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Imaging guidance for spinal intervention

Imaging can assist in the accurate and safe placement of needles in and around the spine. CT has been shown to allow highly accurate needle guidance in a number of procedures including biopsies, drainages, and selective lumbar nerve root blocks. The use of intermittent CT fluoroscopy and a low mA setting (ie low tube current) allows radiation dose to the patient and radiologist to be minimized.[1]

CT fluoroscopic guidance markedly decreases patient radiation dose and significantly reduces total procedure time when compared to conventional CT. At this institution, as has been documented in the literature, a quick check method of fluoroscopy (ie advancement of the needle followed by a single image to check needle placement) is employed to minimise doses.[1, 2, 3]

Visualization of the spinal contents before insertion of a needle also enables recognition of potential causes of inaccurate needle placement or procedure failure. Particularly in the spine, many important anatomical structures are located in close proximity to the target of the needle tip, such as nerve roots, the aorta, vertebral arteries, spinal cord or the thecal sac amongst others.[1]

Imaging Guided Steroid Injections in the Management of Chronic Low Back Pain

Spinal pain is a common variety of chronic pain in society and has a reported lifetime prevalence of 54 – 80 per cent. Pain may arise from a number of origins such as the intervertebral discs, facet joints, ligaments, fascia, muscles and nerve root dura.[5]

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Transformaminal and epidural cortisone injections for radicular pain

Injury of an intervertebral disc would suggest that instillation of a therapeutic agent into the anterior epidural space would maximize therapeutic benefit if such benefit is feasible. Hence, transforaminal or epidural injections would be most useful in targeting discogenic pain after confirmation that the source of pain is from an intervertebral disc.[4]

The underlying mechanism of action of epidurally administered steroid and local anesthetic is based on the theory that neural blockade alters or interrupts nociceptive input, the reflex mechanism of the afferent fibers, self-sustaining activity of the neurons and the pattern of central neuronal activities.[5]

Transforaminal and epidural steroid injections are utilised in the management of radicular pain caused by nerve root irritation as a result of impingement or stenosis, after conservative measures such as oral medications, physiotherapy and lifestyle modifications have failed.

Lumbar transforaminal injections place steroid into the anterior epidural space and area near the spinal nerve as it exits the neural foramen. The transforaminal approach is more selective and can provide diagnostic information as well as symptomatic relief in the patient with radicular pain.

The evidence for lumbar transforaminal epidural steroid injections is Level II (strong) for short-term and Level III (moderate) for long-term relief in managing radicular pain caused by nerve root impingement or stenosis[8] – see **Table 1**.

In the appropriate setting, these procedures can reduce the patient's pain by 64 per cent to 81 per cent,

Table 1 – Evidence Levels

Level I (Very strong) evidence	systematic review of level II studies
Level II (Strong) evidence	randomised controlled trials
Level III (Moderate) evidence	comparative study with concurrent controls: (eg non-randomised, experimental trial, cohort study, case-control study , interrupted time series with a control group) or a comparative study without concurrent controls (eg historical control study, two or more single arm study, interrupted time series without a parallel control group)

disability by 60 per cent and depression by 56 per cent.[5] Studies have also shown that nerve root injections were indeed effective in obviating the need for an operation in more than half of potential operative candidates and that in those where surgery was eventually required, the response to cortisone may help predict the likely success of such surgery.[9] In addition, as even asymptomatic individuals can have radiographic evidence of canal or foraminal stenosis, a selective injection helps to confirm the diagnosis that the patient's pain is arising from the level injected.[2,9,10] A case example is shown in **Figures 1 (a-c)**.

In patients with low back pain and sciatica, caudal epidural injections with steroid is effective.[6] Symptoms in some studies improved in over 70 per cent of patients.[6]

Reported complications of epidural steroid injections are usually minor and transient. The most frequent is a transient headache. Reported major complications are rare.[7]

FACET JOINT INJECTIONS FOR

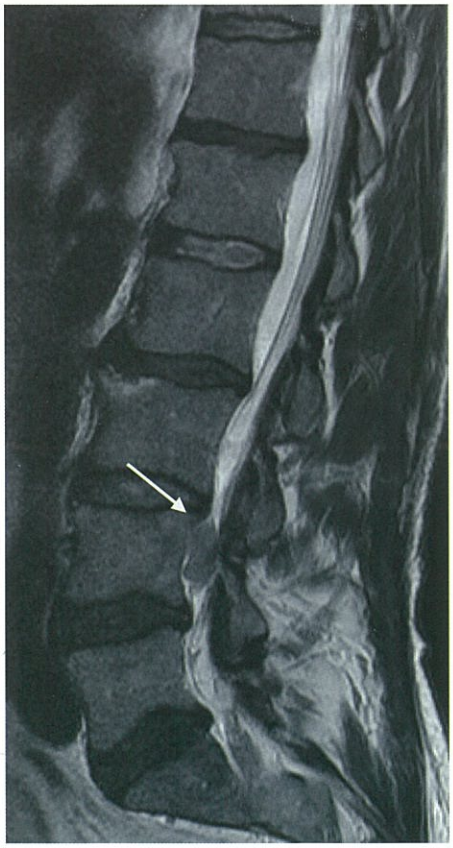

Figure 1(a): *A 61 yo male patient presents with acute onset radiculopathy in a right L4 distribution. On MRI, there is a disc extrusion from L3/4 impinging the L4 nerve root.*

FACET PAIN SYNDROMES

Facet joint (zygapophyseal joint) related pain presents clinically with cramping leg pain involving the thigh but not radiating below the knee, low back stiffness and absence of paraesthesia. The back stiffness is typically most marked in the morning.[23]

Focal tenderness over a facet joint is a strong indication of facet syndrome, along with paravertebral spasm and abnormal facet joints on imaging studies. Cervical facet pain is often characterised by chronic headache, restricted motion and axial neck pain which may radiate sub-occipitally to the shoulders or midback.[22]

Painful zygapophaseal joints can be treated with therapeutic intra-articular injections or ablation of the joint's nerve supply.[4]

The major indications for facet injections include strong clinical suspicion of a facet syndrome, low back pain with normal radiological findings, post-laminectomy syndrome with no evidence of arachnoiditis or recurrent disc disease and persistent low back pain after spinal fusion.[22] A case is shown in **Figures 2(a) and (b)**.

Complications from facet joint nerve blocks, intraarticular injections or radiofrequency neurolysis in the lumbar spine are exceedingly rare.[11] There is good evidence for the use of conventional radiofrequency neurotomy, and fair to good evidence for lumbar facet joint nerve blocks for the treatment of chronic lumbar facet joint pain resulting in short-term and long-term pain relief and functional improvement.[11]

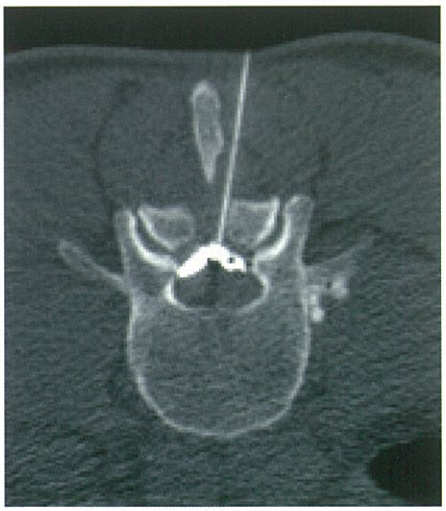

Fig 1(b): He underwent a CT guided lateral recess steroid Injection at L3/4

CT GUIDED

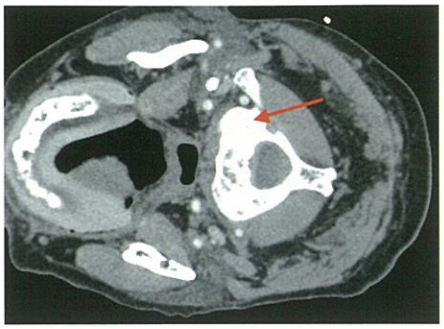

Fig 2(a) CT guided facet joint injection *91 year old patient presents with severe right sided pain radiating to the ear and severe C1/2 lateral atlantoaxial joint synovitis. Pre-procedural planning CT with contrast maps out the adjacent vertebral artery.*

Fig 2(b): *needle placement into the lateral atlantoaxial joint with injection of cortisone results in good pain relief for 3 months.*

Fig 1(c): *3 months later, the extrusion has completely resolved. The patient is pain free 4 years later.*

Radiofrequency Ablation

Percutaneous radiofrequency (RF) neurotomy is a treatment for low back pain stemming from the zygapophysial joints of the lumbar spine. Potential candidates for this procedure are patients who experience significant relief of pain following diagnostic blocks of the lumbar zygapophysial joints. The procedure is performed by placing an insulated needle electrode with an exposed tip adjacent to the nerves that innervate the painful joint. A radiofrequency current applied to the electrode then heats the adjacent tissues and coagulates the nerve supply to the joint.[17]

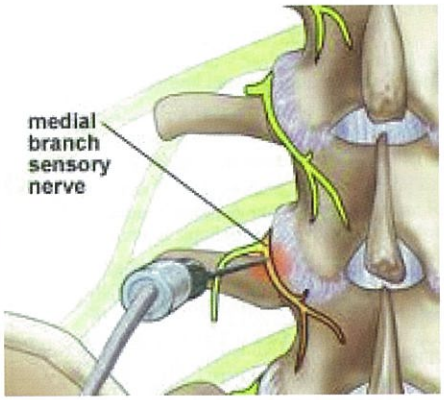

Fig 3(a) *Anatomy of medial branch nerves which supply pain fibres to facet joints.*

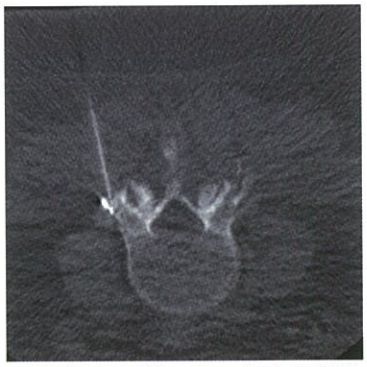

Fig 3(b) *Pre-ablation medial branch block with local anesthetic produced a 2 hour complete relief of lower back pain with pain returning after the anesthetic has worn off.*

Fig 3(c): *electrodes placed at the medial branch nerves produce 5 months of pain relief; the ablation was repeated subsequently with good result.*

The course of the medial branch at the lumbar spine has been shown to be fixed proximally at its origin from the dorsal ramus at the superior aspect of the transverse process and distally as the nerve passes under the mamillo-accessory ligament at the caudal edge of the superior articular process. The superior portion of each lumbar zygapophysial joint receives innervation from the medial branch originating one level cephalad, while the inferior portion receives innervation from the medial branch originating at the same level.[17]

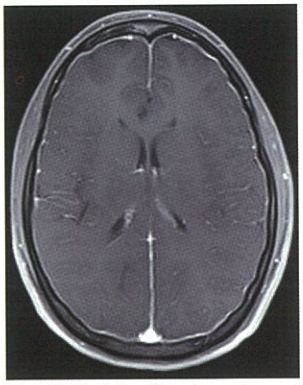

Fig 4(a): *24yo female patient with orthostatic headaches. MRI shows diffuse dural thickening in keeping with intracranial hypotension.*

Fig 4(b): *MRI shows fluid in the epidural space from CSF leak.*

Fig 4(c): *CT guided epidural blood patch.*

Thermal coagulation denatures the nerve and stops conduction of nociceptive traffic, thereby relieving pain. Although the nerve eventually regenerates, the rate of regeneration is slower than after traumatic nerve injuries. When nerves are transacted, axon tubules regenerate within hours of the injury, cross the gap and grow into the distal segment at a rate of 1 mm per day. In contrast, radiofrequency thermal coagulation seals the nerve in situ, providing no gap across which the nerve can regenerate.

The studies to establish the efficacy of radiofrequency ablation neurotomy of medial branch nerves for the treatment of facet origin pain have had variable results. This may be in part due to the varied techniques, electrode placements and orientations of the studies.[19,20,21]

Based on multiple randomized trials and positive observational studies, the evidence for conventional radiofrequency neurotomy in managing chronic low back pain of facet joint origin in the lumbar spine is good for short- and long-term relief.[18]

Relief after medial branch nerve radiofrequency ablation typically lasts between 6 and 12 months. Pain recurs when the nerves regenerate but relief can be reinstated by repeat neurotomy.[19]

The relevant anatomy and an example of this procedure is shown in **Figures 3(a) to (c)**.

CT guided epidural blood patch

Spontaneous intracranial hypotension (SIH) is an under-diagnosed cause of persistent debilitating headaches. Patients usually present with orthostatic headaches associated with low CSF volume and pressure without a history of instrumentation or penetrating trauma. In most cases, SIH is treated successfully with conservative management including bed rest, high fluid intake and caffeine.[12]

Treatment of low CSF pressure headache consists of conservative strategies initially.[13]

When conservative measures fail to resolve symptoms, blind lumbar epidural blood patches have been shown to be

effective at treating the CSF leak . Targeted epidural blood patch can be carried out effectively in a safe manner using CT fluoroscopy and should be considered prior to surgical treatment especially in those cases where blind lumbar epidural blood patches have proven unsuccessful.[12]

Post-operative CSF leaks can also be treated with CT-guided percutaneous patching as defined by CT myelography if the dural defect is less than 5 mm and there is no pseudomeningocele.[14] MR myelography may also be used.

A case example is shown in **Figure 4 (a-c)**.

CT GUIDED SPINAL BIOPSY

The success and safety of percutaneous biopsies of spinal lesions lies in the accurate guidance to the lesion by use of imaging. CT provides accurate localisation and delineation of the lesion including both the osseous and extra-osseous components. A safe access route to the lesion can thus be planned. CT also documents accurate needle placement within the lesion.[15]

Biopsy is usually necessary to determine the appropriate treatment for a vertebral neoplasm. However, performing an open biopsy in a vertebral neoplasm is difficult because of the significant risk of complications.[1,2] CT-guided percutaneous biopsy is safe and mostly painless and this technique is preferred for various spinal pathologies that are located close to vital structures.[16]

The procedure improves the accuracy of both staging and initial diagnosis, with minimal risk and discomfort in patients with known or suspected underlying malignancy.[16]

For lesions in the thoracic spine, the transpedicular, transcostovertebral, or posterolateral paravertebral approach is usually used.[16]

A case example is shown in **Figure 5 (a and b)**.

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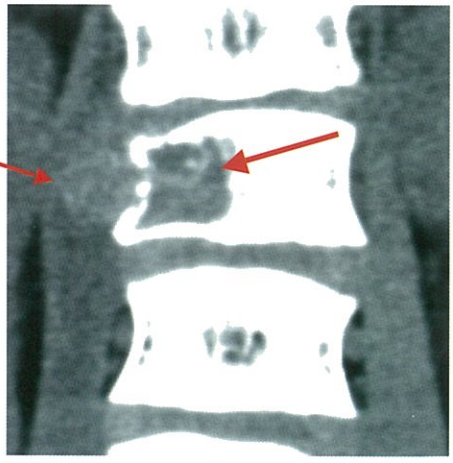

Fig 5(a): *11 yo girl with a 4 month history of paravertebral pain, progressive leg weakness and paresthesia. CT shows a lytic osseous lesion with soft tissue paravertebral and epidural component resulting in a pathological fracture and nerve impingement at L3*

Fig 5(b): *CT guided core biopsy with paravertebral approach into the soft tissue mass; histopathology revealed an osteoblastoma*