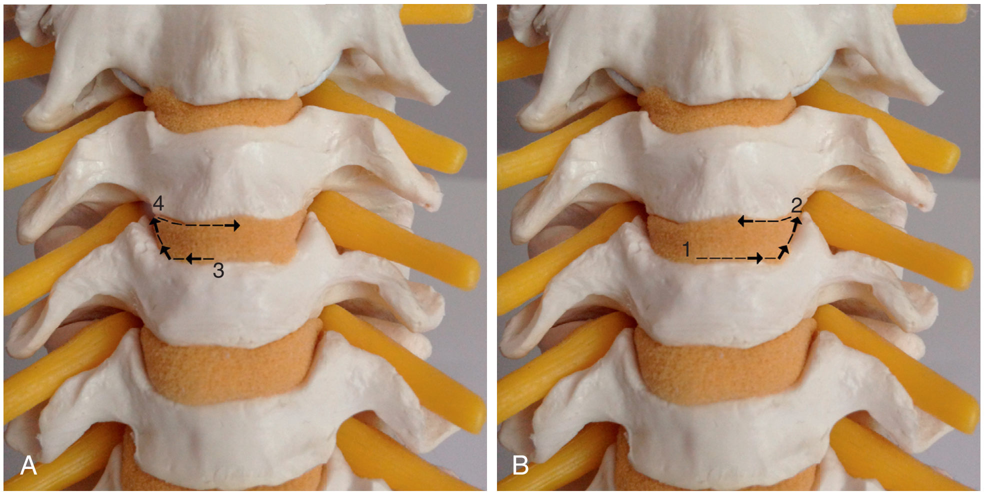

Figures 71-2. A #15 blade is used to cut the anterior ligament and annulus. **A,** The sharp portion of the blade is 11 mm deep. It can be safely used to efficiently remove the anterior disc with the motion demonstrated in the figure. **B,** Cutting medial to lateral along the superior end plate will risk inadvertent injury to the vertebral artery, which lies just lateral to the uncinate.

curette (Codman Microsect 5B) can be held like a dagger while the shaft is stabilized with the other hand while scraping the disc thoroughly. The nondominant hand that is holding the shaft should be resting on the patient with all maneuvers to provide stabilization and control and prevent inadvertent injury to the cord. A side-to-side motion is safe as far lateral as the uncovertebral joint allows. Scraping too vigorously along the superior end plate can cause the curette to go laterally to the disc space and injure the artery. To prevent this, one should (1) not overdistract the disc space, (2) use a large curette that will not fit through the space between the end plates, and (3) scrape from lateral to medial at the uncinate region. The uncinates are thoroughly cleaned out by pointing the curette caudally and laterally and scraping from a dorsal to ventral direction. Do not use a large curette to remove the posterior annulus as it can inadvertently plunge too deeply and injure the cord. Instead, switch to a 2- or 3-mm curette.

Irrigation. We then flood the space with saline and use the suction hose without a tip to vacuum up these fragments. The irrigation also keeps the tissues from drying out. A pituitary rongeur is again used to remove any remaining pieces of disc, bone, and cartilaginous end plate from the field. Keeping the nondominant hand on the patient and using two hands to control the pituitary rongeur will avoid plunging into the canal.

Decompression. The microscope should be tilted to angle into the intervertebral space optimally. Suction in the nondominant hand should rest on the patient for control and stability while in the disc space. If this hand is suspended in the air, it has the potential of being hit or plunging into the disc space and injuring the cord. We use a bur to remove the overhang of the cranial end plate and superficially smooth it down. We save the final decortication until the end of the procedure to minimize blood loss. The bone is saved for local autograft. By removing the overhanging superior end plate, there is no obstruction of the disc space to be decompressed. We use a 2.5-mm matchstick bur to thin down the annulus and thin down the posterior longitudinal ligament (PLL) (Fig. 71-3). We place the suction tip on the ipsilateral side and thin down the contralateral side. Then while moving the tip of the bur in a medial-lateral direction with the tip just grazing the PLL, we gradually move the bur cranially, removing the cranial osteophytes. Once these have been removed, we move the bur caudally until those osteophytes are removed. To avoid perforating the PLL and injuring the dura, we only look at and pay attention to the tip of the bur. As long as this is just grazing the PLL, it will not cut through it. If the tip lifts off of the PLL while moving cranially and caudally, instead of removing the posterior osteophytes, the bur will just cut into the end plate. Keeping it right on the PLL is daunting for the beginner, but with practice, it becomes easy to do and is the most efficient and safe means of removing the posterior spurs. Once the contralateral side is completed, we do the ipsilateral side in the exact same manner. If one side is more compressed than the other, we do the side with greater compression first. The smaller curette can be used to remove any remaining dorsal annular fibers and dorsal osteophyte/PLL if necessary. We inspect behind the PLL for any extruded disc material but do not routinely remove most of it. If there is a large disc herniation, we remove the PLL and visualize the dura to ensure a complete discectomy. Any remaining dorsal lip of vertebral body can be removed with the bur before the PLL is taken, as the PLL serves as a safety backboard.

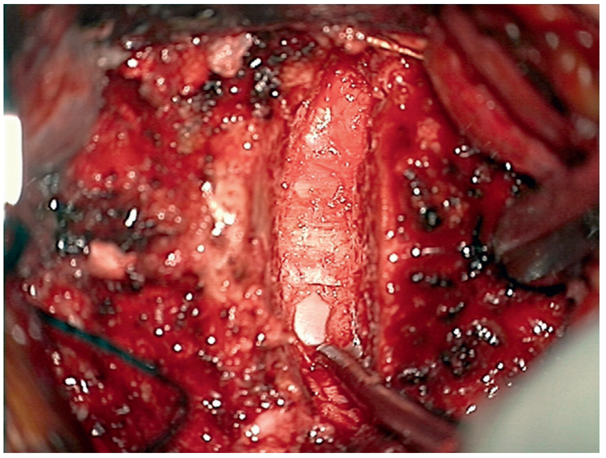

Figure 71-3. Wide exposure from uncinate to uncinate will facilitate a thorough foraminal decompression. The posterior longitudinal ligament separates the posterior disc space from the anterior dura.

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Inadequate foraminal decompression may lead to residual radicular symptoms. For uncinatectomy or wide foraminotomy, the uncinate can be identified by carefully going out of the joint laterally with the 2B curette and turning caudally. A Penfield 4 is then placed lateral to the uncinate, and the space is enlarged such that a Penfield 2 can be placed lateral to the uncinate. This is kept in place to identify the lateral aspect of uncinate and to protect the vertebral artery during the foraminotomy. With the Penfield held by the assistant, the uncinate can be thinned down to 2 to 3 mm with a bur in a ventral-to-dorsal direction. This establishes a lateral bony border. A medial-to-lateral direction is more dangerous, because the bur is then moving toward the vertebral artery, which lies lateral to the uncinate. Then, any remaining disc and bone spur ventral to the root in the foramen is removed with a bur in a medial to lateral direction. Care is taken to keep the bur from wandering past the bony wall established above. Because the root angles ventrally as it exits the foramen, the bur must follow this angle or the root will be injured. Cranial and caudal osteophytes are removed using the same medial-lateral burring technique described earlier for the disc decompression. Once thinned out, remaining posterior osteophytes can be broken off with a curette.

End-Plate Preparation and Call X-ray Technician. As we start to prepare the end plate, we call the radiology technician back to the room. For multiple levels, we wait until we are preparing the end plate of the last level. Although we do not need the technician until the instrumentation is in, he or she can sometimes take 5 to 10 minutes to arrive, so we call well in advance. This minimizes operative time.

Next we perforate the end plate until we see marrow blood oozing out of the hole. The ideal place for this hole is at approximately halfway into the disc space: further back and the blood may ooze behind the graft, too ventrally and the blood will leak out the ventral part of the graft without soaking the posterior part. This is done with a 4-mm curette. If there is minimal bleeding, we perforate the end plate with the tip of the bur and then put the tip of the 4-mm curette through this hole. We then place the tricortical bone with the cortex posteriorly while the disc space is distracted and then tap it in with a tamp and a mallet, if necessary. If the graft is too large, we bur off any excess graft. Placing the graft with the cortex posteriorly allows the blood to exit anteriorly where we can see how profusely it is bleeding. If the bleeding does not stop quickly, we rub demineralized bone matrix into the interstices of the bone, and that coagulates the blood.

After the decompression is complete, a sizer is used to check for the size of the interbody graft. A typical graft size is somewhere around 7 to 8 mm and occasionally larger, and it can be estimated from preoperative imaging studies (especially of adjacent healthy levels). If the sizer is not going in smoothly, it is much safer to gently tap it into place with a mallet than to push toward the spinal cord in an uncontrolled manner. In attempting to access C7-T1 when visualization is difficult because of the angle of the disc space and obstruction of the clavicle, it may be necessary to perform a greater end-plate resection of C7 or even a corpectomy if the added end-plate resection results in a weak surface for graft support.

We prefer to cut our own graft from a piece of fresh, frozen iliac crest tricortical allograft. We measure the depth of disc space by taking a screw and placing it in the disc space. To measure the depth of the graft to be used, we want the screw to be 1 to 2 mm recessed into the disc space before it grazes the PLL or dura. Then we use the screw as a template to cut the graft depth. Now if the graft is placed flush with the ventral vertebral body, it remains 1 to 2 mm off of the dura. We also place a longer screw into the disc space to measure the length of the screw to be used with the plate. For this screw, we want the tip to graze the PLL with the screw head flush with the ventral vertebral body. This will correspond to a screw that is as long as possible without being bicortical. If bicortical purchase is desired, choose a screw that is 2 mm longer. When placing these screws into the disc space, hold the shaft of the screwdriver while resting the hand on the patient. The natural instinct is to hold it at the handle of the screwdriver. But this creates a lot of potential for accidentally stabbing the cord with the screw. By resting the hand on the patient and holding the shaft of the screwdriver at a point just long enough to barely reach into the disc space, it makes it much harder to accidentally injure the cord. All of these measurements are predicated upon the ventral vertebral surface having been adequately smoothed down before starting the discectomy. If that had not been done, then these screw and graft depths would all be overestimates and would need to be adjusted accordingly. After graft placement, no space should be visible between the graft and the end plates. If necessary, the graft or the end plates can be touched up with the bur.

Advanced Grafting Techniques. Although the tricortical fresh frozen allograft has an excellent track record, it is not foolproof and a small percentage of patients will develop a pseudarthrosis. To minimize this risk, we have started to place a second "intrabody" unicortical wedge-shaped graft adjacent to the main tricortical graft. We first place the tricortical graft as far to the contralateral side as possible by thinning down the uncinate and squaring it off to fit the corner of the graft. Then, on the ipsilateral side, we cut slots into the vertebral body approximately 5 to 8 mm into the cranial and caudal bodies and to a depth of about 80% of the body depth (Fig. 71-4). Ventrally, this slot is about 4 mm wide and tapers down to the width of the 2-mm bur posteriorly. We then cut a corticocancellous wedge-shaped graft to press fit into this slot. If the carpentry is done well, it fits snugly. Because the slot is cut into the vascular midvertebral body, the entire construct can often heal nearly as quickly as an autograft, and pseudarthroses are rare.

Plating. Once the plate has been inserted, all the landmarks are obscured, and it is easy for the plate and screws to be misplaced. Some systems allow for drilling of the screw holes while the Caspar pins are still in place marking the midline. Alternatively, the starting point for the upper screws can be marked with a bur prior to placing the plate. The correct plate size should be as short as possible, just spanning the height of the interbody graft, to avoid encroachment on the adjacent discs.

The retractors are then removed, and spot C-arm images are taken. While radiographs are being processed, the wound is checked for bleeders, and hemostasis is obtained with bipolar electrocautery and hemostatic agents and cottonoids. As mentioned previously, we place Surgicel under the longus coli muscle and then wrap the edges with it to prevent bleeding. After the C-arm image is taken, we check for bleeders one last time.

We drain almost all cases with a ¼″ Penrose drain. This is brought out through the incision. Sutures are placed close to the drain such that it is partly folded back on itself. If the sutures are not placed close enough, the wound will drain for a couple of days. If it is placed so close that the drain is tightly held in place, then it will not drain properly. A slightly puckered drain is ideal. We have used many different drains in the past, but this is the only one that will not clot off and result in a retropharyngeal hematoma. We leave approximately 5 cm of it outside the wound. We use an abdominal pad that is folded into thirds, with the drain placed through a slit cut into the first third of the pad and covered with the remaining two

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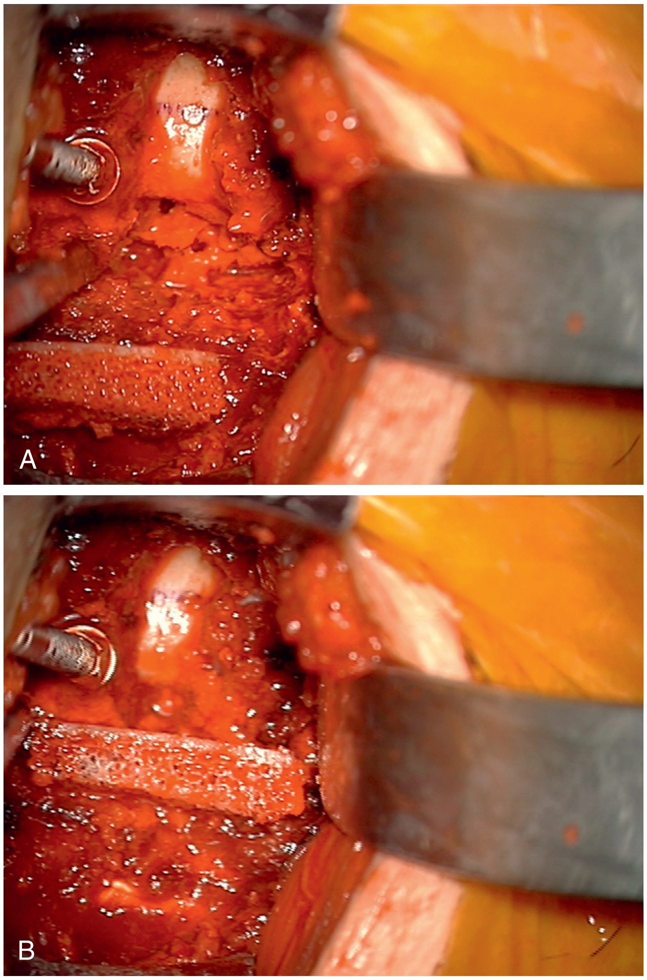

Figure 71-4. Tri-cortical iliac crest allograft can be supplemented with a second "intrabody" unicortical wedge shaped graft. See advanced grafting techniques in body of text.

thirds of the pad. This is removed the next day. If the patient is to be discharged the same day, we inspect the dressing and pull the drain if there is minimal drainage, which is almost always the case for a one- to two-level ACDF. If the dressing has soaked through the second layer, we tell the patient to pull the dressing off the next day, along with the drain. The patient places a sponge over the site where the drain was for 1 minute until it stops draining black blood, which is blood oxidized by the Surgicel. The authors close the platysma with interrupted 3-0 Monocryl, and the skin is closed with interrupted 5-0 Monocryl.

Postoperative Management

For single-level anterior cervical discectomy and fusion, an appropriately sized soft collar is placed before extubation, and the patient is instructed to wear it as needed for comfort. If the patient is osteoporotic or the construct is more than a single-level anterior cervical discectomy and fusion, a Miami J collar is typically used. Patients are instructed to remove it for eating and cleaning (approximately 1 hour a day) but otherwise to wear it for 6 weeks. Patients are observed overnight in the hospital with a continuous pulse oximeter to watch for airway compromise from postoperative hematoma/seroma. Diet and activity are allowed as tolerated. Drains are typically removed on postoperative day 1 (the goal is < 20 mL per 8 hours), prior to discharge.

Complications of Anterior Cervical Discectomy

Complications following anterior cervical discectomy are infrequent but can be life threatening.[16,17] In addition to neurologic deterioration, dural injury, and inadequate decompression with persistent or recurrent symptoms, injuries to vital structures in the neck including the esophagus and the vertebral artery have been reported. These must be promptly recognized and properly treated to minimize patient morbidity. Likewise, postoperative airway compromise must be promptly recognized and emergently treated to avoid patient mortality. Soft tissue swelling associated with prolonged retraction, hematoma, seroma, and implant/graft dislodgement can all contribute to airway compromise. Dysphagia and dysphonia occur following ventral cervical approaches and have traditionally been underreported in the literature. Most of these will resolve with time but in recalcitrant cases should be referred for otolaryngology evaluation.

Vertebral artery injuries require direct repair, stenting, or ligation. Immediate bleeding should be controlled with direct pressure. Avoid injecting hemostatic agents directly into the cerebral vascular system. If available, obtain an emergent consultation with a vascular surgeon or interventional radiologist who can perform an angiogram to assess collateral circulation and potentially stent or occlude the lesion.

Esophageal injuries may not be detected with intraoperative dye.[18] If any suspicion of esophageal injury exists, it is prudent to keep the patient nil per os (NPO) and obtain consultation from a thoracic or head and neck surgeon.

Airway compromise is an emergency with which all personnel caring for postoperative ventral cervical spine surgery patients should be familiar. Voice changes to a high-pitched squeak, difficulty swallowing, and dyspnea are all causes for alarm. Immediate evaluation and treatment are mandatory. Lateral radiographs can help to diagnose implant dislodgement versus hematoma. A tracheostomy and difficult airway cart should be brought to the patient's bedside. Emergent consultation with an anesthesiologist or otolaryngologist should be obtained. If time permits, transfer of the patient to the operating suite will allow a controlled environment for evacuation of hematoma and intubation. Sometimes emergent bedside hematoma evacuation or cricothyrotomy will be necessary.

DORSAL CERVICAL DISCECTOMY

Dorsal Cervical Foraminotomy and Discectomy Technique

Preoperative Planning

Radiographic assessment is similar to that of ventral discectomy procedures. Imaging studies should be carefully reviewed for pathology and abnormal anatomy. Lateral disc herniations without significant uncovertebral spurring are a common indication for dorsal foraminotomy.[19-23] Central disc herniations and "disc-osteophyte complexes" are relative contraindications to dorsal foraminotomy. Dorsal cervical wound complications may be reduced by asking the patient to clip the hair from the dorsal neck the night before surgery. Intravenous antibiotics should be administered within 1 hour of making the skin incision. The operative site should be marked in the holding area.

Intraoperative Procedures

Patients are placed prone on the operating table with the neck in flexion. Gardner-Wells tongs are used to apply traction (10 to 20 pounds) via a flexion vector (Figs. 71-5 through 71-8).

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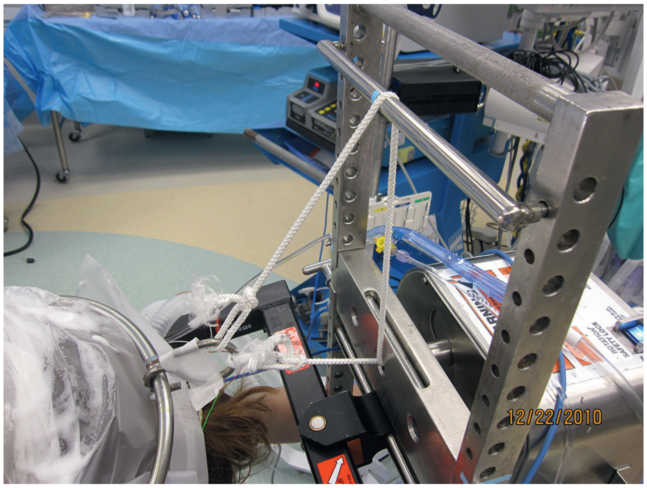

Figure 71-5. Bi-vector traction using cranial tongs allows positioning in flexion or extension by moving 10 pounds of weight from one rope to the next during the procedure. The scrubbed surgeon can manually support the patient's head in the tongs while an unscrubbed assistant (or anesthesiologist) moves the weight from one rope to the next during the procedure.

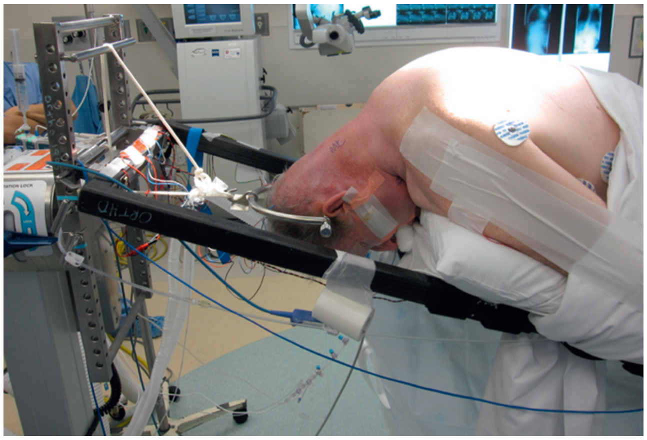

Figure 71-6. Photo of a patient positioned in maximal flexion, which can facilitate posterior laminoforaminotomy by opening the laminar/foraminal space to allow surgical access.

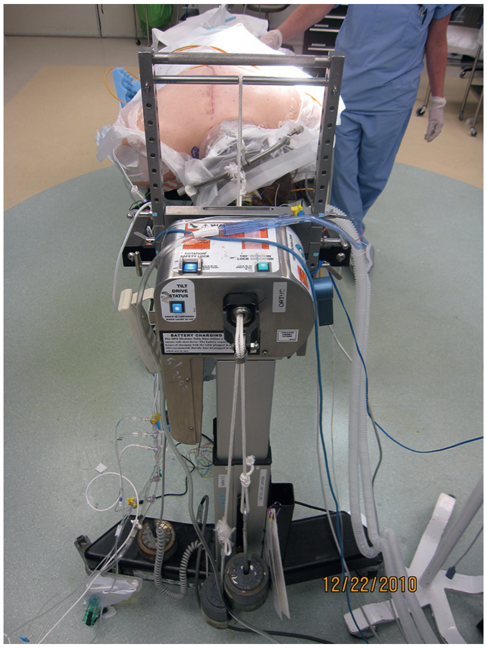

Figure 71-7. View from the head of the bed showing the path of the two ropes that allow bi-vector traction.

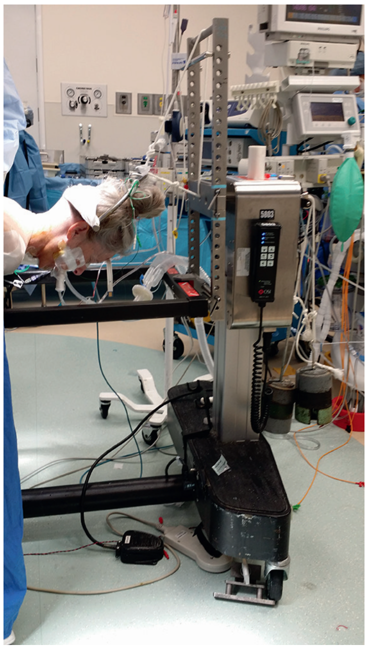

Figure 71-8. View from the side of the bed showing the path of the two ropes that allow bi-vector traction. The patient should be positioned no more than 6 to 10 inches from the top to maximize the direction of pull.

On the OSI (Mizuho Orthopedic Systems Inc.) table, three pins should be in place at the superior portion of the bed. The head of the bed should have the pin placed in the superior-most hole, and the foot of the bed should be placed lower in the H-bar to allow for maximum reverse Trendelenburg position (minimizes venous bleeding). Two traction ropes for intraoperative traction (one for flexion and one for extension) can be used if the plan is to instrument and fuse after the discectomy. The flexion vector is usually through the central portal, and the extension vector is over the central groove in the traction H-bar. When performing a foraminotomy alone without a fusion, we place the flexion vector as low as possible to flex the neck maximally. This opens up the facet joints such that it is easier to perform the foraminotomy. The flexion position is used for the incision and closure as well as decompression (foraminotomy/discectomy). The extension rope is used in performing a concomitant instrumented fusion to allow lordosis. It can also be used to check the adequacy of the foraminal decompression with the patient's neck extended. The full chest pad is placed in the appropriate position with two iliac crest pads placed at the level of the pelvis and a sling for the legs. A strap or tape across the buttocks will prevent caudal migration of the patient once in reverse Trendelenburg position.

Gardner-Wells tongs are applied symmetrically just above the ears. Pins should affix the bone 1 cm above the superior pole of the external ear. Pins that are placed too ventral will be in thinner bone and may cause a painful hematoma in the temporalis muscle.

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After the patient has been flipped prone, a traction cord with 10 to 20 pounds of weight is attached to the flexion rope. The arms should be tucked with a sheet at the patient's side with the hands in neutral position. The full chest pad should be at nipple level with female breasts tucked inferior and the chin and neck free from pressure. The iliac pads are placed just below the anterior superior iliac spine. The legs are placed on multiple pillows in the sling with the knees and ankles separated by foam padding. The abdomen hangs free with the patient in reverse Trendelenburg position to decrease venous pressure and minimize bleeding. The hands are checked to make sure they are not pressing directly on anything hard, and foam material is used to pad the hands and bony prominences accordingly. The shoulders are taped down using 3-inch silk tape from around the acromioclavicular joint, down the arms (supporting them from falling downward), then around the foot of the table. Overstretch with excessive force can cause a brachial plexus injury. The dorsal neck is clipped if the patient did not do this the night before, leaving adequate room for the plastic self-adhesive drape to attach without interfering with the exposure. Benzoin or other adhesive is applied prior to placement of the drapes. The surgical area is prepped widely. The warming blanket is taped to the undersurface of the table, ventral to the patient, allowing the heat to rise to the patient. After skin preparation, a half sheet is placed over the legs, and another half sheet is used to cover the end of the bed. Four blue towels are placed around the surgical field. The towels are placed close to the area of the incision. Then a half sheet is placed over the entire area and a small hole is cut out where the incision is to be made. The blue towels are then pulled back to expose the minimum amount of skin necessary to perform the operation. We prefer to prep the skin widely and then drape narrowly. Local anesthetic/epinephrine is injected into the area of the planned incision, and the surgical site is covered with Ioban strips.

A midline skin incision is made with a full-thickness scalpel cut, down into subcutaneous fat. The incision is deepened with electrocautery while self-retaining retractors are inserted that will aid in hemostasis. Once below subcutaneous fat, it is important to carefully stay in the midline fascia. The actual median raphe may deviate from the actual physical midline by quite a bit but is visible by carefully using the electrocautery on cut rather than coagulate. Care is used to avoid dissecting into the paraspinal muscles, which would lead to greatly increased bleeding and postoperative pain. Crossing bleeders from the venous plexus can be coagulated. The median raphe usually looks like a white band of fascia approximately 3 to 4 mm wide and can be better visualized with loupe or microscope magnification and lighting. In dissecting deep to the fascia, pink muscles fibers should be avoided. The separation between the paraspinal muscles can sometimes be very fine when they merge centrally in the raphe. At the level of the spinous processes, the muscles span the tips and can be preserved in performing a unilateral foraminotomy/discectomy without fusion. When the plan is to fuse or dissect previously fused levels, the interspinous tissue can be taken with the lateral soft tissue flaps so that only bone remains. This will minimize bleeding by staying out of the vascular muscle.

The levels are localized with spine needles on the spinous processes percutaneously prior to incision or with a clamp on an exposed spinous process with intraoperative lateral radiograph. Once subperiosteal dissection has been completed with electrocautery down to the level of the lamina, a Cobb elevator is used to strip the soft tissues laterally with a scraping technique. We then place a spreader between the spinous processes to further distract and open up the facet joints. In performing a foraminotomy, the interlaminar V of the lateral aspect of the desired laminar interspace is the starting point (Fig. 71-9). The

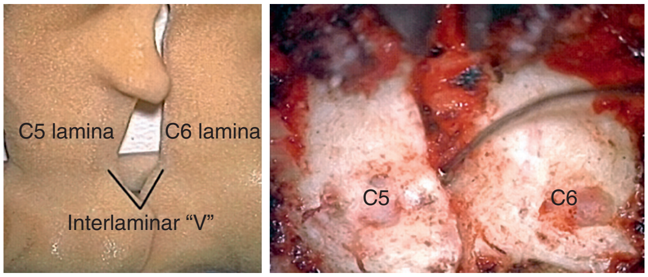

Figure 71-9. When performing a dorsal cervical foraminotomy, one must first identify the medial and lateral borders of the foramen. The interspace between the C5-6 lamina is shown as the interlaminar V on the left. On the right, an interoperative picture shows a ball-tipped probe marking the interlaminar V.

interlaminar V points to the affected joint and disc level. A high-speed bur is used with one hand held like a pencil as close to the bottom of the bur as possible for better control. The surgeon's fingers should point down into the wound as a result; the other hand holds a small Frazier suction tip, and the assistant irrigates. The bur is maneuvered in small, circular motions, getting gradually deeper (ventral); in-and-out motions are to be avoided. The inferior articular process of the superior vertebra is burred away, leaving the superior articular process of the inferior vertebra (Fig. 71-10). Approximately 50% (medial-laterally) of this facet should be removed. Resecting 50% of the cervical facet does not typically require fusion or stabilization. Cranially, enough of this facet has to be removed such that one can palpate the cranial leading edge of the superior articular facet that lies ventrally.

The superior articular facet is removed in three stages. The first stage is to make a small notch at the cranial-most edge of the facet. This establishes the cranial border of the facet removal and helps to prevent an inadequate decompression. The second stage is to create a vertical trough from this point caudally to the cranial border of the pedicle and from there, a horizontal trough to the interlaminar space. These two troughs are progressively thinned down until the bone becomes translucent. If the facet joints are arthritic and have large spurs, the foraminotomy hole can become quite deep. Frequent irrigation and suction will maintain visualization. The suction tip is maintained in the interspace when drilling, to protect the soft tissue overlying the cord in case of a sudden drill "kick" or movement. Alternatively, a curette can be placed into the interspace, hooked into the foramen, to protect the cord. The Codman-Microsect 1B and 2B curettes are ideal tools, as they can be held like a pencil. It is best to avoid burring all of the bone away, as the bur can injure the epineural veins and cause bleeding. Then we crack through the translucent bone with a 1-mm curette and lift the fragment from a medial to lateral aspect. Lifting the lateral aspect can cause the medial aspect to compress the cord (Fig. 71-11). The third stage is to palpate the pedicle and to make sure that there is no facet that overhangs it. If there is, it is removed with a 2-mm curette or a 1-mm Kerrison punch.

The vein that overlies the nerve root tends to bleed profusely, so it is important to understand the maneuvers that can decrease bleeding. Reverse Trendelenburg positioning with the abdomen hanging freely is used to decrease venous pressure. Thrombin-soaked hemostatic gelatin (Gelfoam) and cottonoid patties are packed into the bleeding foraminotomy site, and the decompression is resumed when the bleeding has slowed down.

The thoroughness of the decompression is assessed by palpating the superior and inferior pedicles with the tip of the

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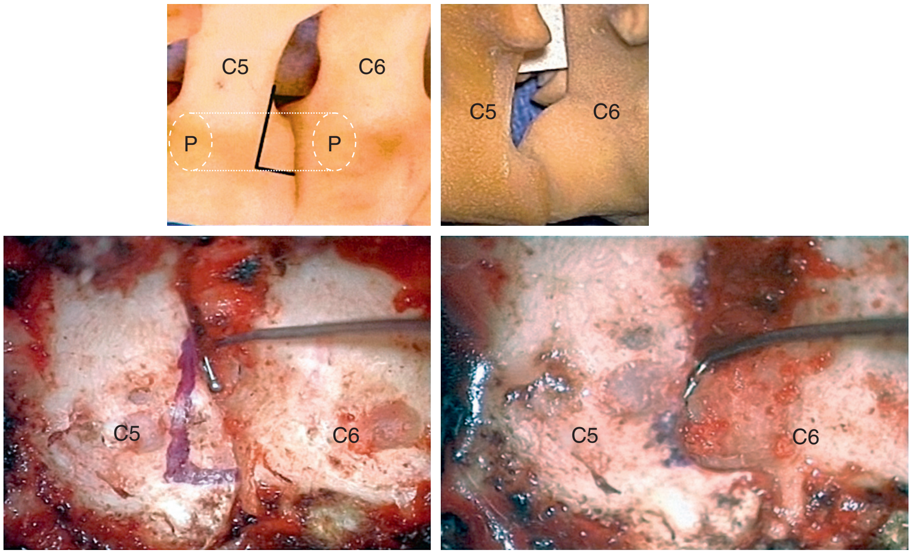

Figure 71-10. The first step of the foraminotomy. In the model, an L-shaped resection of the C5 inferior articular facet is to be made. This goes approximately 50% of the distance between the interlaminar V and the lateral margin of the facet. This is because if one resects 50% of the joint, this is approximately where the lateral margin of the pedicle is. The foramen is bounded by the C5-6 pedicles. If one performs a decompression lateral to the pedicle, the foramen will be completely free. On the right-hand side, as the model shows, this L-shaped area has been removed. One then sees the superior margin of the C6 facet.

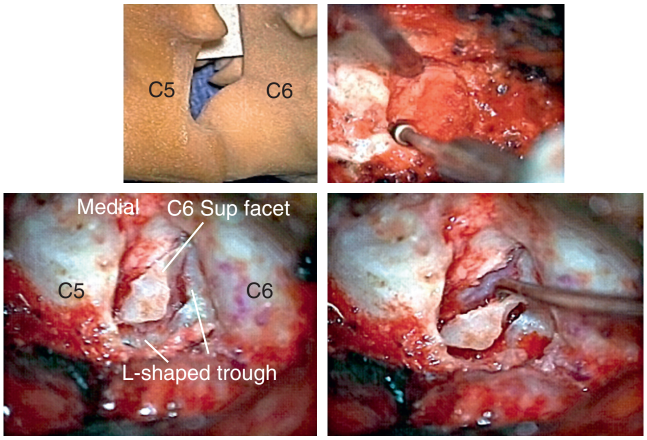

Figure 71-11. A high-speed bur is used to resect the triangular piece of bone using an L-shaped trough. Any bone that is overlying the C6 pedicle is then resected.

Codman curette or a nerve hook. Once the entire interpedicular region has been unroofed, the bony decompression is done (Fig. 71-12). The nerve root can be gently retracted superiorly and the disc material removed with a right-angled micro ball-tipped nerve hook and a micro pituitary rongeur. The nerve hook is used to sweep under the root to remove disc fragments. It is easy to leave fragments behind so one must carefully and methodically search under the root. Even then, one can still leave fragments behind. Occasionally, what appears to be a soft disc on MRI turns out to be an osteophyte. In general, it is best to leave these, as removing them with a bur or other tools can result in nerve injury. To be sure that one is dealing with a soft disc, we typically check a preoperative CT (Fig. 71-13). Moving the nerve root can expose the veins underneath. This can be controlled with small pieces of Surgicel, injectable hemostatic agents and a micro patty (¼″ by

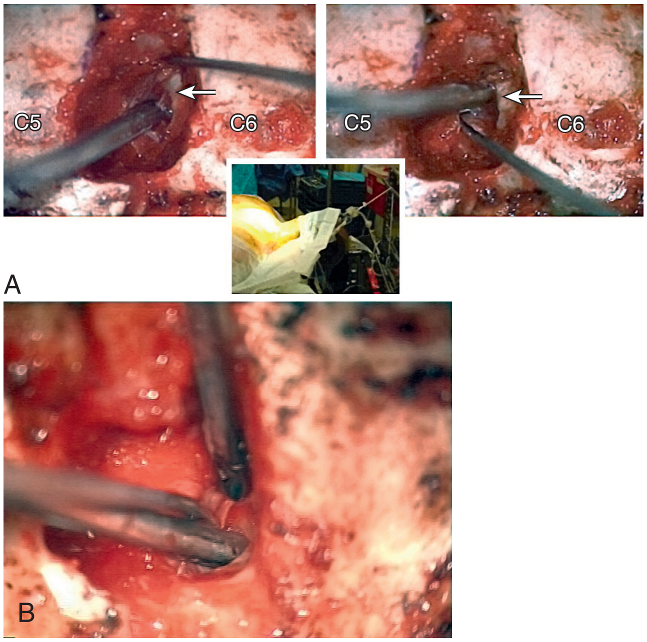

Figure 71-12. A, The arrows point to the C6 pedicle. The nerve is retracted cranially, and a right-angled ball-tipped probe is utilized to hook the herniated disc fragment. If there is no disc fragment and one is just performing a foraminotomy, after making sure that the foramen is completely open, one should recheck with the neck in full extension. This ensures that even with the patient's neck in full extension, the foramen is still wide open. It should also be noted that the entire foraminotomy and discectomy procedure should be performed with the neck in maximal flexion, which opens up the foramen. **B,** The root is retracted cranially, and the small pituitary rongeurs are used to remove the disc fragment.

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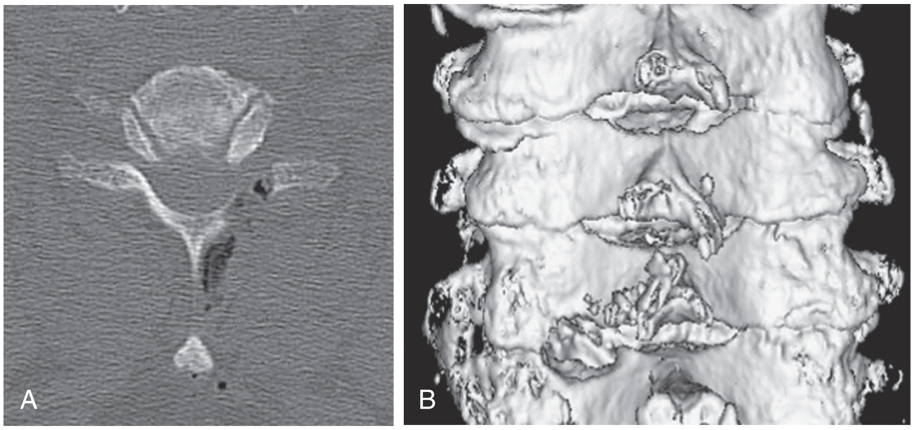

Figure 71-13. A, Postoperative CT showing a foraminotomy at C6-7. **B,** Three-dimensional reconstructed image of the foraminotomy.

¼″). The latter is especially useful to control the bleeding. A 1-mm Frazier tip sucker is also necessary. In closing, a #1 absorbable suture is used for the fascia and muscle. Numerous sutures with small bites are placed in the fascia of the paraspinal muscles deep in an attempt to bring the muscles back together. This combats this incision's tendency to invaginate during healing. It is helpful to tag clamp four to six sutures in the same layer and then tie them before proceeding to a more superficial layer. Meticulous hemostasis and closure of the dead space along with a deep and superficial drain help to prevent postoperative wound complications that are inherent to this approach.

COMPLICATIONS OF DORSAL CERVICAL DISCECTOMY

Similar to anterior cervical discectomy, complications of dorsal cervical discectomy include neurologic deterioration, dural injury, and inadequate decompression with persistent or recurrent symptoms. Air embolism causing stroke was rarely reported in the early literature but has not been reported in recent series in which both the sitting and prone positions were used.

Neurologic deterioration or persistent symptoms should be aggressively investigated and corrected. Evidence of spinal cord injury can prompt consideration of intravenous steroid treatment, although this is controversial. Persistent radiculopathy can arise from a misdiagnosed, unoperated level or from an inadequate decompression. Repeat decompression from either a dorsal or a ventral approach can be successful. Dural injury can result in cerebrospinal fluid leak (pseudomeningocele or fistula). Lumbar drainage can be considered, although local management with fibrin sealant or tissue graft and tight wound closure may be adequate.

Complications associated with cervical discectomy can be minimized with meticulous attention to preoperative planning and the surgical principles described here.

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