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Minimally Invasive Spine Surgery

Advanced Surgical Techniques

Editors
Kern Singh
Alexander R Vaccaro

Foreword
Frank M Phillips





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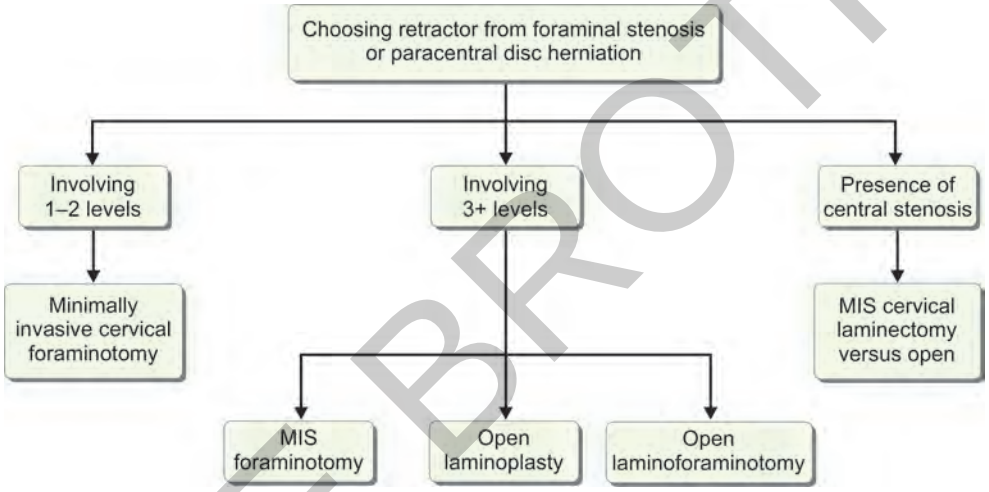
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Chapter

3 Minimally Invasive Posterior Cervical Foraminotomy

Alejandro Marquez-Lara, Alpesh A Patel, Kern Singh



CASE VIGNETTE

A 57-year-old woman presents to the office with a 6-month history of pain, numbness, and tingling in her left upper extremity. The pain begins in her neck and shoulder and radiates into her radial two digits. On examination, the patient has left sided C6 radicular symptoms with motor weakness noticeable with wrist extension on the left side. There are no signs or symptoms of myelopathy. The patient's symptoms are refractory to conservative management with physical therapy and analgesic medication.

DIAGNOSTIC IMAGING

- Plain film radiography—Anteroposterior and lateral views (flexion–extension)
  - Important to rule out instability that may necessitate a cervical fusion
- Magnetic resonance imaging (MRI) (Fig. 3.1)
  - Necessary to evaluate the etiology and severity of the neural compression

Imaging Pearls

- Parasagittal and oblique MRI images (T1 weighted) can help determine the severity of foraminal stenosis.
- CT myelography is the preferred imaging modality for the evaluation of spinal cord compression secondary to bone and in patients with previously placed instrumentation.

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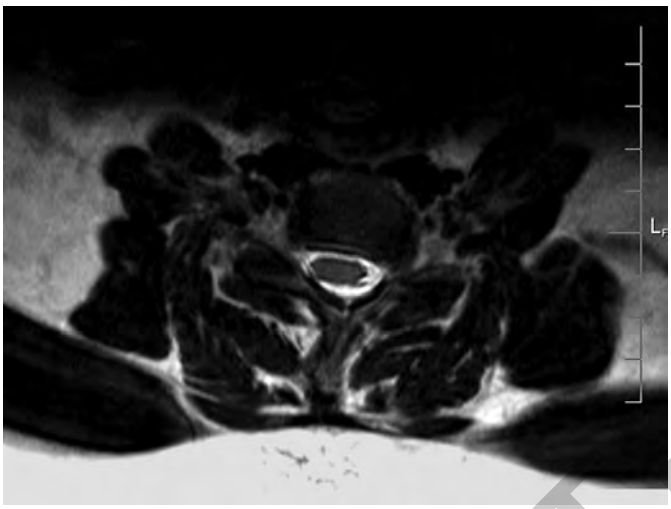


Fig. 3.1: Preoperative axial magnetic resonance image demonstrating left foraminal stenosis at C4–C5 with minimal central stenosis.

- Computed tomography (CT)
  - Helpful in determining soft disc herniation from bony osteophyte or calcified disc herniation
  - CT myelography is useful in patients who are unable to undergo an MRI (ocular implants, cardiac pacemaker).

SURGICAL INDICATIONS

- Single or multilevel paracentral/foraminal herniated nucleus pulposus (HNP)
- Isolated spondylotic foraminal stenosis
- Multilevel spondylotic foraminal stenosis without central stenosis
- Persistent radicular symptoms after anterior cervical discectomy and fusion or anterior cervical disc replacement
- Contraindications to an anterior approach
  - Superficial infection
  - Tracheostomy
  - History of anterior neck radiation

Indication Pearls

- HNP location in regards to the spinal cord (central) and nerve root (foramen) will help determine if the disc can be accessed posteriorly.

Contraindications

- Central disc herniation or osteophytes
- Myelopathy from central canal stenosis
- Ossification of posterior longitudinal ligament (OPLL)
- Kyphotic deformity
- Cervical segment instability

INSTRUMENTATION

- Intraoperative fluoroscopy
- Microscope
- Sequential dilators
- Tubular retractor (16–21 mm) with mounted retractor arm
- Microscopic instruments
  - Rongeurs
    - Pituitary
    - Kerrison
  - Microcurettes
  - High-speed burr

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Fig. 3.2: The patient is placed in a prone position with the neck gently flexed to open the spinal canal.

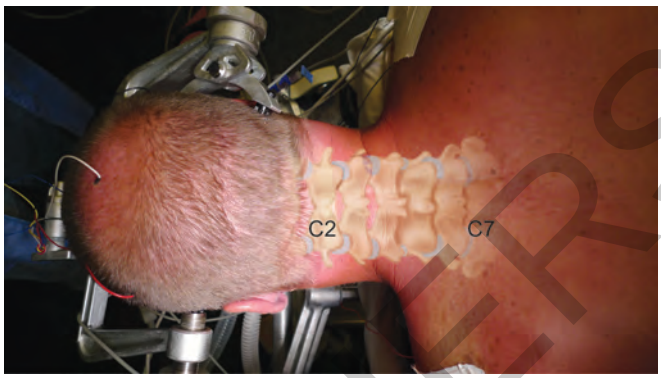


Fig. 3.3: Topographic anatomy of the posterior cervical spine highlighting the C2 and C7 spinous processes that can be palpated to identify the precise surgical site.

POSITIONING AND INTRAOPERATIVE SETUP

- Endotracheal intubation is performed in a supine position.
- The patient is fitted into a Mayfield three-point fixation holder or into Gardner-Wells tongs.
- Modified prone position
  - The patient is placed into a prone position.
    - Appropriate padding is placed over bony prominences.
    - Log rolls are placed along the chest to relieve intra-abdominal pressure. Alternatively, an open frame Jackson table can be utilized.
  - The bed is adjusted to bring the patient into a 30° reverse Trendelenburg position. This elevates the surgical site above the heart to reduce venous bleeding.
  - The head is slightly forward flexed opening the spinal canal (Fig. 3.2).
- Semi-sitting position
  - From a supine position, patient is flexed into a sitting position such that the long axis of the cervical spine is perpendicular to the floor.
- The surgeon is positioned on the ipsilateral side of the surgical site.
- Fluoroscopy and image monitors are placed on the contralateral side of the surgical site.

Positioning Pearls

- Flex the patient's knees prior to changing the bed position to prevent the patient from sliding downward.
- Taping the shoulders down will help expose the lower cervical levels during intraoperative imaging.

Positioning Pitfalls

- There is a risk of air emboli with a semi-sitting position. A precordial Doppler may be utilized to monitor for this rare adverse event.

Surgical Anatomy and Exposure

- The spinous processes of C2 and C7 can serve as superficial landmarks (Fig. 3.3).
- Lateral fluoroscopic images will help determine the proper surgical level.
- The surgical site is marked and infiltrated with a local anesthetic.
- A longitudinal 15-mm incision is made 5–10 mm lateral to the midline on the ipsilateral side of the pathology.
- A longitudinal fasciotomy is made, equal in length to the skin incision, and the starting dilator is advanced gently under fluoroscopic guidance (Fig. 3.4).

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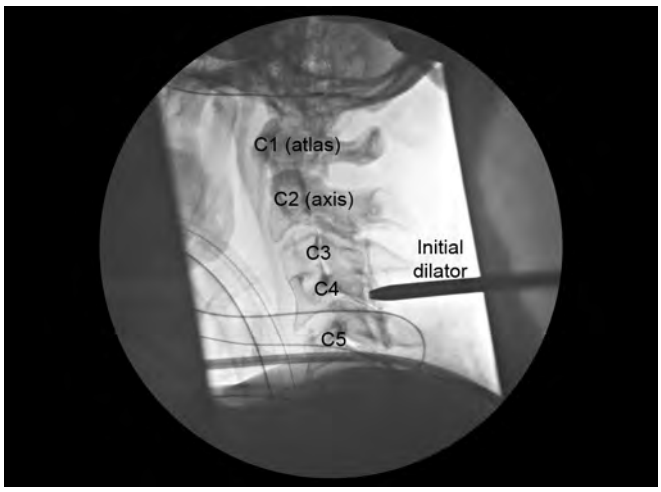


Fig. 3.4: Placement of the initial dilator under lateral fluoroscopic guidance.

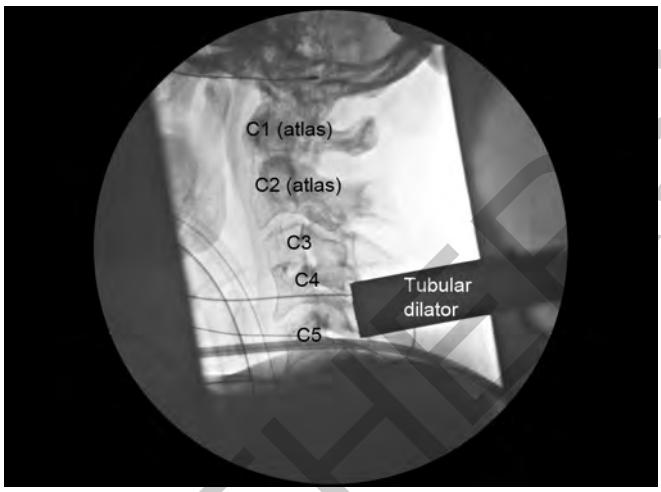


Fig. 3.5: Sequential dilation creates an intermuscular working channel that minimizes soft tissue damage. The final dilator is visualized in the correct position.

- Sequential dilation is performed (Fig. 3.5). Once the final dilator is reached a tubular retractor is placed and locked into the mounted retractor arm.
- Electrocautery and a pituitary rongeur can clear any remaining muscle and soft tissue, exposing the lateral mass, facet joints, and interlaminar space (Fig. 3.6).
  - At this point, a fluoroscopic image is obtained to confirm that the retractor is at the correct level.

PROCEDURE SPECIFIC STEPS

- Step 1
  - With a high-speed burr, the medial third of the inferior articular process of the cephalad vertebra is removed until the superior articular process (SAP) of the caudad vertebra is visualized (Fig. 3.7).
    - A small laminotomy in the superior vertebra may help expose the lateral aspect of the ligamentum flavum overlying the SAP.
    - The ligamentum flavum is carefully excised with a 1- or 2-mm Kerrison rongeur.
- Step 2
  - Next, the medial third of the exposed SAP of the caudal vertebra is resected with a burr or a Kerrison rongeur (Fig. 3.8).
- Step 3
  - With a fine angled dissector, the nerve is inspected from medial to lateral. Palpation ventral to the nerve root is important to identify possible disc fragments or osteophytes.
    - If indicated, the nerve root is retracted superiorly and the herniated disc is removed with a pituitary rongeur.

Anatomy/Exposure Pearls

- A fasciotomy will facilitate sequential dilation.
- If the dilators do not pass smoothly, one can bluntly dissect the fascia and muscles with Metzenbaum scissors.

Anatomy/Exposure Pitfalls

- The K-wire and smaller dilators pose a potential risk to penetrate the interlaminar space and should be avoided.

Step 1 Pearls

- The SAP is the source of bony compression and impingement in the dorsal part of the foramen.

Step 2 Pearls

- Palpating the size of the facet with a bayoneted Penfield no. 4 lateral to the tubular retractor can help assess the extent of resection without having to expose the entire facet capsule.
- The laminar–facet junction can be utilized as a landmark to determine the limit of facet resection.

Step 2 Pitfalls

- During resection, the epineural venous plexus may be encountered. Hemostasis can be obtained with a bipolar cautery, bone wax, or a thrombotic agent.
- Removing >50% of the facet joint complex can lead to postoperative neck pain and spinal instability.

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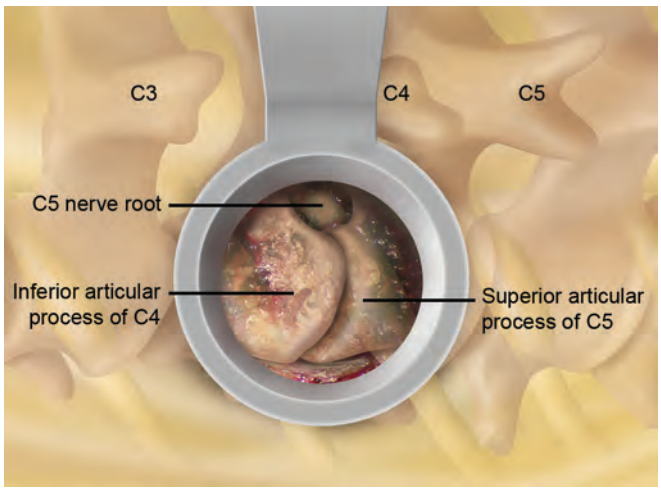


Fig. 3.6: Intraoperative view of the surgical channel after removing the residual soft tissue. The superior and inferior articular processes are clearly identified.

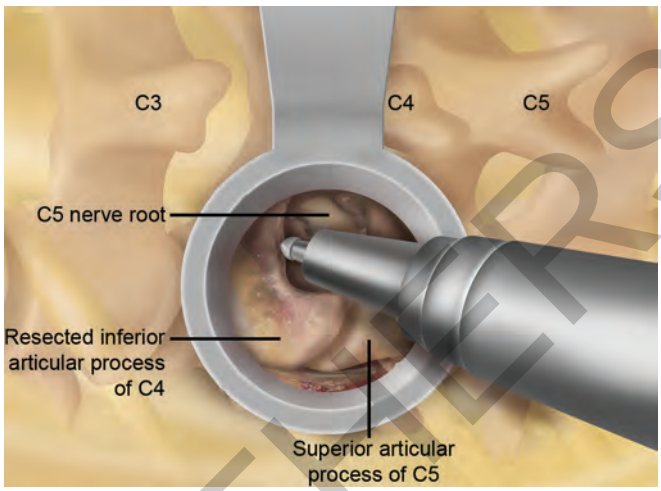


Fig. 3.7: A high-speed burr is displayed removing the medial third of the inferior articular process.

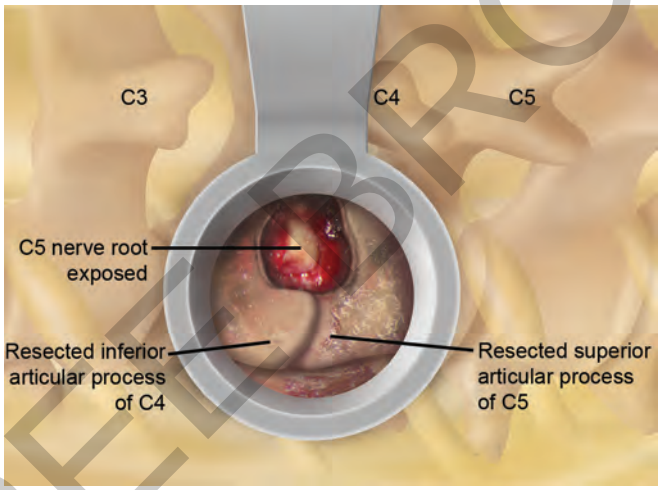


Fig. 3.8: An intraoperative view of the exposed nerve root after partial resection of the inferior and superior articular processes.

- Step 4
  - A final assessment is performed above, below, and medial to the nerve root. Decompression is complete when a nerve probe can be easily passed into the neuroforamen.
- Step 5
  - Copious irrigation of the wound with antibiotic solution and adequate hemostasis is assured prior to wound closure.
  - Final infiltration of local anesthetic to the surgical site will alleviate postoperative pain.
  - Multilayer closure should be performed given the risk of infection with posterior cervical procedures.

Step 3 Pearls

- Additional drilling of the superomedial quadrant of the caudal pedicle improves access to clear ventral debris or disc material and avoids excessive retraction of the nerve root.

Step 3 Pitfalls

- Care must be taken to prevent injury to the anterior motor branch, which can be mistaken for disc material.

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POSTOPERATIVE CARE

Complications

- Superficial wound infections
  - Most resolve with oral antibiotics.
  - If necessary, the wound can be formally irrigated and debrided.
- Incidental durotomy
  - Intraoperatively, the durotomy can be covered with muscle, fat, or gel foam followed by a fibrin glue or synthetic sealant.
  - For larger durotomies, a lumbar cerebrospinal fluid (CSF) diverting drain may be placed for 2 to 3 days to prevent a wound leak.
  - Risk of a postoperative pseudomeningocele and CSF-cutaneous fistula are exceedingly rare due to the minimal dead space around the surgical site.
- Transient nerve root paresis
  - Occur from post-manipulation edema and concurrent revascularization of the ischemic nerve root
  - The C5 nerve root is the most frequently involved.
  - Presents 24–48 hours after surgery
  - Close observation and reimaging is indicated to assess for any residual compressive pathology.
  - Most resolve with conservative management.

Complication Pearls

- The C5 nerve root has the most horizontal trajectory and the sharpest angle between the nerve root and the lateral margin of the dura.

EXPECTED AND ADVERSE OUTCOMES

- Minimally invasive posterior cervical foraminotomy provides symptomatic relief in 87–97% of patients with radicular symptoms from foraminal stenosis or a paracentral herniated intervertebral disc.[1–4]
- Intraoperative blood loss, hospital length of stay, and the need for postoperative analgesics are significantly reduced with a minimally invasive approach.[1–4]
- Expected complication rate after a minimally invasive posterior cervical foraminotomy ranges from 2–9%.
  - CSF leak, superficial wound infections and nerve root paresis are the most common postoperative complications.

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REFERENCE SUMMARY

1. Hilton DL Jr. The authors analyzed the outcomes of a minimally invasive posterior cervical foraminotomy with a standard operating microscope. The surgical outcomes of 222 patients after an average follow-up of 2 years demonstrated symptom improvement in 210 patients (94.6%), improved pain in 9 patients (4.1%), and persistent or worsening pain in 3 patients (1.3%).
2. Winder et al. The authors conducted a retrospective case–control study of 107 patients who underwent a posterior cervical foraminotomy [open vs microscopic tubular assisted foraminotomy (MTPF)]. The MTPF approach demonstrated similar results compared with an open approach while significantly reducing blood loss, postoperative analgesic requirements, and the length of hospital stay.
3. Caglar et al. The authors report on 84 patients who underwent a posterior keyhole laminotomy–foraminotomy under a surgical microscope and discuss the surgical technique, advantages, and disadvantages. This study demonstrated that in select patients, a "keyhole approach" provides excellent results with minimal morbidity.
4. Witzmann et al. A retrospective review of 67 patients with unilateral intraforaminal disease who underwent a posterior cervical foraminotomy under microscope visualization. After an average of 3-year follow-up, 93% of patients experienced complete or partial relief of symptoms. The authors conclude that careful patient selection and microsurgical techniques are essential for obtaining consistent results.

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Minimally Invasive Spine Surgery

Advanced Surgical Techniques

Salient Features

- This book offers the reader an up-to-date and comprehensive review of the indications, techniques, and outcomes of minimally invasive spine surgery (MISS).
- Covers the recent advancements in techniques and instrumentation utilized in MISS.
- Compares the risks and the benefits of commonly utilized constructs and biologics in MISS.
- An algorithmic approach is undertaken in each chapter for identifying appropriate candidates for MISS.
- Each chapter provides a detailed description of each surgical procedure in a step-wise fashion with clinically relevant explanation of the anatomy.
- Integrates the knowledge and experience of eminent spine surgeons to offer pertinent pearls and pitfalls of minimally invasive spine surgery.
- Highlights relevant literature regarding the current evidence and controversies surrounding MISS.
- Includes numerous color images, diagrams, illustrations, and radiological images for understanding of relevant anatomy and procedures.
- Designed to inform medical students, orthopedic and neurosurgery residents, spine fellows, and spine surgeons regarding the role of MISS for decompressive, arthrodesis, deformity, tumor resection, and spinal trauma procedures.
- Extra bonus: DVD-ROM with 11 video clips detailing advanced surgical techniques.



Kern Singh MD has dedicated his career to pioneering minimally invasive spinal surgery. He is the Co-Director of the Minimally Invasive Spinal Institute at Rush Chicago, Illinois. Dr Singh is an award-winning researcher and has published his findings in major medical journals (more than 300 publications, presentations and book chapters). He most recently won awards for his research including Best Paper at the North American Spine Society (NASS) and Society of Minimally Invasive Spinal Surgery (SMISS) International Meetings in 2013. He frequently trains surgeons who observe his newly advanced surgical techniques in the operating room.

Dr Singh has an international reputation in the area of minimally invasive spinal surgery. He frequently teaches minimally invasive techniques to neurosurgeons and spinal surgeons from around the world. He has given lectures at some of the finest institutions in America and across the world. He is also extensively involved in designing new minimally invasive spinal instrumentation for cutting-edge spinal surgery for which he holds several patents.



Alexander R Vaccaro MD PhD graduated Summa Cum Laude from Boston College in 1983 with a BS in Biology. He received his MD degree from Georgetown University School of Medicine where he was promoted with "Distinction". He earned membership in the Alpha Omega Alpha (AOA) Honor Society and graduated with honors in 1987.

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He has over 560 peer-reviewed and 189 non-peer reviewed publications. He has published over 300 book chapters. He is the editor of over 47 textbooks and co-editor of OKU-Spine I and editor of OKU-8. Dr Vaccaro is the Co-Fellowship Director of the Spinal Service at Thomas Jefferson University Hospital where he instructs current fellows and residents in the diagnosis and treatment of various spinal problems and disorders.

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