

THE HISTORY AND NEUROLOGICAL EXAMINATION OF SPINE DISORDERS

Ligia Onofrei, MD
University of Utah
Salt Lake City, UT

When patients have neck or back pain and complaints of numbness, tingling, or weakness, a number of different specialists may participate in their evaluation, including neurologists, physiatrists, sports medicine specialists, pain specialists, orthopedic surgeons, or neurosurgeons. Patients may be referred to a neurologist for initial assessment of the symptoms as well as for clarification in more complex cases, when the etiology of the symptoms may be uncertain, but a neurological issue is suspected. Your job as a clinician is complex because patients often come with preconceived notions regarding their symptoms and potential treatments. You will need to risk stratify their symptoms and understand their primary concern but at the same time you will need to teach them about the complexities of the spine, appropriate imaging, and appropriate interventions.

The neck and low back are complex structures with virtually all of their components being potential sources of pain. Most commonly, we will be asked to evaluate patients with pain stemming from degenerative changes of the discs and vertebrae, however muscles and ligaments can also be significant contributors to pain. Furthermore, it is important to have at least some understanding of shoulder, hip, and SI joint anatomy and patterns of dysfunction as these structures can mimic dysfunction of the neck and low back respectively. Additionally, anxiety, depression, and other chronic medical conditions can affect patients' perception and experience of pain.

Low back pain and neck pain are incredibly common, with two thirds of adults experiencing spine pain at some point in their lives. Neck and low back pain account for approximately 2% of all office visits. Disability secondary to back and neck pain is considerable, with some patients requiring temporary and others permanent disability due to spine related conditions. Spine related disorders are costly, due to the compounded cost of time lost from work, office visits, medications, as well as imaging, procedures, and surgeries. In 2005, the estimated cost of medical care for patients with spine disorders was 86 billion dollars¹.

The history and physical exam have a crucial role in determining the source of the symptoms. As we obtain more advanced imaging of patients' spines, we have learned that the incidence of degenerative imaging findings in asymptomatic individuals is high². Therefore, correlating symptoms with imaging findings is a crucial first step in determining the appropriate intervention².

For the purposes of our lecture, we will use the definition of "arm" for the portion of the upper limb between the shoulder and elbow, "forearm" for the portion between elbow and wrist, and in the lower limb "thigh" between hip and knee, and "leg" between knee and ankle.

Please be aware, all figures are found in the power point slide set.

The history of spine disorders

Chief complaint: Allow patients to tell you in their own words why they have come for consultation. This is often helpful to set the agenda of the visit or to reveal their understanding of why they are coming to see you. Oftentimes, patients may not be fully aware why the referral has been placed. Also, if patients have more than two different areas of concern, this is an ideal time to focus the visit to one or two issues.

When symptoms started: It is important to clarify how long symptoms have been ongoing and whether they have worse or new symptoms.

Where the symptoms are: It is very important to clarify the exact distribution of the patients' symptoms. The use of a body diagram, where patients can draw the areas involved can further help clarify the distribution (Refer to **body diagram** in power point presentation). This step is a key step in the evaluation because it will help narrow the differential diagnosis by clarifying whether the symptoms are focused, such as a radiculopathy or mononeuropathy, or whether they are diffuse, such as a peripheral neuropathy or fibromyalgia. First clarify whether the symptoms are primarily axial (neck or low back) or whether they primarily involve the limb, or if there is a mixture of both. Most patients with radiculopathies have a mixture of neck/ low back and limb pain. Axial predominant pain suggests that the source of pain is myofascial or degenerative spondylosis (facet arthropathy, degenerated discs). Limb predominant pain with no axial involvement suggests the source of pain is peripheral (plexopathy, or peripheral nerve). Processes such as facet arthropathy and shoulder or hip dysfunction can cause some radiating pain into the upper arm, shoulder, trapezius muscle, hip, and upper thigh/buttock areas, but

the pain should not cross the elbow or knee¹. Patients may also have an incomplete radicular pattern. Patients can sometimes have pain that is restricted to a portion of the usual dermatomal distribution or may initially have symptoms which are limited and then evolve to involve the entire distribution of the dermatome. For example, patients with an L5 radiculopathy may only have very severe tenderness over the buttock and lateral area of the thigh. Similarly, some patients with C7 radiculopathy may only have severe pain which radiates into the scapula. Scapular or periscapular pain may be the result of C5, C6, C7, or C8 radiculopathies³.

Symptoms may be a mixture of pain, numbness and tingling, pure numbness, and weakness. Clarify the distribution of the symptoms. The areas of numbness and tingling may not overlap perfectly with the areas of pain given the slightly different distribution of dermatomes, myotomes, and sclerotomes¹. In patients with radiculopathy, limb symptoms tend to predominate.

For the purposes of this lecture, we will predominantly talk about symptoms resulting from cervical and lumbar dysfunction, as thoracic spine problems due to degenerative conditions are much less common than cervical or thoracic spine problems⁴.

Symptoms distribution by cervical root^{1,4} (Refer to Dermatome diagrams in power point presentation):

Nerve root	Pain distribution	Sensory distribution-generally follows dermatomal map	Weakness
C4	Neck, trapezius	Supraclavicular and suprascapular portions of the shoulder and torso	N/A
C5	Neck, scapula, shoulder, anterior/lateral arm	Antero/ lateral aspect of the arm	Shoulder abduction, shoulder external rotation; scapular retraction Less so elbow flexion
C6	Neck, scapula, shoulder, lateral arm and forearm	Antero/lateral aspect of (the arm) and forearm, lateral hand, 1 st and 2 nd digits	Elbow flexion, forearm pronation
C7	Neck, medial scapula, lateral arm, extensor surface of forearm	Dorsolateral arm, extensor surface of arm, extensor surface of hand, 2 nd and 3 rd digits	Elbow extension, wrist extension, finger extension
C8	Neck, medial scapula, medial aspect of arm, and forearm	Medial arm, medial forearm, medial hand, 4 th and 5 th digits	Finger abduction, finger adduction, finger flexion, wrist flexion
T1	Anterior chest, medial arm and forearm	Medial arm, anterior chest	Finger abduction, finger adduction, finger flexion, wrist flexion

Symptom distribution by lumbosacral root^{1,4} (Refer to dermatome diagrams in power point presentation)

Nerve root	Pain distribution	Sensory distribution-generally follows dermatomal map	Weakness
L1	Inguinal region	Inguinal region	None
L2	Back, iliac crest, inguinal fold, upper antero-medial thigh	Upper ventromedial thigh	Hip flexion, hip adduction
L3	Back, lateral hip, anterior thigh, (knee)	Anterior and medial thigh	Hip flexion, hip adduction, knee extension
L4	Back, lateral hip, anterior thigh, knee, anteromedial leg	Anterior thigh, medial knee, medial leg	Hip flexion, hip adduction, knee extension
L5	Back, lateral hip, posterolateral thigh, lateral leg	Anterolateral thigh, anterolateral leg, dorsum of foot, dorsum of great toe	Hip abduction, foot dorsiflexion, foot inversion/eversion, toe dorsiflexion, less knee flexion
S1	Back, buttock, posterior thigh, posterior calf, heel, lateral foot	Posterior thigh, posterior thigh, sole, lateral foot	Hip extension, knee flexion, plantarflexion
S2	Buttock and posterior leg	Posterolateral buttock, thigh, and calf	Possibly plantarflexion and hip extension
Lower sacral	Perineal, saddle	Perianal, gluteal	Bowel, bladder, sexual dysfunction

Please refer to dermatome diagrams in power point presentation for the diagram demonstrating the distribution of the thoracic dermatomes.

Myelopathy symptoms can be very subtle, with most patients having little if any pain. Myelopathy alone does not cause pain. Patients with myelopathy may have pain, which results either from concurrent radiculopathy or concurrent degenerative issues. Most patients with myelopathy present with somewhat vague symptoms in the early phases-dexterity issues, arm heaviness, subtle weakness or balance problems. As myelopathy progresses, symptoms evolve and patients may complain of worsened dexterity, dropping objects, weakness in the upper and

lower extremities, more pronounced gait difficulties, and more rarely bowel and bladder difficulties. The bladder difficulties are typically related to urinary urgency⁴. Sensory symptoms are variable, and may involve the arms, legs, and trunk. Alternatively, patients may have an acute to subacute presentation with symptoms which progress over days to weeks. One feature which can be very useful when present in patients with cervical myelopathy is the presence of C8 radicular symptoms in the absence of a radiographic cause for the radiculopathy. The proposed mechanism is that central stenosis causes engorgement of the venous plexus, which in turn exerts pressure on the C8 nerve root⁵.

Patients with claudication due to lumbar stenosis complain of a variety of symptoms such as heaviness, achiness, pain, numbness, or tingling in the legs with ambulation, with symptoms completely being relieved by sitting. Patients with lumbar stenosis have worse symptoms with lumbar extension and improved symptoms with lumbar flexion. Symptoms may be variable day to day. Patients may have symptoms which involve the low back, entire lower limbs, or just a portion of the lower limbs. Symptoms are typically bilateral, but they may also be unilateral. Patients with lumbar stenosis and claudication may also have superimposed radiculopathies or facet arthropathy.

Patients may also have significant pain due to facet arthropathy. Clinical symptoms suggestive of facet dysfunction include pain which is primarily in the neck or axial low back, with some radiation into the proximal portions of the upper and lower limbs⁶ (refer to figure in power point presentation or Reference 6 for full discussion). Typically, the limb pain caused by facet dysfunction does not cross the elbow or knee, although there have been reports of facet dysfunction causing referred pain which traveled below the knee⁶ (however, the foot was not involved). Upper to mid cervical facet dysfunction causes pain in the posterior occipital region and neck, while mid to lower facet dysfunction causes pain the neck, posterior scapular region, and around the shoulder girdle⁶. Lumbar facet joint dysfunction causes pain predominantly in the axial back, buttocks, and thighs, although the reported pain referral maps vary considerably⁶.

Symptoms referable to SI joint

As many as 15-30% of patients with back pain have symptoms referable to the SI joint⁷. Part of the reason why the SI joint symptoms can vary considerably in terms of presentation is that the symptoms may not be caused just by pathology of the joint itself, but also by involvement of surrounding muscles and ligaments⁷.

Another important distinction is to understand the difference between pain which is referred to the area of the SI joint vs. symptoms which are referred from the SI joint. The SI joint innervation is complex. The anterior portion of the joint receives innervation from the ventral rami of L5, S1 and S2⁸. The dorsal portion of the joint is innervated by the dorsal ramus of L5 and a plexus formed by the dorsal rami of the sacral nerves. The superior part of the joint and iliolumbar ligaments receive innervation from L2 and L3⁸. Disc protrusions or facet arthropathy in the low back as well as hip dysfunction can cause pain which is referred to the area of the SI joint. Pain stemming from dysfunction of the SI joint may present in multiple ways: pain in the buttock, groin area, or pain that radiates into the thigh and leg area, which should not include the foot^{7,8}. Most commonly, patients have pain in the buttock area, overlying the posterior superior iliac spine. Due to complex innervation and variability of presentation, clinical diagnosis based only on symptoms and physical exam can be difficult.

What type of symptoms: The key symptoms which we need to address are pain, numbness, tingling, and weakness. We will discuss later key symptoms which indicate red flags in the evaluation of patients. It is important to determine if the patient has a single problem accounting for all of their symptoms or if the patient has more than one problem (e.g., both a radiculopathy with neck and arm pain, and a carpal tunnel with tingling and numbness in the hand. Of course, patients with radiculopathy can have a combination of pain, numbness, and tingling in the distribution of the affected nerve root.

Additional important symptoms: Bowel/bladder issues, Lhermitte's phenomenon

Lhermitte's phenomenon refers to tingling down the spine and/or extremities with neck flexion and is caused by inflammation or compression of the cervical cord.

What makes symptoms worse or better: Inquire about specific activities such as standing, walking, sitting, lying down, lifting, etc. Each activity has the potential to irritate certain structures more than others, although significant overlap occurs. For example, cervical facet arthropathy is made worse by sudden neck movements such as with driving. Patients with cervical radiculopathy may feel better if they position their ipsilateral arm above their head. Lumbar stenosis is made worse by extension and improved by flexion at the waist. Pain which is worsened by coughing, straining, sneezing or other maneuvers which increase intra-abdominal pressure (Valsalva maneuver) is typical of nerve compression by a disk or other mass (e.g., tumor, abscess).

History of injury: Ask whether an injury preceded the symptoms and if so, clarify the nature and the details of the injury. Clarify the time relationship between the injury and the onset of symptoms. Patients have a tendency to attribute present symptoms to remote injuries.

History of surgery: Ask whether the patient has had prior neck or low back surgery. Prior neck and back surgery is important in a number of ways. If the patient has undergone a limited surgery such as laminectomy, foraminotomy, or discectomy, the previous problem may recur due to normal progression of degenerative changes, new disc protrusion, or due to formation of scar tissue. If the patient has undergone a fusion, new problems may appear at the level above and below the fusion due to adjacent segment degeneration. Other issues related to fusions include failure of fusion and hardware failure. If the patient can recall, clarify whether the symptoms which they are experiencing now are similar to their preoperative symptoms or if they are having new symptoms.

Clarify if additional symptoms are present: Patients often have coexisting issues, so it is important to clarify if any additional symptoms are present. Disorders such as radiculo-plexopathies, mononeuritis multiplex, shingles, motor neuron disease, autoimmune diseases, infectious diseases, neoplasms, and vascular claudication can mimic the presentation of degenerative spine conditions.

Radiculo-plexopathies: brachial or lumbosacral plexopathy sudden or subacute pain in the axilla or groin respectively, with limb numbness, tingling, pain; typically, the pain precedes the onset of sensory or motor symptoms.

Mononeuritis multiplex: Patchy sensory loss and motor weakness; typically not in the distribution of one nerve root.

Shingles: Pain and rash involving one dermatome; if the pain precedes the rash, the symptoms are very similar to radiculopathy.

Motor neuron disease: Patients with myelopathy can have symptoms that are strikingly similar to ALS, although patients with spondylotic cervical myelopathy should not have bulbar involvement or pseudobulbar affect.

Autoimmune disorders: MS, Sarcoid, Neuromyelitis optica. All of these disorders can cause spinal lesions which mimic the presentation of spondylotic myelopathy.

Infectious diseases: Similar to autoimmune disorders, these can cause spinal lesions which mimic spondylotic myelopathy .

Neoplasms: These can cause spinal lesions which mimic spondylotic myelopathy.

Vascular claudication: Symptoms of vascular claudication mimic symptoms of neurogenic claudication; it can be difficult to tell the two apart based purely on history and physical exam.

It is also important to know what symptoms should not be present in patients with degenerative disorders of the neck and back. Patients should not have symptoms which are referable to the cerebral hemispheres, brainstem, or neuromuscular junction.

Tarlov cysts: the true incidence is difficult to estimate, because in most people, Tarlov cysts are asymptomatic. Tarlov cysts consist of fluid filled sacs formed by meningeal dilation surrounding nerve roots typically as they leave the spine⁴. In most people, these cysts do not cause pain and should not be treated⁴. In rare cases, patients may have symptoms of CSF leak or radiculopathy due to the cysts⁴. Tarlov cysts do not cause isolated back pain.

History of recent hospitalizations/major illnesses and health changes: Obtain a brief history of recent health changes; certain situations may be particularly important, such as myelopathy symptoms which developed after an intubation, anterior thigh pain which developed after a femoral central line was placed, or groin pain with weakness and proximal lower limb weakness in a patient with risk factors for retroperitoneal hematoma.

The review of systems

The review of systems is important in clarifying whether there is the possibility of a systemic illness such as neoplasm, an autoimmune process, or an infectious process, etc.

The red flags

Even though we need to keep rare conditions in the back of our mind when evaluating patients with new onset back pain, they represent a relatively small percentage of the patients we evaluate. For example, in patients who present with low back pain, cancer is present in 0.7% of cases, spinal infection in 0.01% of cases, ankylosing spondylitis in 0.3%-5% of cases, pathologic fracture in 4% of cases, and cauda equina syndrome in 0.04% of cases⁹.

Key red flags which we should elicit include:

-for cancer: personal history of cancer, unexplained weight loss, failure of symptoms to improve for more than a month from onset, age greater than 50 or less than 20, or pain which increases when the patient is supine, typically when they are in bed at night⁹.

-vertebral infection: fevers/chills, recent IV drug use, recent infections/recent interventions on the spine/hospitalizations, or history of immunosuppression⁹.

-cauda equine syndrome: urinary retention, decreased ability to sense bladder fullness, decreased ability to sense passage of urine or stool, Severe or progressive motor weakness in the distribution of one or more lumbosacral nerve roots, fecal incontinence, saddle anesthesia a common misconception is that urinary incontinence is the presenting symptom; the most common symptom is actually urinary retention with secondary overflow urinary incontinence; look for a history of voiding difficulties or decrease in the need to urinate^{4,9}.

-vertebral compression fracture: trauma, older age, history or risk factors for osteoporosis, chronic use of corticosteroids⁹.

-ankylosing spondylitis: morning stiffness, improvement with exercise, alternating buttock pain, night time awakening due to back pain in the second half of the night, younger age at symptom onset⁹.

If you identify red flags in the history, official guidelines recommend obtaining appropriate imaging without delay. If red flags are not identified, then imaging can be delayed and conservative treatment should be instituted for 4-6 weeks or longer⁹.

While the red flags are felt to be helpful, the number of patients with cancer, vertebral infections, cauda equina, and vertebral compression fractures is quite low and there is some controversy whether these red flags are ultimately useful, or whether they lead to unnecessary imaging. One study by Downie et al examined the diagnostic accuracy of red flags to screen for fracture or malignancy. Of the red flags for fracture, the factors that individually increased the probability of fracture to 10-33% were older age, prolonged steroid use, severe trauma, and contusion or abrasion, with the presence of multiple factors further increasing the probability to 42-90%¹⁵. Of the red flags for malignancy, the only reliable red flag was personal history of cancer, which increased the probability of malignancy to 7-33%¹⁵. The other red flags for cancer: older age, unexplained weight loss, failure to improve after one month, had post-test probabilities below 3%¹⁵. These findings point out that further research must be made into the utility of red flags and their use for risk stratification of patients and that clinical judgement must still be exercised when obtaining imaging.

Prior imaging: ask whether patients have had prior MRIs, CTs, CT myelograms, or X-rays and whether the current symptoms preceded or followed the imaging.

Previous interventions tried: clarify whether the patient has tried interventions such as formal physical therapy, a home exercise program, chiropractic treatment, medications, or injections. When you ask about previous medications tried, list medications by name as many patients are unfamiliar with the specific use for some of their medications.

One important aspect of the history is whether the patient is involved in litigation. The relationship between litigation and pain is very complex and many factors may change how pain is perceived when the patient is involved in litigation. One aspect is that patients who are more severely injured are more likely to be involved in litigation. Litigation is a very stressful process, and as such pain may be exacerbated by stress. Also, patients involved in litigation are motivated to obtain compensation so they may exaggerate the extent of pain and disability or may continue to report the same level of pain and disability as at the onset of symptoms despite improvements. One study of 200 patients with back pain who were followed for a minimum of 12 months demonstrated that patients with legal action pending were more likely to report worse pain and higher disability than patients who were not involved in litigation. This study also demonstrated that patients who are unemployed tend to report worse pain and higher disability than patients who are employed¹⁰.

All of the factors discussed are important in the evaluation of a patient with new neck or low back complaints. To facilitate obtaining a rapid and systematic history, consider incorporating templates and/or using questionnaires which can remind you of all the elements required for a complete and accurate history.

Please be aware, refer to the power point slide set for illustrative pictures.

The spine exam

Inspection: assess the patient's posture; patients may be kyphotic or excessively lordotic, their neck may be constantly tilted forward, or their pelvis may be malpositioned. Poor posture may result in pain.

Palpation: palpate the axial neck or low back and the levels above and below the areas of pain. Palpate the muscles of the neck or low back. Radiculopathies can sometimes cause significant muscular tenderness in the myotome of a specific nerve root. Classically, C7 radiculopathies can cause tenderness in the muscles

overlying the medial scapula and L5 radiculopathies can cause tenderness in the buttock and overlying the gluteus medius.

Range of motion: For the neck, have the patients flex and extend and laterally rotate the head left and right; for the low back, have the patients flex and extend and bend laterally side to side. Patients with radiculopathy have more pain when the neck or low back are extended, or when the head is turned to the symptomatic side. Patients with lumbar stenosis have worsened symptoms with lumbar extension. Patients with discogenic pain may have more pain with flexion, which tends to place more stress on the disc by compressing it anteriorly. Patients with facet arthropathy tend to have more pain with extension or lateral rotation. Patients who have symptomatic spondylolisthesis will also have pain when asked to move in the direction which worsens their listhesis.

In normal individuals, studies have demonstrated a 54-69 degree range of motion for cervical flexion, a 61-106 degree range for cervical extension, an 11-38 degree range for lateral cervical bending, and a 26-74 degree range for cervical rotation¹¹.

In normal individuals, studies have demonstrated a 59 ±9 degree range for lumbar flexion, a 19±9 degree range for lumbar extension, and a 30±6 degree range for lateral lumbar flexion¹¹.

Strength: Examine upper and lower extremity tone; examine the strength of both upper and lower extremities. Most muscles should be examined individually, comparing side to side. Optimally, you should place the muscle being tested at a mechanical disadvantage. When the patient has true weakness, the muscle is typically overcome in a smooth fashion. Patients may demonstrate give-away weakness when they are in pain or when they are offering suboptimal effort for other reasons such as conversion disorder, trying to help the provider, or lack of understanding. If somebody does not demonstrate peak strength when examining them, ask if the maneuver is painful. If it is painful, try to assess peak strength by having them engage the muscle for just a few seconds. You should compare side to side. Do not forget to include wrist flexion/extension and finger abduction in your exam. Finger abduction is particularly helpful in assessing patients with myelopathy. For assessing L5 and S1 strength, it is helpful to have patients walk on their heels (L5) and toes (S1). Common confounders include prior injury to muscles/tendons, peripheral mononeuropathies such as median or ulnar mononeuropathies, and shoulder/elbow/hip/knee dysfunction.

The sensitivity of manual muscle testing for detecting a radiculopathy varies depending on the level involved¹¹:

Muscle group	Sensitivity in patients with lumbar radiculopathy	Specificity in patients with lumbar radiculopathy
Great toe extension	37-61%	55-71%
Foot dorsiflexor weakness	20-63%	54-89%
Ankle plantar flexion weakness	6-47%	76-100%
Quadriceps weakness	1-40%	89-99%

The pattern of weakness can help you localize which root may be affected^{1,3,11}.

C5-6	Deltoid, Biceps	Arm abduction, Elbow flexion
C5-7	Triceps	Elbow extension
C6-7	Pronator teres Extensor carpi radialis	Pronation of extended forearm Wrist extension
C8-T1	Abductor digiti minimi	Abduction of the fifth digit

L1-L3	Iliopsoas	Hip flexor
L2-L4	Quadriceps	Knee extensor
L4-L5	Tibialis anterior	Foot dorsiflexion
L5	Extensor hallucis, hip abductors	Toe dorsiflexion, hip abductors
S1	Gastrocnemius	Plantar flexion
S2-S3-S4	Bowel, bladder, and sexual dysfunction, minimal limb weakness	Weak rectal sphincter

Reflexes: Typical examination will include brachioradialis (C5-6), biceps (C5-6), triceps (C7), patella (L2-L4, and ankle (S1). Reflexes may or may not be affected in patients with radiculopathy. Common confounders include previous radiculopathy or peripheral neuropathy which may affect the baseline reflex examination.

Sensation: For some patients, it is sufficient to assess sensation to light touch. Alternatively, pin prick testing can be very helpful in delineating the area with sensory deficits. If you suspect a concomitant issue such as peripheral neuropathy, adding vibratory and proprioceptive sensation testing can be useful. The sensitivity of

sensory testing in detecting lumbar radiculopathy varies from 16 to 50% while the specificity varies from 38 to 86%¹¹. When sacral dysfunction is suspected, perianal sensation should also be tested.

Gait: observe the patient's stance, stride, arm swing, and speed. Abnormalities are noted if there is spasticity, weakness, or pain. Patients may have abnormalities such as limping, foot drop, or Trendelenburg gait. The Trendelenburg sign occurs when patients are standing on one leg or walking and the contralateral pelvis, on the nonweight-bearing side, droops downward⁴. The Trendelenburg sign generally represents hip abductor weakness on the weight-bearing side, particularly of the gluteus medius muscle⁴.

The table below summarizes characteristic findings in radiculopathy, myelopathy, and lumbar stenosis^{1, 3, 11}:

	Tone	Strength	Reflexes	Sensation	Gait	Special tests
Radiculopathy	Normal	Decreased in distribution of affected nerve root	Decreased in distribution of affected nerve root	Decreased in distribution of affected nerve root	Only affected if weakness or neural stretch is present	Spurling's is positive
Myelopathy	Normal above affected level, Increased below affected level	Normal above affected level, decreased below affected level in upper motor neuron distribution?; may have decrease in nerve root distribution at the affected level	Normal above affected level, Increased below affected level, May have positive Hoffmanns and Babinski signs	Normal above affected level, decreased below affected level in the distribution of more than one nerve root	Spasticity Tandem gait is affected	
Lumbar stenosis	Normal	Normal or possibly decreased (L5+/or S1)	Normal or possibly decreased (ankle more likely than knee)	Normal or possibly decreased (distal)	Endurance is affected, patient is typically flexed forward at waist	

Special tests

Spurling sign¹¹: This test has two versions. In the first, the neck is extended and the head is rotated to the left or right. In the second version, the first part is performed, with the addition of downward pressure on top of the head. The test is considered positive and indicative of cervical radiculopathy if radicular symptoms such as pain, numbness, and tingling are elicited. Sensitivity for detecting radiculopathy varies from 30 to 77% and specificity varies from 92 to 100% based on various studies¹¹.

Shoulder abduction test¹¹: The shoulder is abducted either passively or actively, elbow is flexed, and the patient's hand is rested on the patient's head. The patient may be supine or sitting. The test is considered positive if the typical symptoms of radicular pain are relieved. Sensitivity for detecting radiculopathy varies from 43 to 50% and specificity varies from 80-100% based on various studies¹¹.

Straight leg raise testing¹¹: There are several variations. In the classical version, the patient is supine and the leg is elevated by the examiner between 30 to 70 degrees¹¹. Other variations include dorsiflexing the foot after the leg of a supine patient is elevated (the "other" Spurling sign)¹¹. To further increase neural stretching, the patient's head may be flexed or the upper body "slumped" while the leg is elevated by the examiner (the foot may also be dorsiflexed). The straight leg test is considered positive if the patient's pain symptoms are reproduced, with pain radiating below the knee. This test is most useful in patients with L4-S1 radiculopathies. The sensitivity of the straight leg test for detecting radiculopathy varies from 72 to 97% while the specificity varies from 11 to 66%¹¹.

The crossed straight leg raised test¹¹: Essentially the same as the straight leg raise test, with the test being positive when pain is elicited in the affected leg when the contralateral leg is elevated by the examiner. The sensitivity of the crossed straight leg raised test for predicting a disc herniation varies from 23 to 29%, while the specificity varies from 85 to 96%¹¹.

The reverse straight leg test also known as the femoral nerve stretch test¹¹: the patient is placed in prone position and the leg is flexed at the knee. The examiner may place one hand at the popliteal fossa, while the other exerts strong pressure at the ankle, flexing the knee as much as possible. To further increase neural stretching, the thigh may be subsequently extended by lifting the knee off of the examination table, with the knee kept in a flexed position. The test is considered positive if the patient's pain symptoms are reproduced. This test is most useful for patients with L2-L4 radiculopathies. Unfortunately, this maneuver can also trigger pain in a number of other conditions including femoral neuropathy, iliopsoas muscle dysfunction, or hip dysfunction. Information on sensitivity and specificity is lacking¹¹.

Quadrant loading¹¹: the examiner is standing behind patient, slightly towards one side. The patient's torso is rotated to the ipsilateral side, and then the examiner firmly grasps the patient's ipsilateral shoulder, extending and bending the spine ipsilaterally. The position is maintained for 3 seconds. While this test is not diagnostic of facet arthropathy, this test frequently causes back pain in patients with facet joint dysfunction¹¹. This test also exacerbates central or neuroforaminal stenosis, thus causing worsened lumbar radiculopathy or lumbar stenosis symptoms.

Shoulder exam: Shoulder dysfunction can mimic cervical radiculopathy. C5 and C6 radiculopathies may present with pain which refers predominately to the shoulder area. Scapular or periscapular pain may be the result of C5, C6, C7, or C8 radiculopathies³.

For the neurologist, a basic shoulder exam is typically sufficient to understand whether the shoulder may be playing a role in the patient's presenting symptoms. The initial component is the inspection of the appearance of the shoulder for obvious deformities and side-to-side differences. Palpate around the shoulder joint looking for areas of tenderness. Range of motion should include flexion, extension, internal rotation, external rotation, abduction, and adduction. Patients with primary shoulder dysfunction may have significant pain with range of motion testing, particularly abduction. If a patient has significant pain with active range of motion, check passive range of motion. Physical exam maneuvers which may indicate shoulder joint or rotator cuff dysfunction include the "empty-can" test, Neer sign, Hawkins test, and the "lift-off test"^{11,12}. All these tests are considered positive if the patient's painful symptoms are reproduced. The "empty-can" test is performed by having the patient abduct the arms to 90 degrees with their hands in neutral position (thumb is pointing up); the shoulder is then internally rotated, so that the thumb points toward the floor^{11,12}. Neer sign is performed by lifting the patient's extended elbow with the shoulder in internal rotation^{11,12}. Hawkins' test is performed by forward elevation of the arm to 90 degrees, bending the elbow to 90 degrees, followed by internal rotation of the shoulder^{11,12}. The "lift off" test, which tests subscapularis muscle function, is performed by having the patient rest the dorsum of their hand in the low back, with the shoulder internally rotated and the elbow flexed⁵. The patient then attempts to extend the shoulder by lifting the hand from the dorsum of the back. For an excellent review of these exam techniques with illustrations, please refer to the article written by Drs. Woodward and Best, titled The Painful Shoulder: Part I. Clinical Evaluation, published in the American Family Physician Journal (Listed under Reference 12).

Hip exam: Hip dysfunction and dysfunction of structures adjacent to the hip can mimic lumbar radiculopathy. Hip dysfunction most commonly presents with pain in the groin and the lateral portion of the hip and less commonly in the buttock area. In particular, radiculopathies at the L1-L5 levels, as well as gluteus medius tendinopathy can mimic hip dysfunction by causing pain overlying the inguinal fold or lateral hip.

For the neurologist, a basic hip exam is typically sufficient to understand whether the hip may be playing a role in the patient's presenting symptoms. The initial component is the inspection of the appearance of the hip for obvious deformities and side-to-side differences. Palpate the groin area and the area overlying the greater trochanter. Range of motion testing should include flexion, extension, internal and external rotation. Physical maneuvers which may indicate dysfunction of the hip joint or adjacent structures includes the log roll, FABER, and FADIR tests¹³. All these tests are considered positive if the patient's painful symptoms are reproduced. The log roll test is performed with the patient in supine position. The examiner then passively internally and externally rotates the leg¹³. The FABER test is performed with the patient in supine position. The examiner then passively flexes the leg at the knee, abducts the thigh, and externally rotates the hip by putting downward pressure on the flexed knee¹³. The FADIR is performed with the patient in supine position. The examiner then passively flexes the leg at the knee, adducts the thigh, and internally rotates the hip¹³. For an excellent review of these exam techniques with illustrations, please refer to the article written by Drs. Wilson and Furukawa, titled Evaluation of the Patient with Hip Pain, published in the American Family Physician Journal (Listed under Reference 13).

Sacroiliac joint testing:

SI joint dysfunction can be difficult to diagnose based on symptoms alone. Furthermore, no one single physical exam maneuver is a gold standard for diagnosing dysfunction due to the complex structure and innervation of the SI joint. There have been several attempts to standardize testing. SI joint dysfunction can be best diagnosed when at least two tests are suggestive. One study has found that if three or more provocative tests were positive, SI joint dysfunction could be diagnosed with a sensitivity of 85% and a specificity of 76%⁷. The same study found that the two most helpful tests for determining sacroiliac dysfunction are the posterior gapping test (compression test) and the thigh thrust test (posterior shear test)⁷.

Anterior gapping test (distraction test): Patient is supine. Apply pressure simultaneously to both anterior superior spines of the ilia, in both a downward and outward direction. If gluteal pain is reproduced, this is considered to be a positive test^{8, 11}.

Posterior gapping test (compression test): Patient is lying on the unaffected side. Stand behind the patient and apply pressure on the upper iliac crest, towards the contralateral iliac crest. If pain in the gluteal region is reproduced, this is considered to be a positive test.^{8, 11}

Thigh thrust test (posterior shear test): the patient is supine, with the hip and knee flexed and the hip slightly adducted. The examiner causes a shearing pressure of the sacroiliac joint by exerting pressure longitudinally through the femur towards the sacroiliac joint, while avoiding further adduction of the hip⁸.

Sacral thrust test (downward pressure test): patient is prone. Examiner places the heels of both hands on the center of the sacrum (around S2) and applies pressure downwards and anteriorly against the ilia. If pain in the gluteal region is reproduced, this is considered to be a positive test^{8, 11}.

Gaenslen test (pelvic torsion test): patient is lying supine on the edge of the exam table. The physician stands next to the exam table. The patient flexes the hip and knee contralateral to the examiner. The lumbar spine and pelvis should be as much as possible in contact with the examination table, fixing the pelvis and spine against the examination table for the duration of the test. Allow the leg ipsilateral to the examiner to dangle off the exam table and slowly extend the hip by applying downward pressure on the ipsilateral anterior lower thigh or knee. If the patient's pain is reproduced, the test is considered positive^{8, 11}.

Remainder of exam:

The general exam can be done quickly but is important to note:

Note if patients have fever which may be a sign of infection, or tachycardia/high blood pressure which may be a sign of pain. Note if patients have rashes on their skin which may give clues to the presence of a varicella zoster infection. When patients have significant edema, this may affect sensation in the extremities. Look for evidence of joint swelling or joint nodules which may be a sign of rheumatoid arthritis.

I always recommend performing a cranial nerve exam which may give clues to other disorders present.

The role of EMG

EMG/NCS is a useful tool an extension of the physical exam and to augment clinical decision making. EMG can also be helpful in delineating whether the symptoms are due to radiculopathy, mononeuropathy, polyneuropathy, myopathy, or plexopathy. In lumbosacral radiculopathy, EMG has a sensitivity ranging from 49 to 86%¹. In cervical radiculopathy, EMG has a sensitivity ranging from 50 to 71%¹⁴. EMG may be useful in demonstrating subclinical findings when patients with suspected radiculopathy have a normal exam. Studies in this regard showed that EMG demonstrated an electrographic radiculopathy in the 30 to 48% of patients with normal exams¹.

One notable limitation of EMG in radiculopathy is that painful symptoms can occur in isolation, without any evidence of denervation on EMG. Overlapping innervation and individual variation in muscle innervation can also limit the ability of EMG to localize a lesion. For example, lumbar radiculopathy at any one of the L2, L3, and L4 levels causes denervation in muscles which are innervated by all three nerve roots, making it difficult to localize the affected nerve root purely on electrodiagnostic criteria. Some of the additional pitfalls of EMG include nonspecific findings in myelopathy and lumbar stenosis with neurogenic claudication. In patients with myelopathy or lumbar claudication, unless concurrent radiculopathy occurs, EMGs may have normal or nonspecific denervation,. One notable exception is the presence of electrographic C8 radiculopathy in the context of cervical myelopathy, which occurs due to congestion of the venous plexus surrounding the lower cervical nerve roots due to stenosis at higher cervical levels. Additionally, EMG will show findings related to previous radiculopathies or chronic injuries, which can further complicate the interpretation of results.

References

[1]: Watson J., Office Evaluation of Spine and Limb Pain: Spondylotic Radiculopathy and Other, Nonstructural Mimickers, Seminars in Neurology, 2011; 31(1): 85-101

- [2]: Chou R. , Qaseem A, Owens D., Shekelle P, Diagnostic Imaging for Low Back Pain: Advice for High-Value Health Care From the American College of Physicians, *Ann Intern Med.* 2011; 154: 181-189
- [3]: Mizutamari M., Sei A., Tokiyoshi A., Fujimoto T., Taniwaki T., Togami W., Mizuta H., Corresponding Scapular Pain with the Nerve Root Involved in Cervical Radiculopathy, *Journal of Orthopaedic Surgery* 2010; 18(3): 356-60
- [4]: Bartleson J D, Deen H G, *Spine Disorders: Medical and Surgical Management*, Cambridge University Press; (July 23, 2009)
- [5]: Hehir, M K, Figueroa J J, Zynda-Weiss A M , Stanton M, Logigian E L , Unexpected Neuroimaging Abnormalities in Patients with Apparent C8 Radiculopathy: Broadening the Clinical Spectrum, *Muscle Nerve* 2012; 45: 859–865
- [6]: Gellhorn A , Katz J , Suri P , Osteoarthritis of the Spine: the Facet Joints, *Nat Rev Rheumatol.* 2013; 9(4): 216–224
- [7]: Szadek K M , van der Wurff P , van Tulder M W , Zuurmond W W , Perez R S G M , Diagnostic Validity of Criteria for Sacroiliac Joint Pain: A Systematic Review, *The Journal of Pain*, 2009; 10 (4): 2009: 354-368
- [8]: Ombregt, L: *A System of Orthopaedic Medicine*, Churchill Livingstone; 3rd edition (May 15, 2013)
- [9]: Chou R, Qaseem A, Snow V, Casey D, Cross T, Shekelle P, Owens D K , *Diagnosis and Treatment of Low Back Pain: A Joint Clinical Practice Guideline from the American College of Physicians and the American Pain Society*, *Ann Intern Med.* 2007; 147: 478-491
- [10]: Suter P B, *Employment and Litigation: Improved by Work, Assisted by Verdict*, *Pain* 2002; 100: 249–257
- [11]: Malanga G.A., Nadler S.F, *Musculoskeletal Physical Examination: An Evidence-Based Approach*, Hanley & Belfus; Har/Dvdr edition (November 4, 2005)
- [12]: Woodward T, Best T, *The Painful Shoulder: Part I. Clinical Evaluation*, *American Family Physician* 2000; 61(10): 3079-3088
- [13]: Wilson J J , Furukawa M , *Evaluation of the Patient with Hip Pain*, *American Family Physician.* 2014; 89(1): 27-34
- [14]: Hakimi K , Spanier D , *Electrodiagnosis of Cervical Radiculopathy*, *Phys Med Rehabil Clin N Am* 2013; 24: 1–12
- [15]: Downie A, Williams CM, Henschke N, Hancock MJ, Ostelo RW, de Vet HC, Macaskill P, Irwig L, van Tulder MW, Koes BW, Maher CG. Red flags to screen for malignancy and fracture in patients with low back pain. *Br J Sports Med.* 2014 Oct;48(20):1518