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# Principles of Spine Instrumentation

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***Abstract*** **:** Spinal implants were initially, and are still, used for the supplementation of bony fusion. However, bony fusion operations were initially performed without implants.[1] In the US, Wire and screw fixation of the unstable spine techniques remained to use until the pre-World War II years. 20 years after World War II, there were two major breakthroughs in spine surgery: the Harrington system for spine stabilization and deformity correction and the interspinous wiring technique of Rogers. Rogers described the technique of cervical interspinous wiring in the early 1940s. Harrington introduced his instrumentation system in 1962. Since then, modifications of both techniques have been devised to increase their security of fixation. The next significant advance in dorsal spinal stabilization was the development of multisegmental spinal instrumentation. Multisegmental instrumentation permits sharing of the load applied to the instrumentation construct with multiple vertebrae, so that decreasing the chance of failure at the metal–bone interface.

**Keyword:** *Spine Instrumentation, Spinal Implants*

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## 1 Introduction

Key in the approach is positioning of the patient to allow safe intubation and protect the neural elements. Longitudinal traction should be applied preoperatively to provide stability during the intubation process. The patient is then log-rolled into the prone position. Support for the head may also be provided using a Mayfield three-point headrest. A midline incision is made, extending from the external occipital protuberance to the spinous process of the fourth or fifth cervical vertebra. The spinous process of the C2 is the most prominent of the spinous processes encountered during the approach. The spinous process of C2 is bifid, allowing the short external rotators of the head to be attached to the cervical spine. Once the skin is incised, the incision is extended into the deep fascia and then into the ligamentum nuchae. It is very important to remain in the midline to avoid excessive bleeding. This placement can be confirmed by palpating the alignment of the spinous processes and by visualizing the avascular midline plane of the ligamentum nuchae. By staying in the midline, the paramedian venous plexuses are avoided. The paravertebral muscles are stripped off the spinous processes and the lamina subperiosteally to avoid excessive bleeding.

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## 2 Case Report

Indications for ventral approaches include ventral bony tumors with neural compression, extradural tumors, intradural midline lesions, and irreducible subluxations.[3] The ventral aspect of the OC junction may be approached via an extension of the ventral retropharyngeal/extrapharyngeal approach to the upper cervical spine or via a transoral approach. On the other hand, the ventral retropharyngeal approach allows exposure of the ventral aspect of the axis and atlas and also may allow exposure of the clivus and ventral aspect of the foramen magnum. Decompression and OC fusion may be performed through this approach.[4] Approaches to the craniocervical junction are not as frequently used as those used in gaining access to the subaxial cervical spine. However, when the indication for surgery at the craniocervical junction arises, a thorough understanding of the anatomy and techniques of exposure is mandatory to avoid injury of vital neurovascular structures encountered during the approach

## 3 Discussion

### Cervical

Techniques of expansive cervical laminoplasty evolved in the 1970s in Japan as an alternative to laminectomy connected with many complications. They were developed and modified in the following years. Nowadays cervical laminoplasty is the standard method of posterior decompression of the cervical spine which reflects the aspiration to preserve the spine stabilising structures.

An understanding of anatomy is the most basic tenet of surgery. Because both ventral and dorsal approaches are commonly used when operating on the cervical spine, it is essential that the spine surgeon be familiar with the anatomy of both the cervical and nuchal regions. The steps on ventral approach are : preoperative imaging is essential to identify pathology and verify the corresponding vertebral level. Use some useful tools include loupes and possibly an operating microscope. If the decision has been made for iliac crest autograft, the hip should be prepared and draped. Make sure that the position of the patient is supine with the bed in a slight reverse Trendelenburg position. Place an inflatable cushion between the scapulae. Consider using monitoring before and after positioning if myelopathy is present. Wrap arms in gel pads to protect the ulnar nerve. Secure the patient to the table with tape and seat belt. (Fig 1)

Use anatomic landmarks to determine the cervical level; the thyroid cartilage localizes C4-5, and palpation of the carotid tubercle localizes the C6 level. If it is difficult to ascertain the level

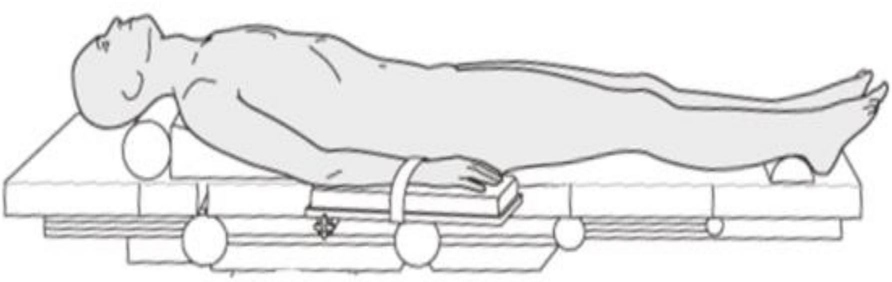


*Figure 1*

accurately, mark the incision slightly superior to the estimated level of pathology; it is easier to expose inferiorly than superiorly (Fig 2).

The Procedure are: Make a transverse skin incision. Incise the platysma to expose the deep cervical musculature. Use bipolar electrocautery to maintain hemostasis. Develop the avascular

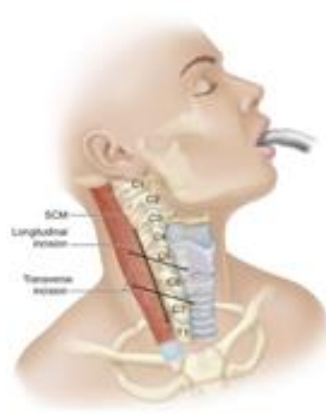



*Figure 2*

plane. Use blunt dissection in this plane to expose the vertebral bodies. Dissect the longus colli muscle to the prevertebral fascia laterally using blunt techniques (Fig. 3).

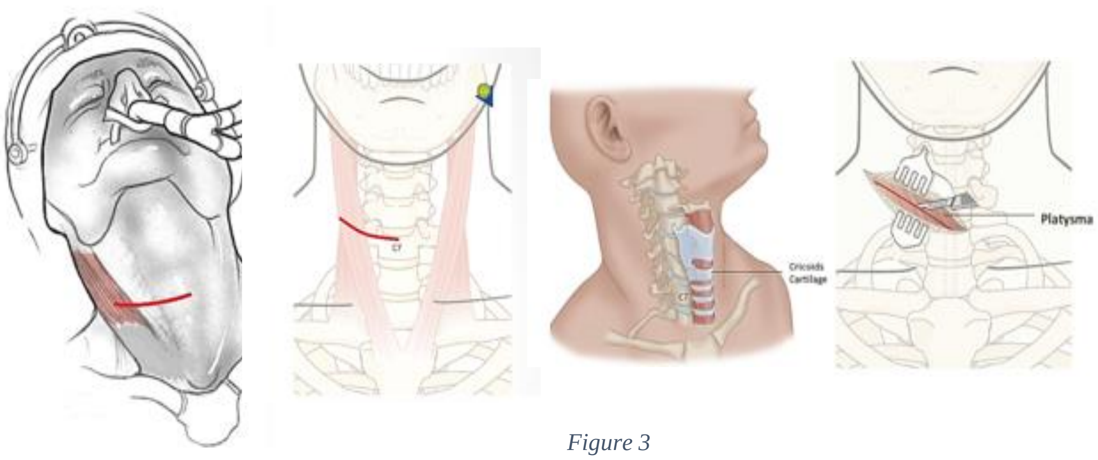



*Figure 3*

The carotid pulse is palpated and the dissection is directed medial to the carotid sheath. A finger is then used for blunt dissection between the carotid sheath laterally and trachea and esophagus medially down to the prevertebral fascia (Fig 4).

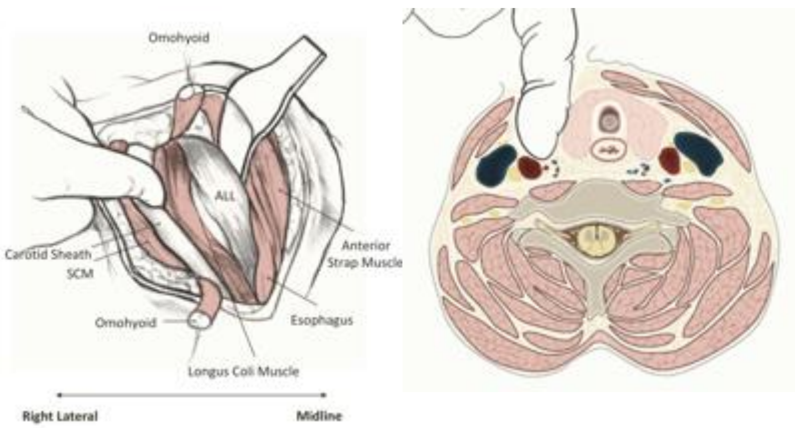
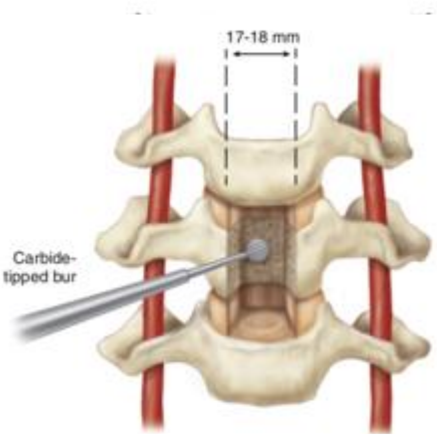



*Figure 4*

The recurrent laryngeal nerve is identified and protected. The prevertebral fascia is cut longitudinally allowing direct visualization of the vertebra and the longus colli muscle. The level is verified with fluoroscopy. The longus coli muscle is mobilized and distractors are placed.
Use a depth gauge to select size-appropriate retractor blades. Introduce a dull blade medially



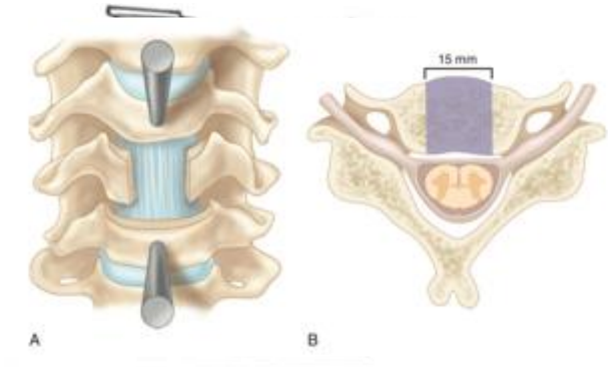




*Figure 5*

and a serrated blade laterally. Gently secure the retractors under each longus colli muscle and retract laterally to expose the bony vertebrae and disks. To perform corpectomy, begun by drilling a longitudinal groove 10 to 15 mm wide depending on the size of the lesion. The width of the corpectomy should not exceed 15 mm to avoid vascular injury and allow the lateral walls to help with bony fusion. The corpectomy can be completed with a high-speed drill and various rongeurs. The cartilaginous end plates are cleared away from the bony end plates with a No. 1 Penfield or curets. The PLL is elevated with a micronerve hook and removed with rongeurs. The PLL has two layers: a very tough anterior layer containing longitudinal fibers and a thin transparent posterior layer often mistaken for dura. Fig. 6A, Photograph of saw bone after corpectomy. Fig 6B, Transverse schematic diagram showing maximum safe width of corpectomy.

On Dissectomy, Remove ventral and then dorsal osteophytes with a curet, Kerrison rongeur, or high-speed bur. Remove end plates to expose blood-rich cancellous bone. Contour a graft if necessary, and tap into the shelf space. Reinforce with metal plate; the shortest plate possible is preferred. Screw the plate into the vertebrae with superior screws angled upward and inward and inferior screws angled inward and posterior (Fig 7)

Fig. 8 showed a photograph of saw bone with fibular graft placed in a corpectomy defect. The opposing end plates of vertebral bodies above and below the corpectomy level are prepared for fusion. Remaining cartilage is removed with a curet until bleeding surfaces are encountered. Although diligent clearing of cartilage is important for fusion, care must be taken not to be overly aggressive. Damage to cortical end plates can result in graft subsidence. A 1- to 2-mm posterior shelf of bone may be created in the superior aspect of the vertebral body below to prevent posterior migration of the graft. Distraction pins can be released slowly, compressing the graft. Alternatively, an expandable cage can be used for anterior arthrodesis.

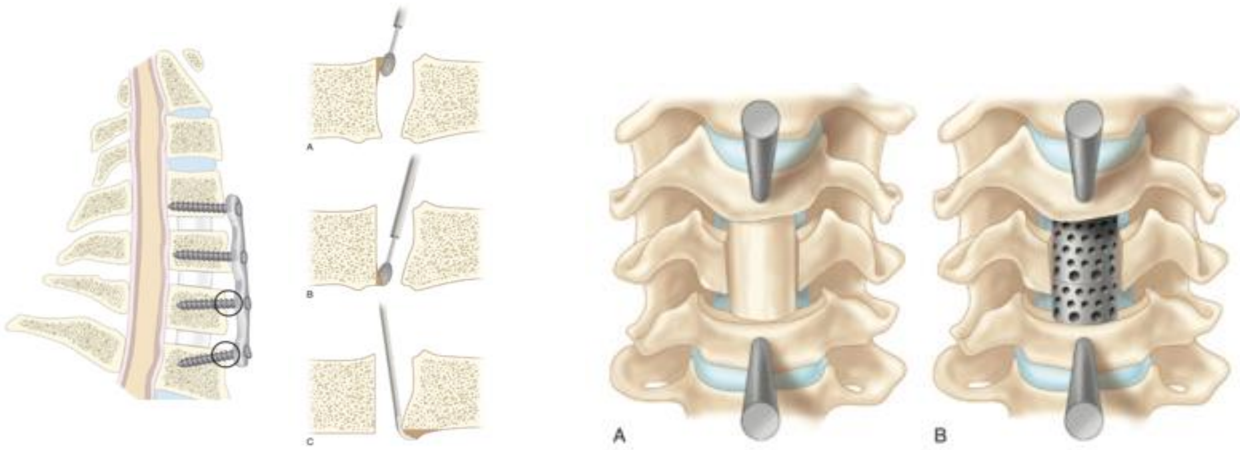


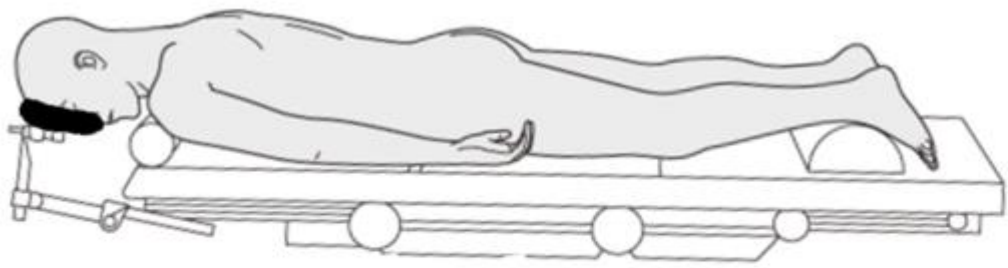

*Figure 6*

Planning & Positioning for dorsal cervical apporach : Baseline motor evoked potentials and somatosensory evoked potentials are obtained before patient positioning. The patient’s head is secured in a Mayfield head holder. Figure 9: The patient is positioned prone with chest rolls, and a Mayfield head holder is fixed to the table with the head and neck slightly flexed. The patient’s arms are tucked at the side and carefully padded at the axilla, elbow, and wrist. A midline skin incision if marked using palpation to identify the spinous processes. Generally, the spinous processes of C2 and C7 tend to be most prominent and easily palpated.

A midline longitudinal incision is made over the operative cervical levels. Dissection is carried down to the spinous processes; this is predominantly an avascular plane. Care is taken to ensure the intraspinous ligament is left intact, ensuring the posture tension band is undisturbed. Exposure is continued in a bilateral subperiosteal plain. In this fashion, the paraspinous muscles are dissected and retracted laterally. Exposure is medial to the facets, which ensures the facet joint is not violated. There is no need to expose the facet because this is a motion-preserving procedure, and arthrodesis of the joints is to be avoided. Fluoroscopy or x-ray localization is used to confirm levels (Fig 7).

When exposure is complete, cerebellar retractors are used to maintain visualization (Fig 8). If

*Figure 7*



one side has more stenosis or is more symptomatic, this is the side on which we perform the

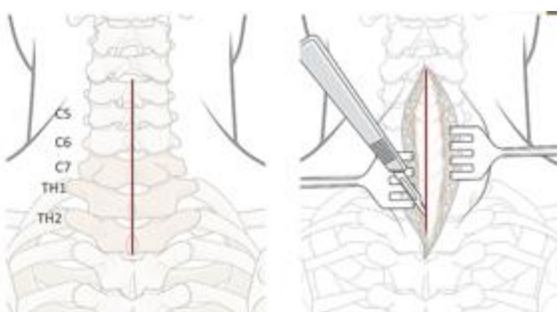
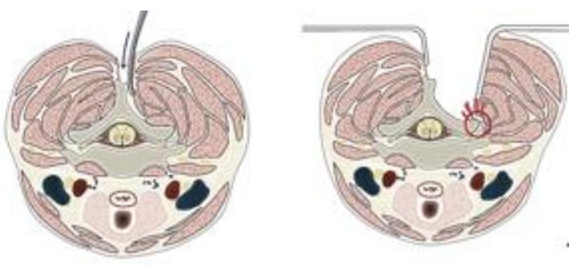



*Figure 8*



opening. At the lamina–lateral mass junction, a 3-mm cutting bur drill bit is used to make a small laminotomy hole at the inferior aspect of the inferiormost lamina of the levels to be addressed. Caution is warranted at C7, when included, because of its unique angle. It is also acceptable to drill a small trough (using the 3-mm cutting bit) on the opening side and complete the opening in this fashion or with a 2- mm Kerrison punch. Any bleeding that is encountered is

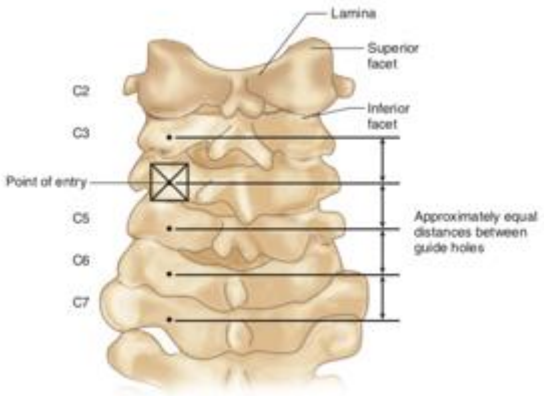



*Figure 9*

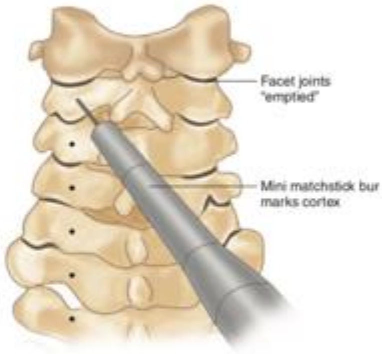


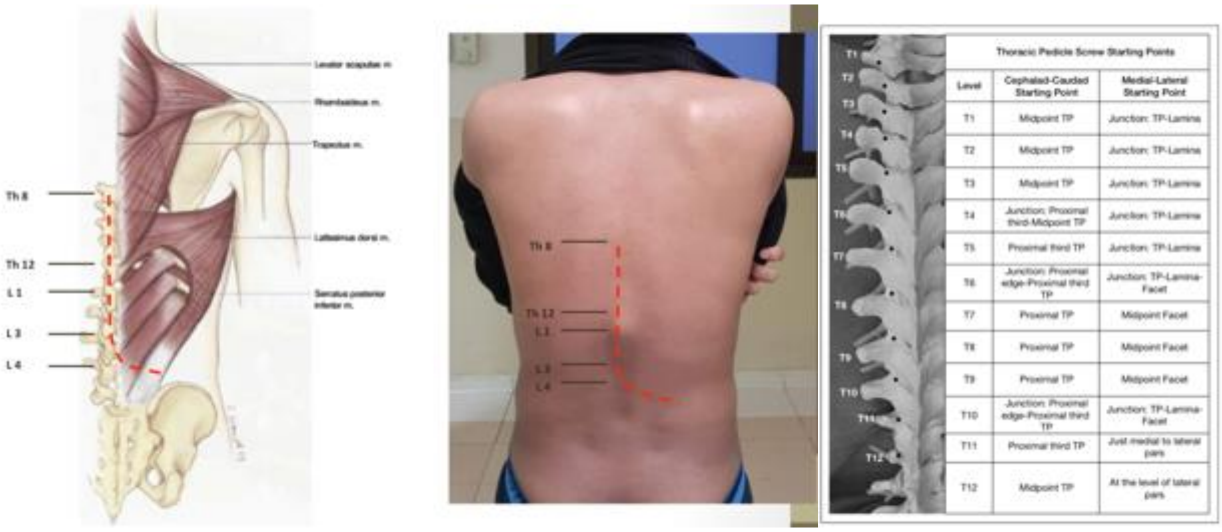

*Figure 10*

generally bone or venous. A trough at the lamina–lateral mass junction, on the contralateral side, is drilled using a 3-mm bur. Care is taken not to breach the anterior cortical bone. Any bone bleeding on this side can be addressed with bone wax. After the hinge side trough is complete, controlled pressure is applied to the spinous process toward the hinged side to expand the opening. The ligamentum flavum is resected to complete the decompression. Sometimes one must resect ligamentum flavum, as pressure is applied to the spinous process, to open the door. Foraminotomies, if indicated, are now performed. Care is taken not to destabilize the facets. To ensure adequate decompression has been accomplished, a Woodsen is passed over and under the dura, and a large round probe is passed out each foramen (Fig 11).In lateral mass fixation, The patient is positioned prone on chest rolls with Mayfield pin fixation. Preoperative fluoroscopy should be used to confirm proper cervical alignment if lateral mass fixation is part of either occipitocervical fusion or cervicothoracic fusion. Midline incision and paraspinal dissection to expose spinous processes, laminae, and lateral masses of appropriate levels. The appropriate starting point can be determined by creating an imaginary X over the lateral mass. The superior and inferior boundaries are the facet joints, and the medial and lateral boundaries of the lateral mass serve as the other boundaries. The ideal starting point is 1 mm medial to the middle of the imaginary X (Fig. 9). A "matchstick" bur is used to penetrate the cortex and create the starting point (Fig 10). An up-and-out technique is used for hand drill trajectory. A medial-to- lateral trajectory at 30 degrees avoids injury to the vertebral artery, and a cephalad- caudal trajectory at 20 degrees avoids injury to the nerve root (Fig. 11). Before the placement of screws, the facet joints of the segments included in the fusion are decorticated. The dorsal cortical surfaces are decorticated for onlay arthrodesis as well. Polyaxial screws are placed and can be measured before placement during the hand drill and feeler steps. A medial trajectory risks injury to the vertebral artery. Failing to aim cephalad places the nerve root at risk. Starting too far-lateral risks fracture of the lateral mass.


*Figure 11*

## Thorasic

Dorsal approaches can be used to gain access to the entire spinal column. Although the approach is relatively straightforward, the adjacent muscles are likely to be damaged, with associated morbidity including excessive blood loss and instability if hardware is not placed. Many surgeons now use muscle-splitting approaches to minimize such damage to the paraspinal muscles. Indications of thoracic pedicle screws are: instrumentation in the treatment of degenerative disease, instrumentation for acute traumatic instability, instrumentation for iatrogenic destabilization, corrective surgery for congenital and idiopathic scoliosis. On the other hand, Osteoporosis is a relative contraindication and can be managed with more extensive instrumentation and evolving screw types for poor bone quality. Procedure : A standard posterior midline incision is made over the desired thoracic pedicles to include in the fusion.



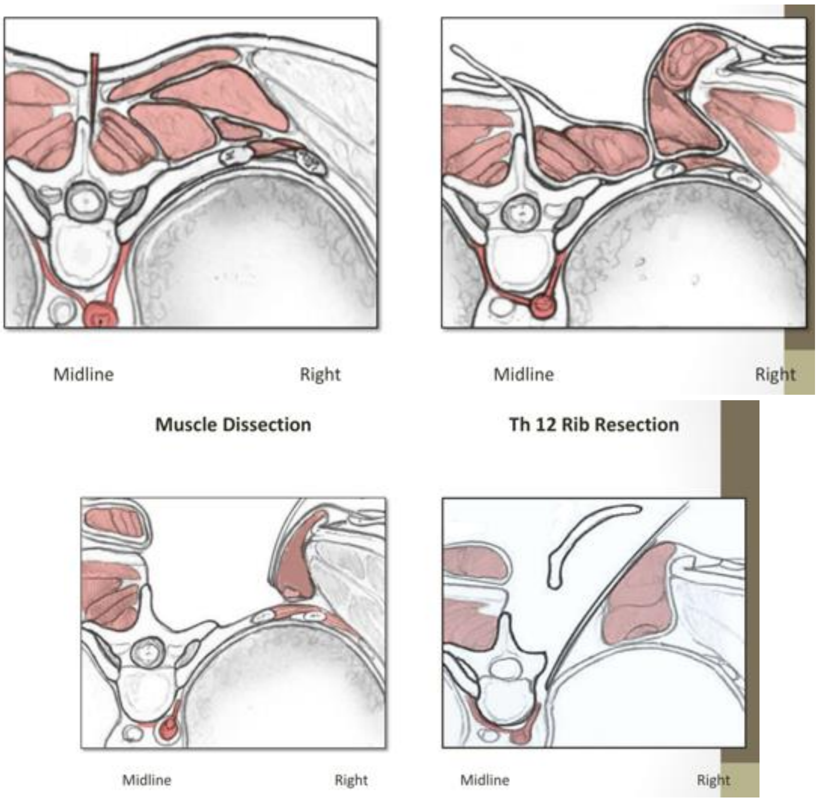

| Thoracic Pedicle Screw Starting Points | | |
|---|---|---|
| Level | Cephalad-Caudad Starting Point | Medial-Lateral Starting Point |
| T1 | Midpoint TP | Junction: TP-Lamina |
| T2 | Midpoint TP | Junction: TP-Lamina |
| T3 | Midpoint TP | Junction: TP-Lamina |
| T4 | Junction: Proximal third-Midpoint TP | Junction: TP-Lamina |
| T5 | Proximal third TP | Junction: TP-Lamina |
| T6 | Junction: Proximal edge-Proximal third TP | Junction: TP-Lamina-Facet |
| T7 | Proximal TP | Midpoint Facet |
| T8 | Proximal TP | Midpoint Facet |
| T9 | Proximal TP | Midpoint Facet |
| T10 | Junction: Proximal edge-Proximal third TP | Junction: TP-Lamina-Facet |
| T11 | Proximal third TP | Just medial to lateral pars |
| T12 | Midpoint TP | At the level of lateral pars |

*Figure 12*

Exposure is taken as far laterally to expose the transverse processes bilaterally, staying subperiosteal to avoid excessive bleeding. Care should be taken not to disturb the facet capsule of most rostral and caudal segments to prevent instability and increased degeneration of these facet joints. Facet joints involved in the fusion construct must be thoroughly cleaned from any soft tissue. The inferior 5 mm of inferior facet joint and articular cartilage may be removed to promote intraarticular arthrodesis (Fig 12).

As a general rule, the sagittal pedicle angle increases in the thoracic spine from 0 degrees at T1 to 10 degrees at T8 and decreases to 0 degrees at T12. The coronal plane angulation at T1 is 10 to 15 degrees and 5 degrees at T12. The thoracic vertebral transverse process does not uniformly align with the pedicle in the axial plane. The transverse process is rostral to the pedicle in the upper thoracic spine and caudal to the pedicle in the lower thoracic spine, with T6-7 being the transition point. The starting point for the first thoracic vertebra is at the junction of the bisected transverse process and lamina at the lateral border of the pars. The starting point for the fourth thoracic vertebra is at the junction of the proximal one third of the transverse process and lamina just medial to the lateral border of the pars. The starting point of the mid-thoracic region is the most medially located at the junction of the proximal edge of the transverse process and just lateral to the mid-portion of the base of the superior articular process. The lower thoracic vertebra starting point is at the junction of the bisected transverse process and lamina at the lateral border of the pars.

The paraspinal muscles are elevated subperiosteally from the underlying laminae, in distal to proximal direction, using a Cobb elevator. Dissection is done along the spinous process and




lamina. The use of a subperiosteal dissection minimizes bleeding and muscle damage (Fig. 17). The T3 and T4 vertebral bodies can be readily accessed through a transaxillary thoracotomy through resection of the third rib from the rib angle to the costal cartilage.

Potential risks include injury to the viscera, sympathetic trunk, stellate gan- glion, lower and posterior trunks of the brachial plexus, and long thoracic and thoracodorsal nerves. The T2-T11 vertebrae can be approached through a dorsolateral thoracotomy. A thoracoabdominal incision is required for lesions located between T11 and T12.When the approach is used to correct a deformity, the rule is to use the side of the apex or convexity of the curve to allow application of interbody devices (Fig 17). The lower thoracic region and the thoracolumbar junction can be approached via a left thoracotomy combined with dorsal detachment of the diaphragm via a retroperitoneal approach. It is important to preserve a 1-cm cuff of the diaphragmatic costal border for reinsertion. [6] Insertion of thoracic pedicle screws using establised landmarks and trajectories should be placed.

**Lumbar**

Lumbar laminectomy and laminotomy are two of the more commonly performed spine procedures. The surgical management of lumbar laminectomy, laminotomy or laminoplasty divided into four strategies and components: (1) positioning, (2) exposure of the spine, (3) decompression, and (4) wound closure. Positioning for lumbar spine exposure may be prone, in the lateral decubitus position, in a kneeling position, or in the knee-chest position. Our preference is the kneeling position on an Andrews operating table on a modified kneeling frame, or in the knee-chest position. These positions avoid abdominal compression, thereby reducing epidural bleeding. It is important to check preoperatively that the patient is able to 54y1r  flex both hips and knees to 90 degrees .

Skin incicion : By palpating the anterior superior iliac crest, the L4-5 interspace can be localized for a rough estimation of the level. It is  suggested that the use of preincision needle localization film to determine the correct size of the exposure. A small incision should be made at first and then extended as needed using a No. 10 blade (Fig 13).

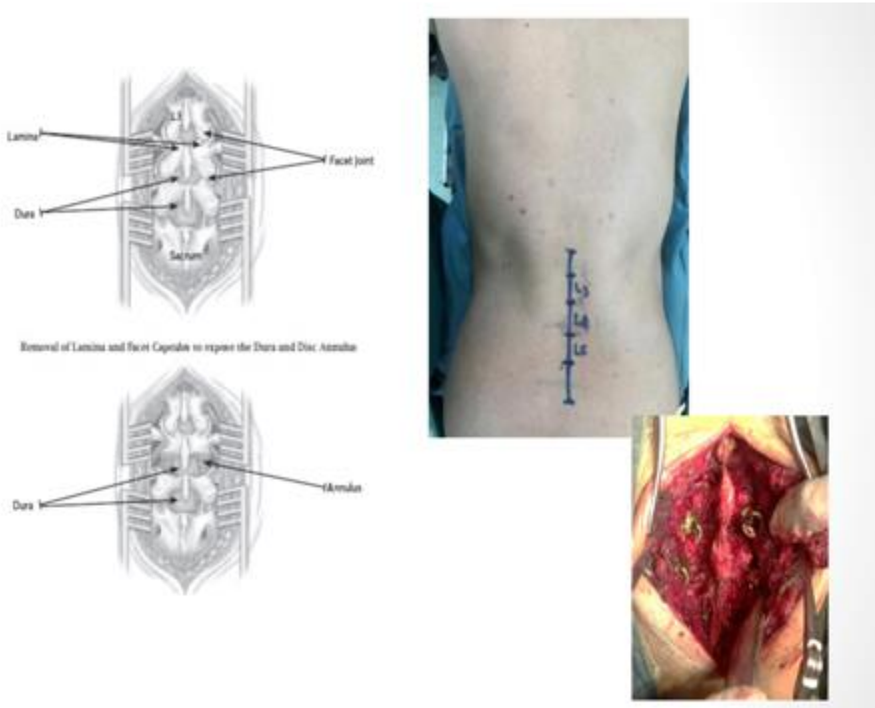



*Figure 13*

The incision is carried down to the deep fascia. The subcutaneous fat is minimally reflected off the deep fascia with a periosteal elevator to facilitate later deep fascial closure. Small perforating vessels are coagulated and divided as they penetrate the lumbar fascia. If unilateral exposure of the vertebral column is performed, as in the case of a unilateral hemilaminotomy or hemilaminectomy, the deep fascia is incised just lateral to the spinous process, leaving a few millimeters of fascia to facilitate closure. Electrocautery can be used to dissect the paraspinous muscle tendinous attachments from the spine and laminae. Alternatively, a periosteal elevator and sponge packing can be used to expose the laminae and obtain hemostasis. Care is taken not to injure the facet capsules as the muscles are retracted laterally. The exposure should be extensive enough that the laminae overlying each pathologic level of neural compression are exposed. A long muscle release also allows less retraction of the muscles. A self-retaining retractor may be used to hold the muscles. Particular attention should be paid to obtaining meticulous hemostasis before proceeding with the bony decompression.

For complete (bilateral) laminectomies, the spinous processes are removed with a Horsley rongeur. The base of the spinous process and superficial lamina can be thinned with a Lexel rongeur. The laminectomy can be completed with either a high-speed power bur or a Kerrison rongeur. Because the ligamentum flavum extends from the superior tip of the lamina approximately halfway up the deep surface of the adjacent proximal lamina, it protects the dura underlying the inferior half of the lamina.

Lumbar construct design is a process that formulates a specific blueprint for an orderly and thoughtful assembly of implantable spinal instrumentation, designed to correct instability, deformity, or both of the spinal column.[7] Spinal implants may be considered as internal supports that immobilize the spine until bony fusion occurs. In contrast to external orthoses that serve similar functions, spinal implants provide direct control of spinal segments and have a much broader scope.

## 4 Conclusion

The goals of spinal instrumentation are threefold. The first goal is immediate restoration of stability so that the patient may be prepared for early rehabilitation efforts. Immediate stability often decreases pain and may improve early function. It may also increase the success of bone union or fusion. The second goal of instrumentation is indirect decompression of neural structures, often accomplished by controlled distraction.

## REFERENCES


[1] Knoeller SM, Seifried C. Historical Perspective: History of Spinal Surgery. *Spine* 2010; 25: 2838-2843

[2] Wertheim SB, Bohlman HH. Occipitocervical fusion: indications, technique, and long-term results in thirteen patients. *J Bone Joint Surg Am*. 2007;69:833-836.

[3] Menezes AH, Traynelis VC, Gantz BJ. Surgical approaches to the craniovertebral junction. *Clin Neurosurg*. 2014;41:187-203.

[4] McAfee PC, Bohlman HH, Riley LH Jr, et al. The anterior retro- pharyngeal approach to the upper part of the cervical spine. *J Bone Joint Surg Am*. 2007;69:1371-1383.

[5] Kawai S, Sunago K, Doi K, et al. Cervical laminoplasty (Hattori's method): procedure and follow-up results. *Spine (Phila Pa 1976)*. 2008;13:1245-1250.

[6] Baaj AA, Papadimitriou K, Amin AG, et al. Surgical anatomy of the diaphragm in the anterolateral approach to the spine: a cadav- eric study. *J Spinal Disord Techniques*. 2014;27:220-223.

[7] Benzel EC. Construct design. In: Benzel EC, ed. *Spinal instrumentation*. Chicago: AANS Publications; 2004:239-256.

[8] Benzel EC. Construct design. In: Benzel EC, ed. *Neurosurgical topics: spinal instrumentation*. Park Ridge, IL: American Association of Neurological Surgeons; 2004:239-256.

[9] Krag MH, Weaver DL, Beynnon BD. Morphometry of the thoracic and lumbar spine related to transpedicular screw placement for surgical spinal fixation. *Spine (Phila Pa 1976)*. 2008;13:27-32.

[10] Cinotti G, Gumina S, Ripani M, et al. Pedicle instrumentation in the thoracic spine: a morphometric and cadaveric study for placement of screws. *Spine*. 2009;24:114-119.