Diagnosis and Treatment of Cervical Radiculopathy and Myelopathy

Jean-Christophe A. Leveque, MD[a], Bintu Marong-Ceesay, MS[b], Teresa Cooper, MN, MPH[c], Chris R. Howe, MD[d,*]

KEYWORDS

• Cervical • Radiculopathy • Myelopathy • Anterior cervical discectomy and fusion • Foraminotomy

KEY POINTS

- The surgical treatment of degenerative discs is generally discouraged.
- Symptomatic cervical radiculopathies can improve with nonoperative management.
- The decision to pursue surgery, or surgical consultation, is appropriate when myelopathic symptoms are present.

INTRODUCTION

The following guideline is intended as a community standard for health care providers who treat injured workers or others with symptomatic cervical pathology. The guideline aims to help ensure that the diagnosis and treatment of cervical neck conditions are of the highest quality. The emphasis is on accurate diagnosis and curative or rehabilitative treatment.

The recommendations are based on the best available clinical and scientific evidence from a systematic review of the literature, and on a consensus of expert opinion when scientific evidence was insufficient. The following table summarizes the recommendations:

CERVICAL SURGERY REVIEW CRITERIA

Disclosures: None.

[a] Group Health, Seattle, Washington, USA; [b] Department of Health, Olympia, Washington, USA; [c] Department of Labor and Industries, Olympia, Washington, USA; [d] Proliance Orthopedic Associates, Renton, Washington, USA

* Corresponding author. Proliance Orthopedic Associates, 4011 Talbot Road South, Suite #300, Renton, WA 98055, USA.

E-mail address: c.howe@proliancesurgeons.com

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A Request May Be Appropriate for	And the Diagnosis Is Supported by These Clinical Findings			And This Has Been Done (if Recommended)
Surgical Procedure & Diagnosis	Subjective	Objective	Imaging	Conservative Care
Surgery (in general) for: neck pain without subjective, objective, and imaging evidence of radiculopathy or myelopathy	Surgery is not recommended (the surgical treatment of disc degeneration or facet arthropathy without an associated radiculopathy or myelopathy is not well established in the literature and is generally contraindicated			
ACDF, TDA, laminotomy, foraminotomy for: radiculopathy single level	Sensory symptoms (radicular pain and/or paresthesias) in a dermatomal distribution that correlates with involved cervical level	Motor deficit OR Reflex changes OR Positive EMG Findings should correlate with involved cervical level	MRI OR Myelogram with computed tomography (CT) scan Abnormal imaging read by radiologist (moderate-to-severe foraminal stenosis) that correlates nerve root involvement with subjective and objective findings	At least 6 weeks[a] of conservative care, such as: • Physical therapy emphasizing active modalities • Osteopathic manipulation • Chiropractic manipulation • Anti-inflammatory medication • Epidural injections
	AND		AND	AND
		OR	In the case of discordant reading between surgeon and radiologist, an independent radiologist opinion is needed	[a]In the case of clear motor deficit after an acute injury, the 6 weeks of conservative care are not required
	Sensory symptoms (radicular pain and/or paresthesias) in a dermatomal distribution that correlates with involved cervical level	A positive response to a selective nerve root block, as determined and documented by the interventionist, in the case of complaints of radicular pain without motor, sensory, reflex or EMG changes. Criteria for selective nerve root blocks (see page 9 for details): • Use low-volume(≤1.0 cc) local anesthetic, with fluoroscopy or CT scan • No sedation should be given with SNRB, except in extreme cases of anxiety • Document a baseline level of pain • Meaningful improvement in pain (80% improvement from pre-block baseline, or 5-point change on VAS) • Only one level of surgery will be approved if SNRB is the sole basis for objective diagnosis		

ACDF, TDA, laminotomy, foraminotomy, or corpectomy for: radiculopathy—2 levels	A 2-level surgery may be considered if the following criteria are met: All of the criteria previously described for single-level fusion (not including SNRB) are present at the primary level, AND • The adjacent level has radicular pain correlating with at least moderate foraminal stenosis or lateral recess herniation, OR • EMG changes, muscle weakness, or reflex changes that indicate involvement of the adjacent level If the first level has no findings except the response to SNRB, a second level is generally not recommended Total disc arthroplasty is contraindicated in the presence of moderate-to-severe facet arthropathy or measurable instability (>3.5mm) and/or >11° of rotational difference to either adjacent level
ACDF, laminotomy, foraminotomy, or corpectomy for: radiculopathy-3 or more	All the objective criteria previously described for single-level radiculopathy, which does not include SNRBs, must be met for each level for which surgery is being requested
ACDF, laminotomy, foraminotomy, or corpectomy for: adjacent segment pathology	There is insufficient evidence in the medical literature to support a causal link between symptomatic adjacent segment pathology and cervical fusion; therefore, treatment for ASP should generally not be accepted in workers' compensation claims, unless there is compelling radiographic evidence that previous surgery has directly compromised (eg, hardware displacement) the adjacent segment

ACDF, TDA, laminectomy ± fusion, or corpectomy for: myelopathy, single- level	History of: Hand clumsiness or incoordination, gait disturbance, bowel or bladder dysfunction, AND	A combination of abnormal lower and upper motor neuron findings in upper extremities OR Upper motor neuron signs in the lower extremities Examples: • Loss of fine motor control • Weakness • Hand clumsiness • Gait disturbance • Bowel or bladder dysfunction • Increased tone in arms and/or legs • Hyperactive reflexes including Hoffman sign and/or clonus	Myelogram with CT scan OR MRI Abnormal imaging that correlates with subjective and objective findings: AND Cord signal change OR Compression with loss of circumferential CSF signal OR Stenosis (≤8mm AP diameter) In the case of discordant reading between surgeon and radiologist, an independent radiology opinion is recommended	Not required if there is evidence of myelopathy

<table>
<tr><td>ACDF, laminectomy ±fusion, laminoplasty, corpectomy for: myelopathy, multilevel</td><td colspan="4">If the criteria previously described, including imaging findings, are met for single-level myelopathy, the levels of surgical intervention are generally deferred to the surgeon given the complexity of surgical decision making</td></tr>
<tr><td>Repeat surgery for: pseudarthrosis</td><td>Axial neck pain
AND</td><td>No definitive physical examination findings
AND</td><td>CT finding of nonunion (after 1 year or more)
OR
Hardware failure
OR
Flexion/extension radiographs showing >2 mm of interspinous motion.

CT SPECT if previously described findings not definitive</td><td>Repeat surgery for pseudoarthrosis is generally not considered until 1 year after original surgery</td></tr>
<tr><td>Repeat Surgeries at same level not due to pseudarthrosis</td><td colspan="4">All the criteria described previously for single-level radiculopathy must be met

Consideration for repeat surgeries should proceed with considerable caution; there should be documented and substantial improvement in pain and function on a validated instrument after the first surgery before a second surgery will be approved or a clear documented reason for lack of improvement after the initial procedure</td></tr>
<tr><td>Hybrid Surgeries (defined as a ACDF next to a TDA)</td><td colspan="4">The department considers hybrid procedures to be investigational. There is insufficient evidence in medical literature to permit conclusions on its safety and efficacy</td></tr>
</table>

Abbreviations: ACDF, anterior cervical discectomy and fusion; AP, anteroposterior; ASP, adjacent segment pathology; CSF, cerebrospinal fluid; EMG, electromyography; SPECT, single-photon emission computed tomography; SNRB, selective nerve root block; TDA, total disc arthoplasty; VAS, visual analogue scale.

[a] For nicotine users: Abstinence from nicotine is recommended for all fusions and repeat fusions done for radiculopathy. This does not apply to progressive myelopathy or motor radiculopathy.

BACKGROUND AND PREVALENCE

Neck-related pain is common in both the workers' compensation and general populations. Many cases of axial neck pain are temporary and will resolve with time and nonoperative treatment.[1] It can be difficult to distinguish between an acute or chronic condition related to work and the chronic pain and degeneration associated with aging.

Cervical degenerative disc disease (DDD) is a common cause of pain and disability, affecting approximately two-thirds of the US adult population.[1] Most symptomatic cases present between the ages of 40 and 60,[2] although many individuals never develop symptoms. MRI studies have documented the presence of DDD in 60% of asymptomatic individuals aged greater than 40 years and 80% of patients over the age of 80 years (**Figs. 1** and **2**).[3,4] Previous neck injuries, cervical strains, and arthritis increase the risk of developing DDD, which may result in the development of abnormal bony spurs (spondylosis). Less commonly, cervical DDD progression and its sequelae may directly compress parts of the spinal cord (myelopathy), affecting gait and balance. It may also result in foraminal narrowing, compressing the exiting nerve root (radiculopathy), resulting in a dermatomal distribution of numbness, pain or parasthesias, or a myotomal distribution of weakness (**Figs. 3** and **4**).

Treatment options for DDD include conservative and surgical measures. In the general population, the rate of surgery for degenerative disc disease of the cervical spine increased 90% between 1990 and 2000.[5] In elderly patients in the United States, rates of cervical fusions rose 206% between 1992 and 2005.[6] Annual costs for anterior cervical fusions increased 3 fold ($1.62 billion to $5.63 billion) between 2000 and 2009.[7]

ESTABLISHING WORK-RELATEDNESS

The etiology of radiculopathies and myelopathies can be multifactorial or unknown. A cervical condition presenting with a history of radiating arm pain, scapular pain,

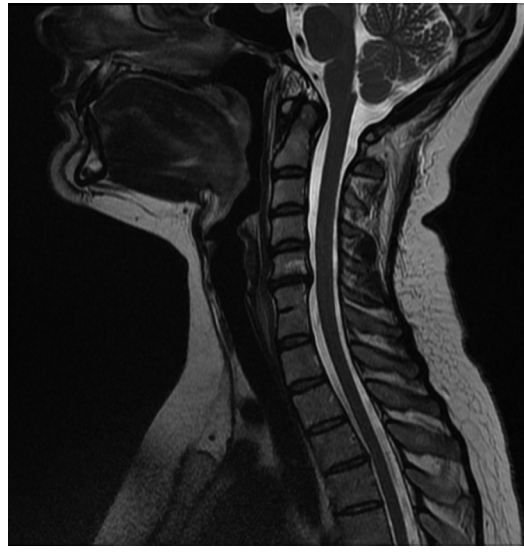

Fig. 1. Sagittal magnetic resonance image demonstrating mild degenerative cervical changes at C5/6 in a patient with moderate neck pain but no radicular or myelopathic syptoms.

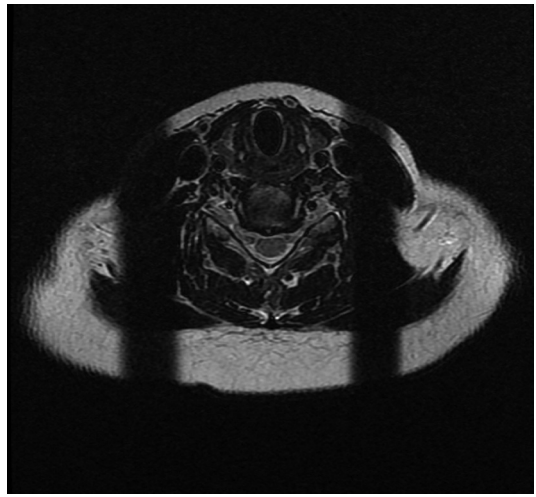

Fig. 2. Axial magnetic resonance image in the same patient showing disc bulging but no central or foraminal stenosis.

diminished muscle stretch reflexes, loss of sensation, or motor weakness may be classified as an occupational injury or occupational disease depending upon the circumstances giving rise to the condition. If there was a single inciting event that occurred within the work environment resulting in objective medical findings, the condition is likely the result of an occupational injury. If there was no single inciting event, the condition may have risen as the result of an occupational disease. The pain and other manifestations of both industrial injuries and occupational diseases generally become

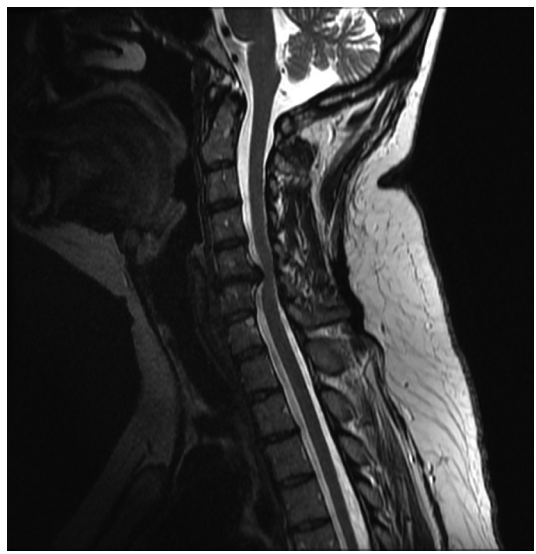

Fig. 3. Sagittal magnetic resonance image demonstrating a large focal disc herniation at the C5/6 level causing radicular pain and weakness.

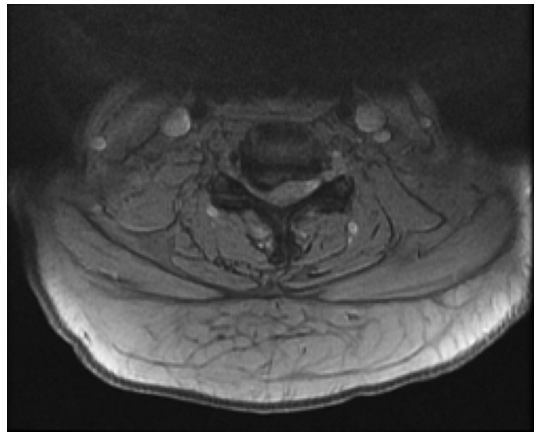

Fig. 4. Axial magnetic resonance image in the same patient demonstrating a large right C5/6 disc herniation with severe foraminal narrowing.

evident within 3 months of the inciting event. For this reason, a condition reported for the first time more than 3 months after a patient was first seen by a provider may not be industrially related. Attribution of such a condition to an industrial event should be based upon careful analysis and thoroughly documented.

Cervical Conditions as Industrial Injuries

Mechanisms of injury to the cervical spine may include distortion of the neck caused by sudden movement of the head, being struck by an object, or a fall from a height.[8–10] Examples of these injuries include motor vehicle crashes, high impact accidents, explosions, and gunshots.[11–13]

An acute injury to the cervical spine should be clinically diagnosable as work-related within 3 months of the injury. For an injury claim to the neck to be accepted beyond 3 months, the attending provider should be able to present substantial evidence linking symptoms directly to the initial industrial injury. Claims with insufficient documentation linking clinical symptoms to the initial industrial injury beyond 1 year should generally not be accepted.

Cervical Conditions as Occupational Diseases

Cervical spine conditions may also develop as a natural consequence of aging, resulting in the deterioration of the cervical disc. To establish a diagnosis of an occupational disease all of the following are required:

1. Exposure—workplace activities that contribute to or cause cervical spine conditions
2. Outcome—a diagnosis of a cervical spine condition that meets the diagnostic criteria in this guideline
3. Relationship—for a cervical condition to be allowed as an occupational disease, the provider must document that, based on generally accepted scientific evidence, the work exposures created a risk of contracting or worsening the condition relative to the risks in everyday life, on a more-probable-than-not basis (*Dennis v. Dept. of Labor and Industries*, 1987).[14] In epidemiologic studies, this will usually translate to an odds ratio (OR) of at least 2.

MAKING THE DIAGNOSIS

History and Clinical Examination

The classic presentation of cervical radiculopathy includes radiating arm pain, scapular pain, diminished muscle stretch reflexes, loss of sensation, and motor weakness, with or without neck pain. Cervical myelopathy is characterized by loss of motor control, hand clumsiness, gait disturbances, spasticity, and bowel or bladder dysfunction.

Diagnostic Testing—Imaging/Myelogram/Electromyographys

Requirements for diagnostic testing and imaging are specified in the criteria table. The basis for the selection of a diagnostic imaging procedure should be based on the information obtained from a thorough clinical examination.

Selective Nerve Root Blocks

Selective nerve root blocks (SNRBs) are only considered criteria for surgery when a worker presents with radicular pain, imaging findings, and a history of 6 weeks of conservative care (as in the criteria table), but does not have the objective signs of motor, reflex or EMG changes. SNRBs should be used only under particular circumstances:

- The worker has clear sensory symptoms indicative of radiculopathy or nerve root irritation.
- The worker's symptoms and examination findings are consistent with injury or irritation of the nerve root that is to be blocked.
- Injury or irritation of the nerve root to be blocked has not been shown to exist by electrodiagnostic, imaging, or other studies.

It is recommended that the provider giving the injection has the principal responsibility to document the outcome of the selective nerve root block. The provider should

- Perform a preinjection examination and document the pain intensity using a validated scale
- Explain to the worker the use and importance of the postinjection pain diary
- Use low-volume local anesthetic ($\leq$1.0 cc) without steroid for the selective nerve root block; conscious sedation should not be used in the administration of SNRBs, except in cases of extreme anxiety. If sedation is used, the reason(s) must be documented in the medical record, and the record must be furnished to the department or self-insurer
- Administer the selective nerve root block using fluoroscopic or computed tomography (CT) guidance. An archival image of the injection procedure must be produced, and a copy must be provided to the department or self-insurer (**Fig. 5**).
- Onset (within 1 hour) of pain relief should be consistent with the anesthetic used; duration generally lasting 2 to 4 hours.
- Keep the worker in the office for 15 to 30 minutes after the injection if possible, and assist with starting the pain diary.
  - Immediately preceding the block, the worker should record the level of pain using a validated scale. Every 15 minutes thereafter, for at least 6 hours following injection, the worker should indicate his or her level of pain. For the remaining waking hours during the 24 hours following the administration of the block, hourly documentation of pain levels is desirable.
  - An example of a pain diary is included in this guideline. Pain must be measured and documented using validated tools such as a visual analog scale or a 10-point scale. See labor and industries (L&I's) opioid prescribing guideline

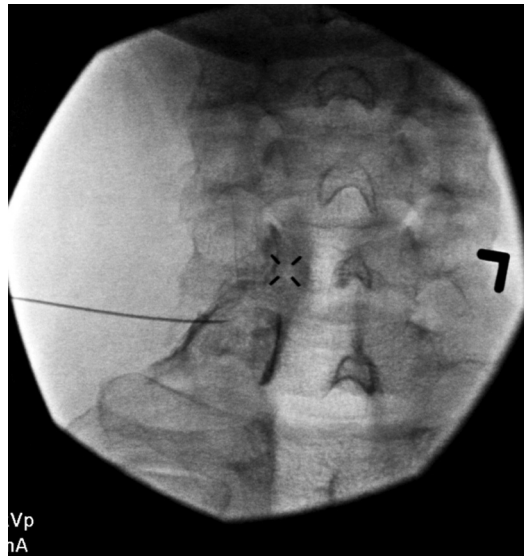

Fig. 5. Fluoroscopic image during a selective nerve root block demonstrating contrast dye outlining the region of injection along the C7 nerve.

(www.opioids.LNI.WA.GOV) for a 2-item graded chronic pain scale, which is a valid measure of pain and pain interference with function.

- Document the effect of the block.
  - A positive block is indicated by
    - An overall 80% improvement in pain or pain reduction by at least 5 points on a 10-point scale or visual analog scale
    - Pain relief that lasts an amount of time consistent with the duration of the anesthetic used
  - A negative block may be indicated by
    - No pain relief or less than 5 points on a 10-point scale or visual analog scale
    - Pain relief that is inconsistent in duration with the usual mechanism of action of the local anesthetic given
- Ensure that the surgeon and the department or self-insurer receive the previously described information.

If the block is negative, surgery is generally not recommended. Only 1 level of surgery should be considered if the sole basis of the objective diagnosis is the SNRB.

TREATMENT

Conservative Treatment

Conservative management of cervical radicular symptoms may include active physical therapy, osteopathic manipulation, chiropractic manipulation, traction, nonsteroidal anti-inflammatory drugs (NSAIDs) and steroid injections.

- There is some evidence that an active treatment approach results in better outcomes.[15,16] Physical therapy accompanied by home exercise for 6 weeks has been shown in a randomized trial to substantially reduce neck and arm pain for patients with cervical radiculopathy.[17]

- Steroid injections may provide short-term pain relief for patients with radiculopathy,[18,19] although they are not without risks. The injection typically includes both steroid and a long-acting anesthetic. See Washington States L&I's guideline on spinal injections at http://www.lni.wa.gov/ClaimsIns/Providers/TreatingPatients/TreatGuide/spinal.asp.

There is a warning about epidural steroid injections. On April 23, 2014, the US Food and Drug Administration (FDA) put out a warning that the injection of corticosteroids into the epidural space of the spine may result in rare but serious adverse events, including loss of vision, stroke, paralysis and death (FDA Drug Safety Communications 4-23-2014).[20]

Surgical Treatment

The ideal surgical approach for radiculopathy related to herniated disc remains a matter of debate. Various studies have compared the different surgery types and found no significant difference among them. Cervical surgeries can be divided into 2 major approaches: anterior (with or without fusion) and posterior.

Anterior cervical decompression alone

Discectomy is a surgical procedure to remove part of a herniated disc to alleviate pressure on the surrounding nerve roots. Discectomy is generally a safe procedure with associated risk such as dysphagia, pseudoarthrosis, and nerve damage. Studies, albeit dated, comparing discectomy with discectomy plus fusion have found no statistically significant difference between simple discectomy and discectomy followed by fusion in the treatment of cervical radiculopathy.[21–23]

Posterior surgeries

Posterior cervical laminotomy/foraminotomy is a highly effective therapeutic procedure for both myelopathy and radiculopathy, as it maintains cervical range of motion, and minimizes adjacent segment degeneration.[24–26] Kyphosis, incomplete neurologic decompression, and continued persistent neck pain have been concerns with posterior foraminotomies, but studies have shown it to be comparable to anterior cervical discectomy with fusion (ACDF) in clinical outcomes.[27–29]

Anterior cervical discectomy with fusion

Anterior cervical fusion surgery has become a standard treatment for cervical disc disease, and it is a proven intervention for patients with myelopathy and radiculopathy as it affords the surgeon the ability to provide direct (from the discectomy) and indirect (through restoration of disc height) decompression and stabilization.[30–32] Various implant and graft devices have been developed for use with ACDF.[21,22]

Total disc arthroplasty

Total disc arthroplasty (TDA) has been proposed as a viable alternative to ACDF. The theoretic basis for cervical arthroplasty is that it maintains motion and may decrease the likelihood of adjacent segment disease and therefore reduce the rate of reoperations.[33,34] Various studies have shown similar outcomes for ACDF and TDA.[35–37]

TDA is not indicated for cervical disease at more than 2 levels. Various devices have FDA approval for single-level TDA, and the FDA has also approved a single devise maker for 2-level adjacent disc arthroplasty in 2013. These devices are indicated for skeletally mature patients for reconstruction of disc following discectomy at a single level or adjacent (in the case of the Mobi-C) levels for radiculopathy or myelopathy.

Patients should have failed 6 weeks of conservative treatment or demonstrate progressive signs and symptoms.

Multilevel surgeries

For radiculopathy, a multilevel (2 levels or more) surgery may be considered if all of the criteria for a single-level surgery, not including SNRBs, are present at each level being considered for surgery. Multilevel fusion for myelopathy is more common and may be done if indications are met (Figs. 6 and 7).

A condition requiring at least 2 levels of surgery is unlikely to be a work-related injury or disease. All requests for 3 or more levels under a worker's compensation program should be pursued with caution.

Hybrid surgeries

Hybrid surgeries combine artificial disc replacements and anterior cervical discectomy with fusion at select vertebral bodies (adjacent or nonadjacent) in a single procedure. There is insufficient evidence in the medical literature to permit conclusions on its safety and efficacy. In general, hybrid procedures are considered experimental and investigational. New evidence will be examined as it becomes available.

Repeat surgeries

Request for repeat surgeries should be pursued with caution and on an individual basis. There should be documented and substantial improvement in pain and function on a validated instrument after the first surgery before a second surgery will be approved or clear documentation of the reason for failure of the initial procedure.

Intraoperative monitoring

Somatosensory evoked potentials (SSEP) and motor evoked potentials (MEP) are sometimes used in neurologic and spinal surgeries. The use of intraoperative

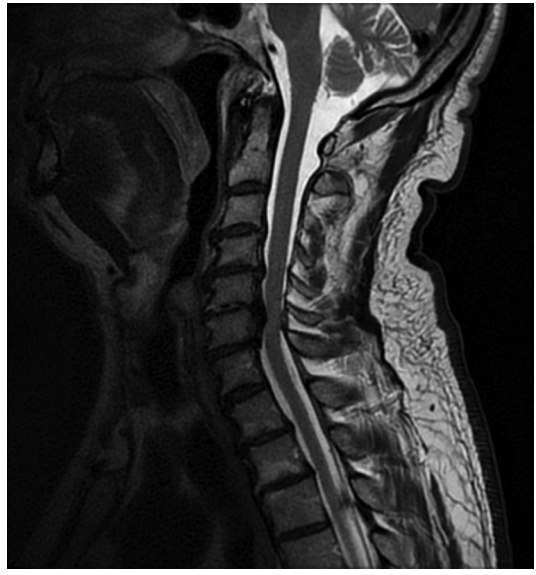

Fig. 6. Sagittal magnetic resonance image demonstrating multilevel central canal narrowing from C4/5 down through C6.

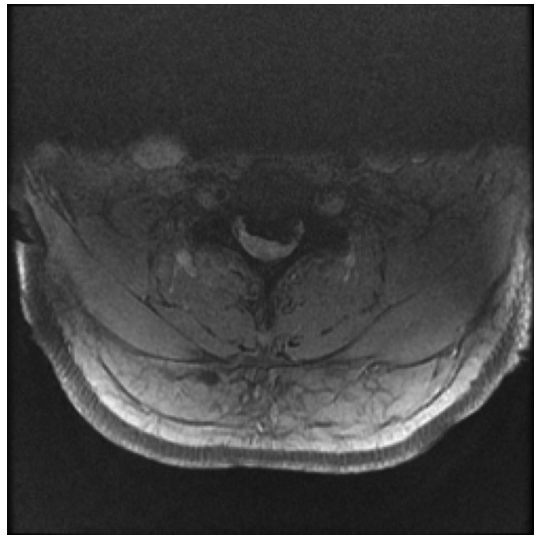

Fig. 7. Axial magnetic resonance image in the same patient demonstrating severe central canal narrowing at the C6 level.

neurophysiologic spinal cord monitoring is increasing despite a lack of consensus regarding accuracy, appropriate indications, and overall clinical benefits.[38–43]

The use of intraoperative monitoring for routine decompressive procedures (eg, discectomy or laminectomy) with or without fusion is generally discouraged. Intraoperative monitoring may be recommended for treatment of spinal deformities, traumatic dislocations, myelopathy, or posterior cervical instrumentation.[44]

Pseudarthrosis (non union)

Pseudarthrosis exists when there is a complete absence of bridging bone and either hardware failure or measurable instability. Symptomatic pseudarthrosis can be diagnosed based on clinical presentation and diagnostic imaging (**Fig. 8**). For a repeat surgery to be considered, CT SPECT or CT imaging showing nonincorporation of bone or flexion and extension radiograph showing interspinous motion greater than or equal to 2 mm is required.

A contributor to pseudarthrosis is smoking, as nicotine is a vasoconstrictor and also seems to block the ability of osteoblasts to form new bone.[45–47] Other patient-specific metabolic conditions such as diabetes may also contribute to nonunion.[48]

Smoking Cessation

Nicotine use is a strong contraindication to spine surgeries. Patients undergoing cervical fusions and repeat fusions for radiculopathy are required to abstain from nicotine for 4 weeks before surgery. In cases of myelopathy, smoking cessation is strongly encouraged but not required, since the progression of disease may preclude the time required for the patient to cease all nicotine-containing compounds.

ADJACENT SEGMENT PATHOLOGY

Adjacent segment degeneration, adjacent segment disease, and adjacent segment pathology (ASP) are terms commonly used to describe a degenerative pathology of the spine. The phenomenon of ASP is not fully understood. It has been predicted

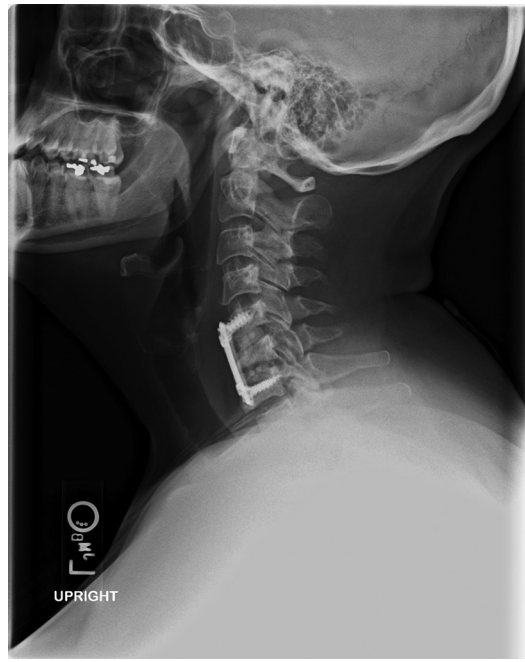

Fig. 8. Lateral radiograph of the cervical spine suggesting pseudoarthrosis at both operated levels, with bony nonunion and subsidence of the lower graft. Confirmation of pseudoarthrosis would require CT imaging.

that more than 25% of all patients would develop ASP during the first 10 years after ACDF.[49]

It remains unclear as to whether these conditions are related to altered biomechanics or represent the natural history of the cervical spine. It has been suggested that excessive motion of segments adjacent to a fixed fusion leads to an increased risk of disc degeneration. Fusion has been associated with ASP, but various studies have failed to show that it is an isolated factor.[50,51] Adjacent segment pathology has been seen after both anterior and posterior surgeries, as well as noninstrumented cases, suggesting that other factors may be involved in accelerating pathologic changes.[52,53]

ASP has been the driving force for the development of new alternative treatment methods such as TDA. These options were theoretically designed to be ideal substitutes for ACDF because of their motion-preserving benefits.[32,54] However, short-term studies comparing ACDF with TDA have failed to show any significant difference in the rate of adjacent segment disease following surgery.[37,55–62]

There is insufficient evidence in the medical literature to support a causal link between symptomatic adjacent segment pathology and cervical fusion. Therefore, treatment for ASP will generally not be accepted under a workers' compensation program unless there is compelling radiographic evidence that previous surgery has directly compromised (eg, hardware displacement) the adjacent segment (**Figs. 9–12**).

MEASURING FUNCTIONAL IMPROVEMENT

The goal of treatment is to improve pain and function. Providers should measure and document functional improvement throughout conservative and surgical treatment.

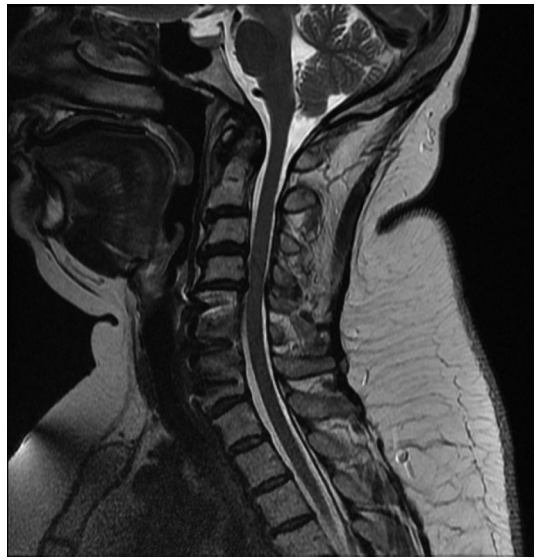

Fig. 9. Sagittal magnetic resonance image demonstrating C4/5 disc bulge in a patient with a previous C5/6 fusion. Further operative intervention at the C4/5 level would not be covered as adjacent segment failure.

Levels of pain must be documented when evaluating the results from SNRBs. Visual analog scales (VAS) or 0-point scales have been useful for this purpose. The 2-item graded chronic pain scale, as recommended in the L&I opioid prescribing guideline (http://lni.wa.gov/ClaimsIns/Files/OMD/MedTreat/FINALOpioidGuideline010713.pdf), is a simple way to document how much pain is interfering with function.

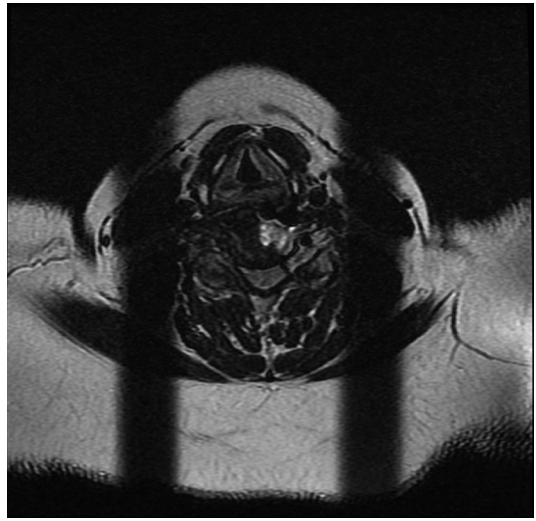

Fig. 10. Axial magnetic resonance image in the same patient demonstrating foraminal narrowing.

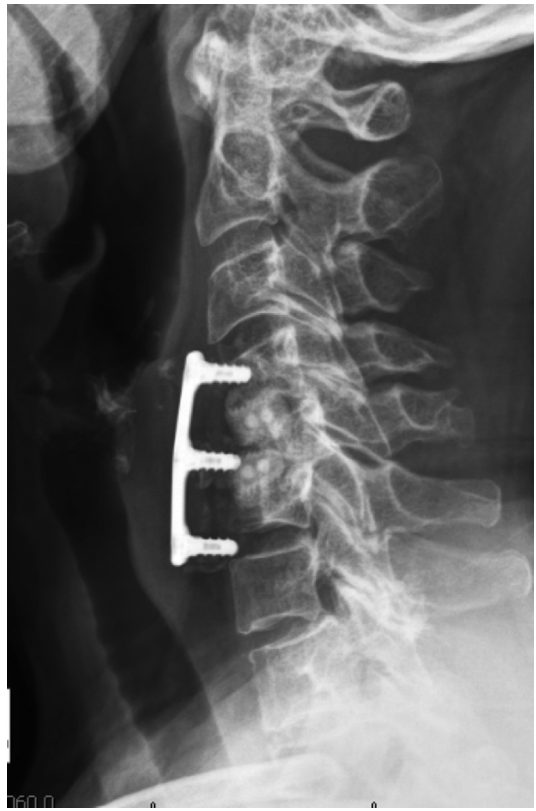

Fig. 11. Lateral radiograph image demonstrating a profound hardware failure and nonunion from a previous C fusion. Operative correction would generally be covered under the provision for symptomatic hardware failure.

The Neck Disability Index (NDI), Short Form Health Survey (SF)-36, SF-12, and VAS are tools recommended by the North American Spine Society (NASS) to assess pain and function and to measure outcome of treatment. Other validated scales and instruments may be used to document improvement or lack thereof.

POSTOPERATIVE PHASE AND RETURN TO WORK

It is important for the attending provider and the surgeon to focus on preoperative planning for postoperative recovery, reactivation, and return to work activities. During the immediate postoperative period, (6 weeks), the surgeon should help direct these activities. It is the responsibility of the attending provider to determine if the patient can be allowed to perform temporary duties with or without restrictions.

Pain relief will likely be a concern during recovery. Pain can be effectively managed with passive and active therapies, nonopioid pain relievers, or short-term opioids. For information and tools on how to use opioids in the perioperative period, see Washington State's L&I's opioid prescribing guideline at www.LNI.opioids.wa.gov.

Evidence shows that work accommodation combined with conservative care during the early recovery period can help prevent disability. Jobsite modifications are dependent on the nature of the patient's work tasks, his or her injury, and his or her response to rehabilitation. Typically, factors such as lifting, pulling, and repetitive overhead work

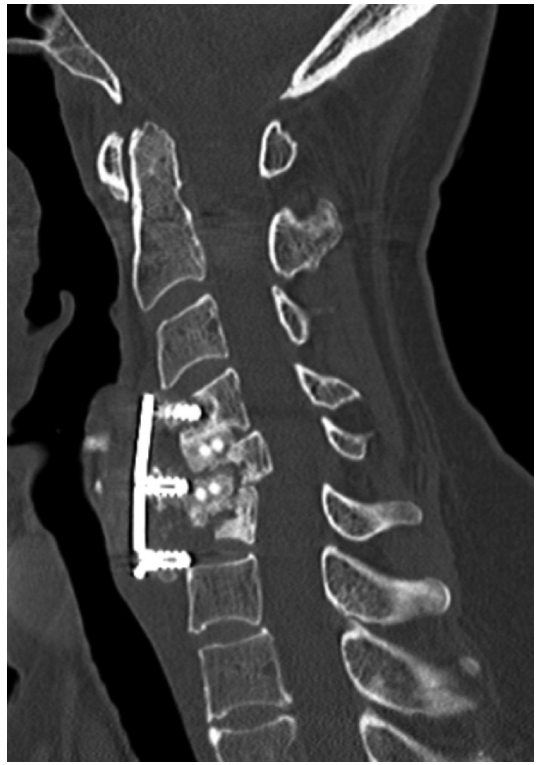

Fig. 12. Sagittal CT image in the same patient demonstrating loosening of the fixation screws and pseudoarthrosis of the interbody grafts.

require modifications in position, force, repetitions, and/or duration. Those workers returning to jobs with heavy lifting or prolonged overhead work may need additional weeks of rehabilitation.

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