



Surgical Approach Decision-Making

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Pearls/Pitfalls

- Plain neutral, flexion, and extension films are essential for a full radiographic evaluation of degenerative cervical myelopathy and radiculopathy. Evaluation of this imaging provides valuable information regarding cervical alignment, stability, and preoperative planning.
- In order to provide successful surgical management of cervical spondylosis in the patient with radiculopathy and/or myelopathy, evaluating the need for decompression, maintenance, or improvement of cervical alignment and long-term stabilization is necessary.
- Most patients with multilevel myelopathy suffer from cord compression at the interspace as opposed to directly posterior to the vertebral body and thus are

excellent candidates for anterior segmental decompression and fusion.

- Posterior cervical approaches are reserved for lateral soft disc herniations and myelopathy due to multilevel congenital stenosis or ossification of the posterior longitudinal ligament which cannot be safely or adequately addressed with an anterior approach.
- In patients where larger foraminal decompression is desired after posterior cervical instrumentation, interfacet spacers have shown to increase foraminal area and provide high fusion rates while maintaining lordosis.

Introduction

Cervical spondylotic myelopathy is the most common cause of spinal cord dysfunction in the elderly [1]. The surgical approach must address the patient's neurologic symptoms, provide adequate decompression of the neural elements, and maintain or improve alignment and stability. Ideally the surgical approach should be cost-effective and have a low complication rate [2, 3]. The patient's clinical symptoms, location of compressive pathology, number of levels

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involved, and overall cervical spine alignment are critical when considering the surgical approach. Other factors to be noted include the body habitus, prior cervical procedures, and comorbidities especially smoking and steroid usage that may affect fusion potential. These components contribute to the decision process for a particular surgical approach to the cervical spine.

Technological advancements in instrumentation along with a better understanding of cervical spine biomechanics and alignment parameters have improved surgical outcomes, but the optimal approach is still defined by the specific details of each particular case [4]. Systematic-based reviews comparing the superiority or efficacy of different cervical spine approaches have been published; however given the heterogeneity of patient population and the variety of surgical techniques, drawing blanket conclusions can be difficult. There is evidence that provides direction in choosing a particular surgical approach, but in some instances, there is equipoise between anterior and posterior surgical strategies. This chapter presents a systematic approach to the surgical management of degenerative cervical radiculopathy and myelopathy.

General Considerations

Radiographic Evaluation

Determining the appropriate surgical approach requires a comprehensive evaluation of all pertinent radiographic data. Asymptomatic patients with imaging findings of degenerative changes do not require surgical intervention [5, 6]. The radiographic evaluation of symptomatic patients should include plain films in neutral, as well as flexion and extension, views. Sophisticated imaging to evaluate the neural structures is critical, and this may be accomplished with magnetic resonance imaging (MRI) or a postmyelogram computed tomography (CT). Patients with suspected ossification of the posterior longitudinal ligament, significant facet arthropathy, or bony foraminal stenosis should be evaluated with both

MRI and CT. In these cases, myelography is frequently unnecessary if there is an adequate MRI. Radionuclide bone scans are occasionally helpful to verify whether a facet joint is the potential pain generator but are not required in all patients.

Neutral, flexion, and extension radiographs are used for the evaluation of overall cervical alignment, instability, extent of spondylosis, disc height, facet changes, endplate sclerosis, and osteophytes. Baseline films are also useful to assess numerous alignment parameters after surgical intervention which are important to correlate clinical outcomes with radiographic data during follow-up [7]. Flexion and extension films are the most efficient means of accurately evaluating instability which is key to planning a successful surgery. Reversal of cervical lordosis and the presence of kyphosis on neutral radiographs are key drivers for performing an anterior surgery.

The imaging modality of choice for evaluation of the effect of cervical degenerative disease on the neural elements is MRI as it clearly outlines the subarachnoid space, central canal, and neural foramina. It also may demonstrate T1- and T2-weighted signal changes in the spinal cord which may be of prognostic significance. MRI can demonstrate a herniated disc and synovial cysts among other neural compressive entities [8].

CT is invaluable as a means to evaluate osseous anatomy, osteophyte formation, endplate sclerosis, facet degeneration, and bony foraminal stenosis. It is critical to obtain a CT in patients in whom ossification of the posterior longitudinal ligament (OPLL) is suspected on the MRI [6]. CT can direct the management in many ways. For example, patients with significant endplate changes or facet arthropathy as determined by CT are not optimal candidates for cervical arthroplasty [9].

If MRI or CT fails to provide clear visualization of the necessary structures, CT myelogram should be obtained. This is commonly the case in patients who have had prior instrumented fusions or where the pathology is at the cervical thoracic junction. CT myelography is the imaging modality of choice in patients who cannot undergo an MRI.

Cervical Spine Deformity

Our understanding of sagittal alignment has evolved especially in the last decade. Cervical lordosis and overall sagittal alignment have been correlated to the severity of myelopathy and general health scores. Cervical alignment also appears to be related to thoracolumbar spinal pelvic alignment [10]. Thoracolumbar deformity can influence cervical alignment and vice versa. Patients in whom a thoracolumbar deformity is suspected should also be evaluated with full-standing anteroposterior and lateral scoliosis radiographs. Patients symptomatic due to a cervical deformity in the absence of myelopathy or radiculopathy will benefit from correction of cervical deformity. The correction of symptomatic cervical deformities requires complex planning and frequently employs multiple sequential operative techniques, the review of which is outside the parameters of this chapter [11].

Surgical Decision-Making

The treatment of cervical spondylosis varies, and surgical decision-making is essential for an optimal outcome. Cervical radiculopathy often resolves with nonoperative therapy and the passage of time, but the same is not true of myelopathy. All of the literature supports the concept that cervical myelopathy is a progressive disease which only responds to surgical intervention [12–14].

Successful surgical management of cervical spondylosis in the patient with radiculopathy and/or myelopathy must address the following three elements: decompression of the neural elements, maintenance or improvement of alignment, and long-term stabilization. A secondary goal would be the preservation of motion, but this is only important if the first two issues are dealt with in a positive manner. The critical factors which help dictate the approach include the location of pathology in relationship to the spinal cord and/or nerve root(s), number of involved levels, presence of instability, and segmental and overall sagittal alignment. The treatment of

malalignment in the myelopathic patient also is directed by whether the deformity is fixed or reducible.

Anterior Cervical Approach

Anterior cervical approaches include anterior cervical foraminotomy, anterior cervical discectomy(ies) and fusion or arthroplasty, and cervical corpectomy(ies). Anterior approaches directly address pathology that involves the disc space and the vertebral body and are a key means of correcting or maintaining proper sagittal alignment. It is important to assess vocal cord function in all patients with previous anterior neck surgery. Patients with significant swallowing dysfunction or those who have had extensive cervical radiation may not be candidates for an anterior approach.

Anterior Cervical Foraminotomy

Patients with purely cervical radiculopathy may benefit from an anterior cervical foraminotomy. Since this chapter is focused on myeloradiculopathy, the anterior foraminotomy is not a treatment choice. Anterior microforaminotomy was first performed in 1968 and most recently described by Choi et al. [15]. This surgical approach is associated with an increased risk of Horner's syndrome and a high recurrence rate of symptoms. It should be reserved for very specialized indications [16].

Anterior Cervical Discectomy and Fusion

Anterior cervical discectomy and fusion (ACDF) is used in patients with cervical instability, kyphosis or paracentral or central disc herniation, radiculopathy, or myelopathy. An anterior cervical approach provides direct decompression of the neural foramina and central canal and stabilization of the disc space and is often an excellent means of restoring or at least maintaining proper sagittal

alignment. ACDF is not ideal in cases where the primary vector of spinal cord compression is posterior, such as may occur with ligamentum hypertrophy and multilevel congenital stenosis. Dural involvement in cases of OPLL is a relative contraindication to an ACDF. In patients with multilevel cervical disease with minimal involvement posterior to the vertebral body, ACDF is superior to corpectomy because of its increased ability to correct cervical alignment and superior immediate stabilization due to segmental grafting and fixation [17]. Most patients with multilevel myelopathy suffer from cord compression at the interspace as opposed to directly posterior to the vertebral body and thus are excellent candidates for anterior segmental decompression and fusion. ACDF allows for bilateral foraminal decompression at each treated level which is useful in many patients. In patients with radiculopathy alone, ACDF and posterior foraminotomy have comparable results [18]. The decision to treat posterior in these patients is predicated on the location of the neural compression of the exiting nerve root. If it is due to a lateral disc herniation or proximal neural foraminal narrowing, the outcomes are similar [19]. If not, the results may be disparate. Fusion rates at 12 months in one- and two-level ACDF have been reported to be 97% and 94% although the actual number may be lower given the fact that patients with myelopathy are more likely to have comorbidities which adversely affect fusion [20]. Although it has been reported that anterior and posterior approaches for the treatment of cervical spondylotic myelopathy are equal in terms of efficacy and safety, there is a growing body of literature which supports the anterior approach as being associated with better neurological improvement, better alignment, increased cost utility, and greater patient satisfaction [2, 17, 21–25].

Anterior Cervical Corpectomy and Fusion

Anterior cervical corpectomy and fusion is utilized in cases of anterior spinal cord compression that cannot be addressed with discectomy and fusion alone. In some patients, the pathology extends

beyond the disc space and is behind the vertebral body and cannot be adequately addressed with an ACDF alone. These are rather rare occurrences but they do present from time to time. There is a conception that to perform a corpectomy to decompress multiple levels is more efficient in terms of operative time but that has not been our experience. The same meticulous decompression of the foramina at each interspace is required in both instances, and this requires time. Additionally, it is more efficient in terms of time to place interbody devices as opposed to the cages or grafts to needed to reconstruct a vertebral body resection. Multilevel corpectomies require posterior instrumentation which further decreases the value of this technique [26, 27]. Patients with extensive cervical disease involving the retrovertebral space are probably best managed using a hybrid approach combining corpectomy(ies) and anterior cervical discectomy as opposed to corpectomies alone [28].

Cervical Arthroplasty

Motion-preserving options in the treatment of cervical degenerative disc disease can be accomplished with cervical arthroplasty [29]. The Food and Drug Administration (FDA) has approved the clinical effectiveness of cervical arthroplasty in one- and two-level applications with non-inferiority and superiority when compared to ACDF [30]. As the inherent goal of arthroplasty is motion preservation, patients with baseline limited neck movement are unlikely to achieve any additional benefit with cervical arthroplasty as opposed to decompression and fusion. Additionally, patients with osteoporosis or endplate damage are not good candidates for arthroplasty. There are 7-year data available to show superiority of arthroplasty over ACDF in appropriately selected cases [31].

Posterior Cervical Approach

Posterior cervical approaches include posterior cervical foraminotomy(ies), laminectomy, laminoplasty, and fusion. These procedures are gener-

ally reserved for lateral soft disc herniations, foraminal stenosis, and myelopathy due to multi-level congenital stenosis or OPLL which cannot be safely or adequately addressed with an anterior approach. Posterior cervical approaches are sometimes advocated because of physician comfort and avoidance of perceived difficult anterior cervical anatomy; however, in a retrospective nationwide database study of 8548 patients, the incidence of mortality and inpatient complications was higher in those patients undergoing posterior fusion [32]. A single institution study in patients with cervical spondylotic myelopathy alone showed overall complication rates were similar [22].

Posterior Cervical Foraminotomy

Patients with purely cervical radiculopathy without myelopathy may benefit from posterior cervical foraminotomy. It is used when clinical symptoms correlate to the involved nerve root on imaging. Compression can be from osteophyte formation, foraminal stenosis (frequently secondary to facet arthropathy), or a herniated disc. In rare cases, a synovial cyst may cause neural foraminal compression. A foraminotomy is not the best treatment strategy in patients with compression medial to the foramen, with myelopathy, instability, or kyphosis.

Cervical Laminectomy

Cervical laminectomy allows for multilevel decompression but can increase the risk of developing a deformity. While this technique may be useful in older individuals with very stiff spines, over 20% of patients who undergo laminectomy for cervical spondylotic myelopathy will develop kyphosis [33]. Because of the risk of kyphosis, the authors do not recommend laminectomy. Those with perceived “stiff” spines will not suffer from adding a fusion to the laminectomy procedure, and this is a safer and more complete treatment than laminectomy alone.

Cervical Laminoplasty

Cervical laminoplasty is utilized in relatively young patients with myelopathy due to congenital stenosis and good cervical spinal mobility [34]. It is critical that patients who have at least some lordosis are not kyphotic [35]. Primary anterior compression is a negative prognostic factor for neurologic recovery after laminoplasty [36]. We fully evaluate the C45 neural foramina with CT preoperatively and consider significant foraminal stenosis at this level as a contraindication to laminoplasty since it may increase the risk of developing a postoperative C5 palsy.

Cervical Laminectomy and Fusion

Patients with multilevel cervical stenotic myelopathy without irreducible kyphosis may benefit from laminectomy and fusion. As in other posterior approaches, the neurologic compression should be posterior to the cervical cord. If it is primarily anterior and there is relatively preserved lordosis, then a posterior decompression will usually allow for adequate indirect decompression. Posterior cervical instrumentation with lateral mass fixation is advocated as the method of choice for fixation given low complication rate. Posterior cervical instrumentation and fusion has been shown to improve neck pain significantly after surgery compared to those undergoing laminoplasty; however, there is a higher reoperation rate and increased cost associated with posterior cervical lateral mass fixation [37, 38]. In patients where larger foraminal decompression is desired after posterior cervical instrumentation, interfacet spacers have shown to increase foraminal area and provide high fusion rates while maintaining lordosis [39, 40]. Laminectomy and fusion does not appear to be a favorable means of improving sagittal alignment, and it is associated with a decrease in lordosis in most series [37, 41–43]. It is our practice to try and reposition the patient intraoperatively after decompression to optimize lordosis.

Combined Anterior and Posterior Approach

Combined cervical approaches are primarily used in cases of anterior and posterior compression of the spinal cord. Additionally, patients with multilevel anterior pathology requiring corpectomy involving three or more levels require supplemental posterior instrumentation, and patients with kyphosis undergoing posterior decompression for dorsal pathology will also need anterior decompression and fusion to address ventral draping of the spinal cord. Finally, patients with poor bone quality secondary to metabolic disease such as osteoporosis and severe renal disease or patients who are smokers may require supplemental fixation [44]. These are also used for the management of complex patients and require a level of decision-making which is outside the context of this chapter.

Case Presentations

Several case examples are illustrated to highlight key thought process in pursuing surgical approach decision-making.

Anterior Cervical Discectomy and Fusion

A 65-year-old male with history of right arm discomfort. On motor examination, there was slight weakness of his right triceps and tingling dysesthesias to light cutaneous stimulation in the C6 and C7 dermatomes on right. There were no long tract signs. Plain cervical radiographs reveal C2–C7 SVA of 35.1 mm, C2–C7 lordosis of 20.5 degrees, and no instability on flexion/extension views (Fig. 13.1a). MRI revealed degenerative changes at C5–C6 and C6–C7 with disc collapse, disc bulging with osteophyte formation, and bilateral neural foraminal narrowing, right greater than left (Fig. 13.1b, c). Given he has failed conservative management, and imaging findings of severe nerve compression, he was an excellent candidate for a two-level ACDF at C5/C6 and C6/C7 (Fig. 13.1d).

Discussion In this case, given the disc collapse and bilateral neural foraminal narrowing, an ACDF was an appropriate option.

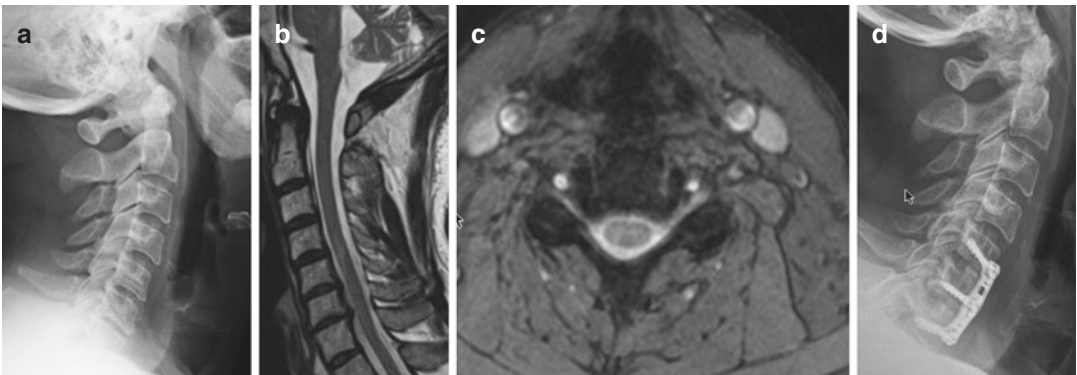


Fig. 13.1 (a) Plain neutral cervical radiograph demonstrating a C2–C7 SVA of 35.1 mm and C2–C7 lordosis of 20.5 degrees. (b) Sagittal and (c) axial T2-weighted magnetic resonance imaging (MRI) demonstrates degenerative changes at C5–C6 and C6–C7 with disc collapse, disc

bulging with osteophyte formation, and bilateral neural foraminal narrowing, right greater than left. (d) Plain cervical postoperative radiographs demonstrated C5/C6 and C6/C7 anterior cervical discectomy and fusion (ACDF)

Posterior Cervical Foraminotomy

A 35-year-old male with 1-year history of left neck, scapular, and arm pain who failed conservative management. The pain was worse when extending his neck or tilting it to the left. He also experienced numbness and tingling in the third–fifth digits and weakness in his left hand. On motor examination, he had a positive Spurling’s maneuver, tenderness in his neck to palpation, focal weakness in his handgrip and hand intrinsics, and

tingling dysesthesias to light cutaneous stimulation in the left C7 and C8 dermatomes. On neutral, flexion, and extension radiographs, there were degenerative changes from C3 to C7 and loss of disc height at multiple levels (Fig. 13.2a). On MRI, he has congenital stenosis with two large disc herniations at C6/C7 and C7/T1 eccentric to the left causing significant compromise of the foramina and nerve root compression (Fig. 13.2b–d). He underwent C6/C7 and C7/T1 foraminotomies which produced an excellent result.



Fig. 13.2 (a) Plain neutral cervical radiograph demonstrates degenerative changes from C3 to C7 and loss of disc height at multiple levels. (b) Sagittal T2-weighted MRI demonstrates congenital stenosis with two large disc

herniations. Axial T2-weighted MRI demonstrates (c) C6/C7 and (d) C7/T1 disc herniations eccentric to the left causing significant compromise of the foramina and nerve root compression

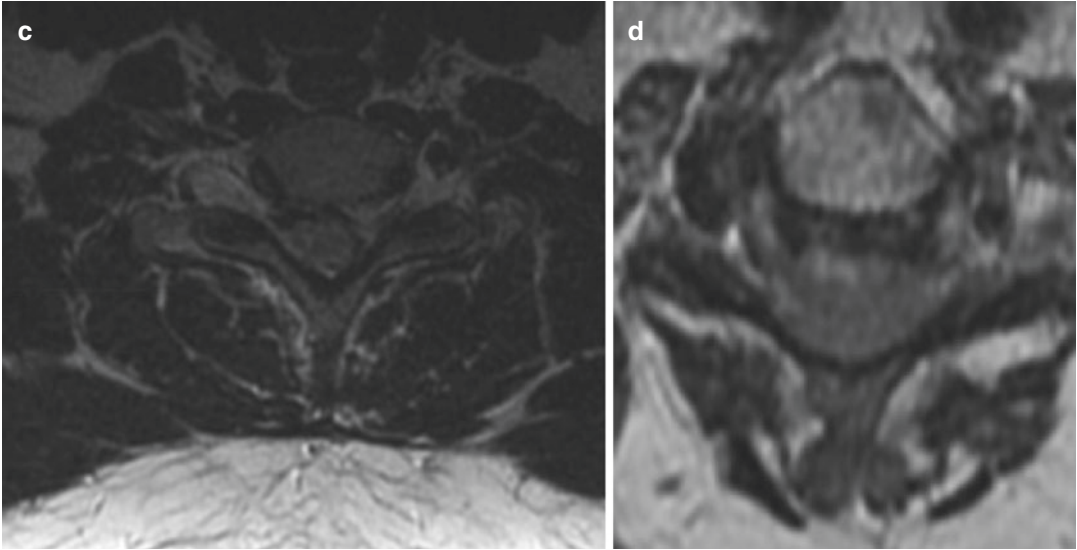


Fig. 13.2 (continued)

Discussion The patient did not want to proceed with ACDF because he wanted to spare motion. Posterior foraminotomy was an adequate treatment option given the lateral location of the disc herniation.

Posterior Cervical Laminectomy and Fusion

A 72-year-old male with recent history of recurrent falls, right constant lateral neck pain, and progressive weakness in his hands and his legs. On examination, he had difficulty with rapid movements of his hands, hyperactive reflexes, and positive Hoffman's and Babinski signs. Plain radiographs revealed good lordosis (Fig. 13.3a). MRI of the cervical spine revealed marked stenosis from C3 to C6 and cord signal change at the cord at C3 (Fig. 13.3b, c). The patient underwent C3–C5 laminectomies and C3–C6 posterior fusion.

Discussion This patient has progressive cervical myelopathy due to stenosis. Options dis-

cussed with the patient included laminoplasty or a laminectomy and fusion. Given his age and radicular symptoms which are likely due to C4 radiculopathy, laminectomy and fusion was a better option.

Anterior Cervical Arthroplasty

A 49-year-old female presented with right and shoulder pain, posterior neck pain eccentric to the right, and paresthesias radiating down in her arm. She did not have any gait abnormalities. On examination, she did not have neck tenderness. On motor testing, she has 4/5 strength in her right triceps and hypesthesia in the right C7 dermatome. She did not have any long tract signs. On neutral radiographs, there is disc collapse at C5/C6 and some collapse at C6/C7. The C2–C7 SVA is 30.2 mm; C2–C7 lordosis is 3.4 degrees (Fig. 13.4a). Flexion and extensions with minimal movement at C5/6. MRI revealed degenerative changes at C5/C6 and C6/C7. At C6/C7 there is disc herniation which is central and eccentric

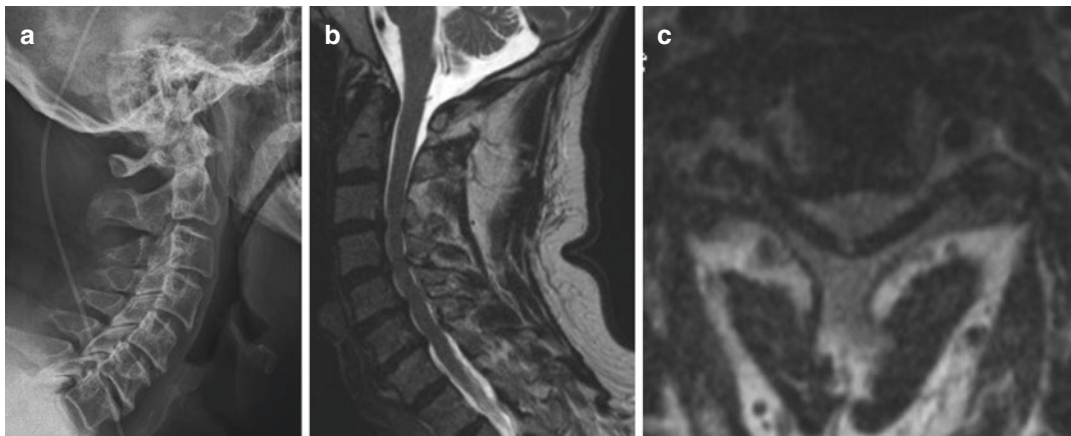


Fig. 13.3 (a) Plain neutral cervical radiograph demonstrates appropriate cervical lordosis. (b) Sagittal and (c) axial T2-weighted MRI demonstrates marked stenosis from C3 to C6 and cord signal change at the cord at C3

to the right causing significant neural foraminal stenosis of the exiting nerve root (Fig. 13.4b, c). She underwent a C6/C7 arthroplasty without complication (Fig. 13.4d).

Discussion Although the patient does have a narrow canal, there is no hypertrophy of the posterior ligamentous structures. Given her radiculopathy symptoms, age, and baseline neck mobility, arthroplasty was the chosen surgical option.

Posterior Cervical Laminoplasty

A 46-year-old male with several months of numbness and tingling in his hands as well as difficulty using his hands and trouble walking. On examination, he had difficulty with rapid movements of his hands. MRI of the cervical spine reveals marked spinal cord compression. Radiographs reveal good lordosis and no motion on flexion or extension films (Fig. 13.5a). MRI of the cervical spine reveals marked spinal cord compression (Fig. 13.5b, c). The patient underwent a C3 laminectomy and C4–C7 laminoplasty which resulted in the resolution of his symptoms (Fig. 13.5d).

Discussion Although a two-level decompression and arthrodesis would decompress the stenosis, there is significant posterior compression secondary to the congenital stenosis. There are also degenerative changes in the lower cervical spine which if he does become symptomatic would 1 day almost certainly require fusion.

Anterior-Posterior 360° Cervical Reconstruction

A 70-year-old man with a history of myelopathy was treated with a C3–C6 laminectomy. His myelopathy did not improve, and he developed significant neck pain which was most likely due to the postlaminectomy kyphosis (Fig. 13.6a). He was successfully treated with a multilevel anterior decompression and fusion followed with placement of posterior instrumentation (Fig. 13.6b). His neck pain resolved, and he improved in terms of his myelopathy.

Discussion Sagittal alignment is needed to be restored. A multilevel ACDF was able to restore alignment, while a posterior construct provided stability.



Fig. 13.4 (a) Plain neutral cervical radiograph demonstrates disc collapse at C5/C6 and some collapse at C6/C7. The C2–C7 SVA is 30.2 mm; C2–C7 lordosis is 3.4 degrees. Flexion and extension radiographs revealed minimal movement at C5/C6 (not pictured). (b) Sagittal T2-weighted MRI revealed degenerative changes at C5/

C6 and C6/C7. An (c) axial T2-weighted MRI at C6/C7 demonstrated a disc herniation primarily central and eccentric to the right causing significant neural foramen stenosis of the exiting nerve root. (d) Postoperative plain neutral cervical radiographs revealing a C6/C7 arthroplasty



Fig. 13.5 (a) Plain neutral cervical radiographs reveal appropriate cervical lordosis and no motion on flexion or extension films (not pictured). (b) Sagittal and (c) axial T2-weighted MRI of the cervical spine reveals marked

spinal cord compression. (d) Postoperative plain neutral radiographs demonstrating a C3 laminectomy and C4–C7 laminoplasty

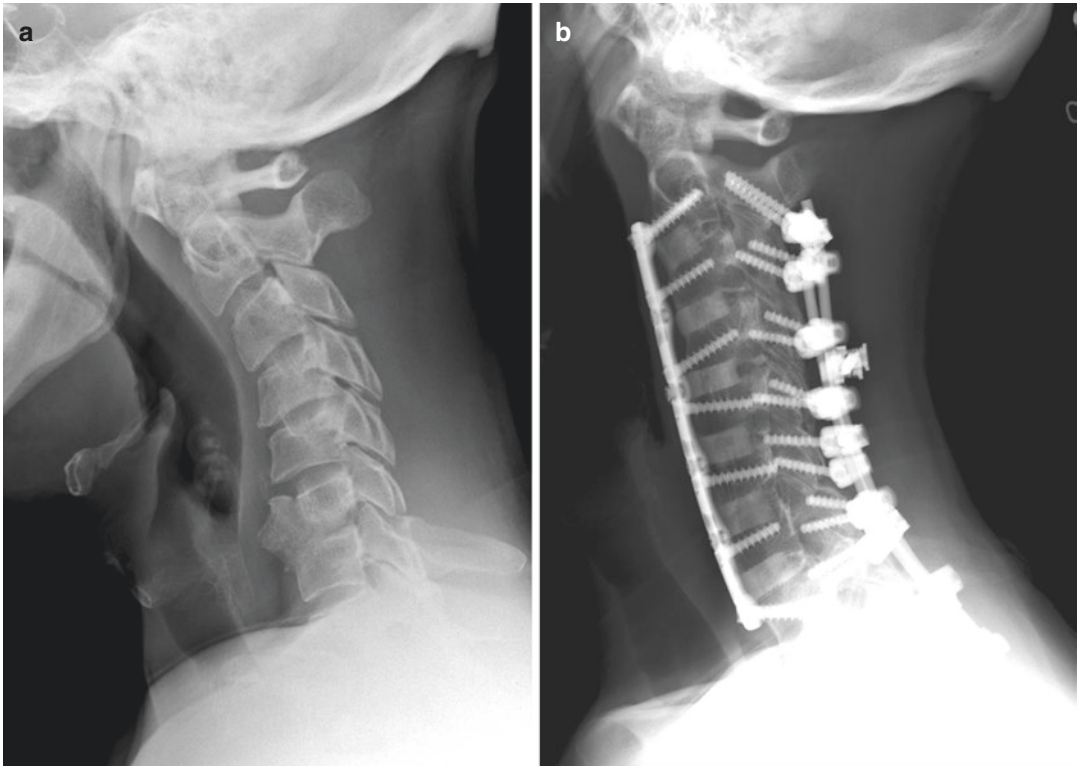


Fig. 13.6 (a) Plain neutral cervical radiograph revealing postlaminectomy kyphosis after a C3–C6 laminectomy. (b) Postoperative neutral cervical radiograph demonstrat-

ing a multilevel ACDF with posterior instrumentation from C2 to T3 with correction of cervical lordosis

Conclusion

Due to the heterogeneity of presentation, no stringent recommendations for one surgical approach over another for the treatment of cervical spondylotic myelopathy can be advocated. Rather it is an individualized decision-making process. It is clear that surgery is beneficial for patients with cervical spondylotic myelopathy. Systematic-based reviews have suggested surgical approaches with varying radiographic and clinical findings that are likely to be of benefit when addressing cervical degenerative disease.

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