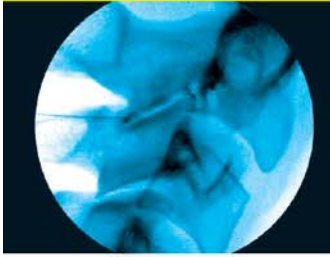


Key words: Image-guided procedures; nerve blocks; epidural steroid injections; sacroiliac joint injections; facet joint injections; facet nerve blocks; radiofrequency rhizotomy



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Image-guided pain management

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Abstract

Image-guided spine injection procedures provide a minimally invasive tool for the evaluation and treatment of symptoms caused by degenerative changes in the spine. Neck, back and radicular pain typically represent a diagnostic challenge because multilevel pathology is common and a number of structures may be involved. Anatomical assessment of intervertebral discs, ligaments, nerve roots, facet joints, sacroiliac joints and paraspinous soft tissues is important, but not conclusive, for evaluating the source of pain symptoms. Spine injection procedures provide functional and physiological information which are not obtained from physical examination and imaging studies, and therefore serve as an important adjunct to the diagnostic process. Many of the procedures performed are used for preoperative evaluation in order to improve surgical outcomes through the confirmation of suspected sources of symptoms and the exclusion of adjacent levels or structures. In addition, these procedures are utilised as pain management modalities, in order to decrease dependence on oral pain medication, increase physical performance and facilitate rapid return to normal activities of daily living and vocational pursuits. Image-guided procedures are typically performed using fluoroscopy, computed tomography and, less commonly, magnetic resonance imaging. In this section, we review a number of image-guided interventional spine procedures utilised for pain management.

Epidurography and epidural steroid injections

Epidural steroid injections have been performed for decades and are one of the most common spinal injection procedures performed. This palliative procedure is an effective means for treating neck and back pain.¹⁻³ The epidural space is in contact with a number of nociceptors, which are stimulated in the setting of degenerative spine disease. A number of studies have shown the presence of inflammatory cells,

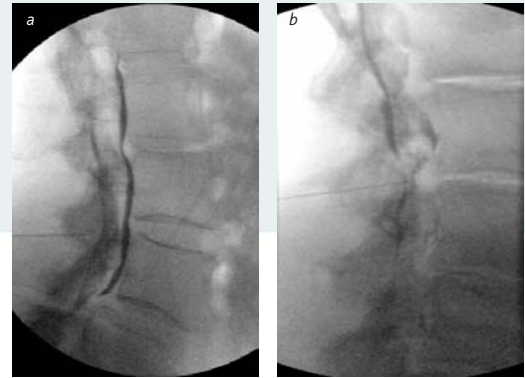


Figure 1. Intralaminar lumbar epidurography performed prior to injection of local anaesthetic and steroid suspension into the epidural space. (a) Lateral radiograph demonstrates widespread dispersal of contrast within the epidural space circumferentially, surrounding the unopacified thecal sac. (b) Lateral epidurogram in another patient revealing severe stenosis at the L2-3 level and moderately severe stenosis at L1-2.

increased CSF protein and neuronalisation occurring in the setting of degenerative changes in the spine. Delivery of the therapeutic materials is performed after placement of the needle in the epidural space, either in the midline via an intralaminar approach (Figure 1) or via a transforaminal approach (Figure 2) for patients who suffer radicular symptoms in addition to neck or back pain.

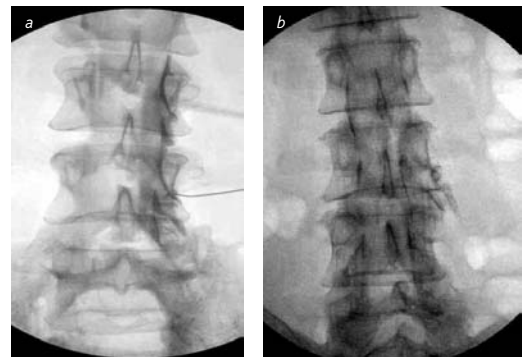
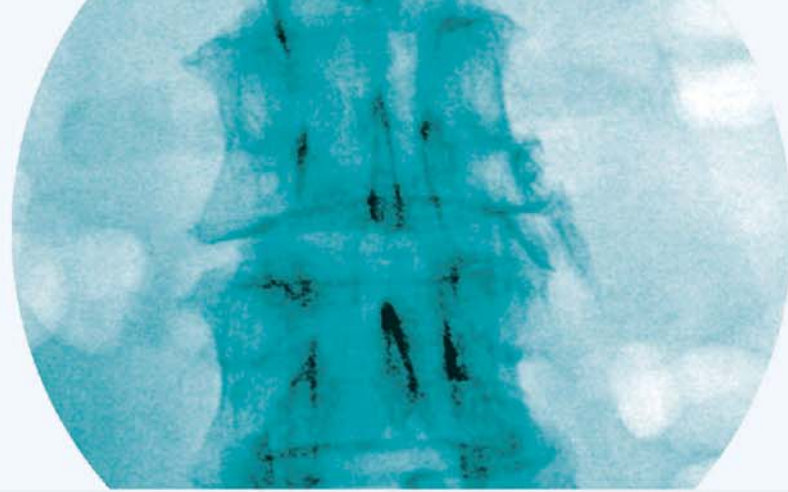


Figure 2. Transforaminal lumbar epidurography. (a) Contrast injected by right transforaminal approach reveals opacification of proximal nerve sheaths and extension into the right lateral epidural space. (b) Films obtained following injection of therapeutic substances reveal widespread dispersal of injected materials within the lumbar epidural space bilaterally.

Epidurography is performed to assess the anatomy of the epidural space and document the subsequent delivery of therapeutic materials to the correct



compartment. This helps prevent unintentional vascular and intrathecal injections, as well as evaluate for epidural scarring which may prevent delivery of therapeutic substances diffusely within the epidural space. This important component of the examination improves efficacy and helps avoid the potentially devastating complications of misguided administration of therapeutic substances. Patients are monitored for 20–30 minutes following the injection and the initial response to local anaesthetic is evaluated. Response to steroids typically takes 1–2 days, and up to 10 days before full efficacy of steroid response is appreciated.

Indications for epidural steroid injections

- Acute neck or back pain with or without radiculopathy
- Chronic neck or back pain with or without radiculopathy

Selective nerve root injections

Selective nerve root blocks are used for the evaluation and treatment of patients with radicular pain.^{4,5} It is often clinically important to differentiate referred pain in a radicular distribution from true nerve root pain, secondary to irritation or compression of a specific nerve root or ganglion. Imaging studies may not be conclusive, as mechanical compression of a nerve root is not required for the generation of pain symptoms. Alternatively, there may be abnormalities on imaging studies which do not result in the generation of pain or other symptoms. By blocking the nerve in question, the relative contribution to the patient's pain can be assessed. Local anaesthetic is administered for the diagnostic component and a steroid suspension is added to mitigate inflammation for the relief of pain symptoms on a longer-term basis.

In the lumbar spine, the foramen is approached from a posterolateral trajectory after sterile preparation of the skin, draping and localisation using fluoroscopic guidance. A radiculogram is obtained using water-



Figure 3. Selective lumbar nerve block. AP radiograph reveals opacification of the proximal right L4 nerve sheath with a small amount of epidural reflux prior to injection of anaesthetic and steroid suspension.



Figure 4. Selective cervical nerve block. AP radiograph demonstrates a 25 gauge needle in the lateral aspect of the right C6-7 foramen with opacification of the proximal right C7 nerve sheath. After filming and negative aspiration, local anaesthetic (with steroid suspension for therapeutic injections) is injected.

soluble nonionic contrast material to confirm accurate placement within the nerve root sleeve (Figure 3) and exclude vascular or intrathecal injection. Following filming, an appropriate dose of local anaesthetic and steroid is injected. The patient is monitored for response and this is recorded in the diagnostic report. Cervical nerve blocks (Figure 4) should only be performed by experienced personnel. Due to the immediate proximity of the vertebral artery and radicular arteries which vascularise the spinal cord, real-time evaluation of contrast distribution is required to prevent the inadvertent injection of therapeutic substances into these structures.

Indications for selective nerve block

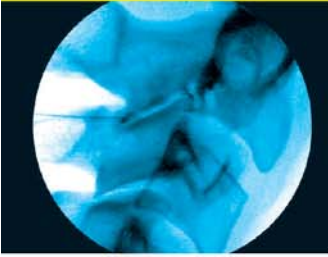
- Acute radicular pain
- Chronic radicular pain

Sacroiliac joint injections

A number of studies have demonstrated the role of the sacroiliac (SI) joint as a source of low back pain.^{6,7} The diagnosis of SI joint pain in patients who suffer from low back, buttock or hip pain is often elusive

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based on history and medical examination alone. The accurate assessment of this joint as a potential pain generator can be done quickly, using image-guided placement of therapeutic materials within the joint. Prior to injection with these substances, SI joint arthrography is performed to confirm accurate placement within the joint and to assess joint morphology (Figure 5).



Figure 5. Sacroiliac joint arthrography. Films obtained prior to injection of therapeutic substances (local anaesthetic and steroid) reveal diffuse opacification of the left sacroiliac joint and normal morphology.

Following filming of this study, a local anaesthetic and steroid are injected and the patient is monitored for initial response to the local anaesthetic. Transitional joints at the lumbosacral junction may be evaluated and treated using the same technique.

Indications for sacroiliac joint injection

- Chronic low back pain
- Buttock pain
- Hip pain (not secondary to hip joint pathology)

Facet joint injections

The zygapophyseal joints (or facet joints) are richly innervated and a frequent cause of neck and back pain.⁸⁻¹² Symptoms vary and the clinical evaluation may be difficult, even with the benefit of imaging studies. The diagnostic evaluation of facet joint pain is best performed using image-guided injections, which also provide a minimally invasive therapeutic modality. After needle placement within the joint, arthrography is performed using a small amount of nonionic contrast medium to confirm intraarticular delivery of the injectate and to assess joint morphology (Figure 6). The joint is then filled with a therapeutic mixture consisting of local anaesthetic and steroid. A pars interarticularis defect (spondylolysis) can be evaluated and treated using the same technique.

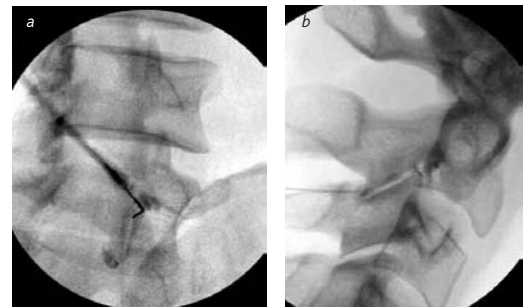


Figure 6. Facet joint arthrography. (a) Oblique radiograph of a lumbar facet joint arthrogram reveals intraarticular dispersal of contrast media prior to injection of therapeutic substances. Joint morphology is normal. (b) Lateral radiograph showing cervical facet joint arthrography. There is uniform dispersal of contrast media revealing normal joint morphology.

Facet joint injections may also be used therapeutically for symptomatic synovial cysts (Figure 7). If the articular space communicates freely with the cyst, the cyst can be dilated and ruptured via a facet joint injection,

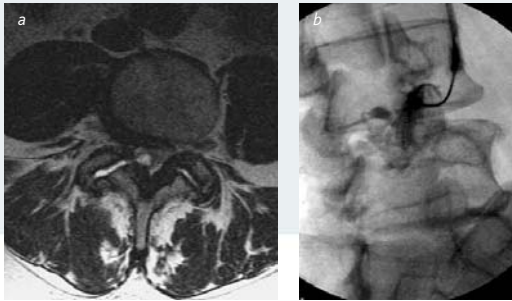


Figure 7. Synovial cyst at L4-5. (a) Axial long TR MR image demonstrates a right L4-5 facet joint effusion with a synovial cyst projecting into the spinal canal, compressing the traversing right L5 nerve root within the subarticular recess. (b) Lumbar facet joint arthrogram obtained during injection reveals opacification of the L4-5 facet joint with extension of contrast media into synovial cyst within the spinal canal. Following filming, a therapeutic mixture consisting of local anaesthetic and steroid suspension was injected, resulting in cyst rupture and relief of pain symptoms.

often leading to relief of pain symptoms following decompression.

Indications for cervical facet injection

- Neck pain
- Upper extremity radicular pain
- Suspected cervicogenic headache

Indications for thoracic and lumbar facet injections

- Back pain
- Lower extremity radicular pain

Facet nerve injections and rhizotomy

Diagnostic medial branch blocks for the diagnosis and treatment of posterior compartment or facet joint pain are another diagnostic and therapeutic option.^{13,14}

Rather than delivering therapeutic substances to the joint, the sensory nerve to the facet joints can be blocked. It is important to bear in mind that there is dual innervation of facet joints, so the adjacent levels should be blocked as well. Bony landmarks are utilised to localise the nerves, which follow a predictable course in the lumbar spine (Figure 8) and in the cervical spine (Figure 9). After image-guided placement of the spinal needle to the respective nerves, a mixture of local



Figure 8. Lumbar facet nerve (medium branch of the dorsal ramus) block. AP radiograph reveals needle placement at the junction of the superior articular process and transverse process, along the course of the medial branch.

anaesthetic and steroid are injected. The patient's pain response is evaluated 20 minutes after the injection. If the patient shows a significant response, a long-term benefit may be achieved using a radiofrequency (RF) facet nerve rhizotomy.

The approach to the nerve is similar for a facet nerve rhizotomy, but instead of a small gauge spinal needle, an RF probe is advanced to the nerve, with a trajectory chosen to maximise contact between the small medial branch (facet nerve) and the active tip of the probe. Motor stimulation testing is performed to exclude extremity motor activity (the medial branch is immediately posterior to the motor nerve). Multifidus contractions are typically observed if there is good

Image-guided pain management *continued*

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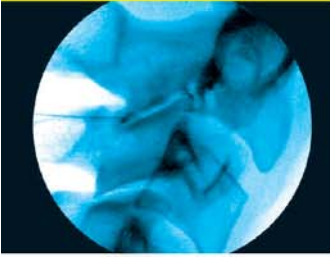


Figure 9. Cervical facet nerve block. AP and lateral radiographs reveal needle placement at the waist of the articular pillar, along the course of the left C4 medial branch.

contact with the medial branch, providing physiological confirmation of accurate needle placement. After filming and physiological testing have confirmed optimal placement, lesioning is performed via the application of RF energy to the nerve.

Indications for lumbar facet nerve injection

- Chronic low back pain
- Acute or chronic radicular pain
- Hip pain (not secondary to hip joint pathology)

Indications for cervical spine facet nerve injection

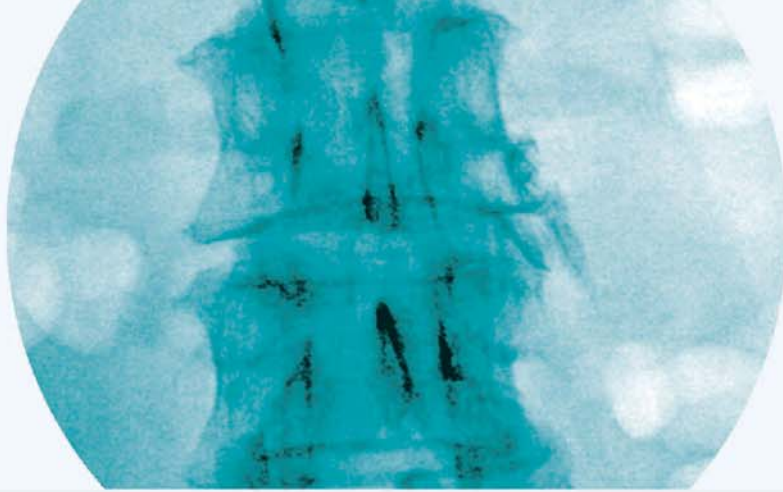
- Acute and chronic neck pain
- Cervicogenic headache

Indication for rhizotomy

- Significant pain relief (greater than 75%) provided by facet nerve block

Conclusion

The use of spinal injection procedures provides a minimally invasive tool for the diagnosis and treatment of spine related symptoms. These image-guided procedures can be performed in an outpatient setting and supplement clinical and imaging findings for patient evaluation and pain management.



Key Learning

- Image-guided spine procedures provide physiological information not available from diagnostic imaging studies
- Fluoroscopy provides the advantage of real-time observation during contrast injection to assess for vascular opacification. CT and MR are additional modalities utilized for image-guided procedures
- Early intervention for spine pain sufferers helps to decrease dependence on oral pain medication, improve physical performance and facilitate a rapid return to normal activities of daily living and vocational pursuits
- Image-guided spine procedures are minimally invasive and can be performed on an outpatient basis
- With extensive training on imaging equipment safety and operation, and familiarity with image-based anatomy and image-guided procedures, radiologists are best suited to perform these spine interventions

References

1. Johnson BA, Schellhas KP, Pollei SR. Epidurography and therapeutic injections: technical considerations and experience with 5334 cases. *AJNR Am J Neuroradiol* 1999;**20**:697–705.
2. White AH, Derby R, Wynne G. Epidural injections for the diagnosis and treatment of low-back pain. *Spine* 1980;**5**:67–86.
3. El-Koury GY, Renfrew DL. Percutaneous procedures for the diagnosis and treatment of lower back pain: diskography, facet-joint injection, and epidural injection. *AJR Am J Roentgenol* 1991;**157**:685–91.
4. Johnson BA. Image-guided epidural injections and spinal nerve blocks. In: Latchaw RE, Kucharzyk J, Moseley ME, eds. *Imaging of the nervous system: diagnostic and therapeutic applications*. Philadelphia, USA: Elsevier Mosby, 2005, Volume II:1555–65.
5. Karppinen J, Malmivaara A, Kuranlahti M, et al. Periradicular infiltration for sciatica: a randomized controlled trial. *Spine* 2001;**26**(9):1059–67.
6. Dreyfuss P, Michaelsen M, Pauza K, et al. The value of medical history and physical examination in diagnosing sacroiliac joint pain. *Spine* 1996;**21**:2594–2602.
7. Schwarzer AC, Aprill CN, Bogduk N. The sacroiliac joint in chronic low back pain. *Spine* 1995;**20**:31–7.
8. Bogduk N, Lord S. Cervical zygapophysial joint pain. *Neurosurgery Quarterly* 1998;**8**:107–17.
9. Bogduk N, Long E. The anatomy of the so-called “articular nerves” and their relationship to facet denervation in the treatment of low back pain. *J Neurosurg* 1979;**51**:172–7.
10. Schwarzer AC, Wang S, Bogduk N, et al. Prevalence and clinical features of lumbar zygapophysial joint pain: a study in an Australian population with chronic low back pain. *Ann Rheum Dis* 1995;**54**:100–6.
11. McCall IW, Park WM, O’Brien JP. Induced pain referral from posterior lumbar elements in normal subjects. *Spine* 1979;**4**(5):441–6.
12. Mooney V, Robertson J. The facet syndrome. *Clin Orthop* 1976;**115**:149–56.
13. Johnson BA. Facet nerve blockade and radiofrequency neurotomy. In: Jensen ME, eds. *Neuroimaging Clinics of North America*. Philadelphia, USA: W.B. Saunders Company, 2000, 493–501.
14. Schellhas KP. Facet nerve blockade and radiofrequency neurotomy. *Neuroimaging Clin N Am* 2000;**10**:493–501.