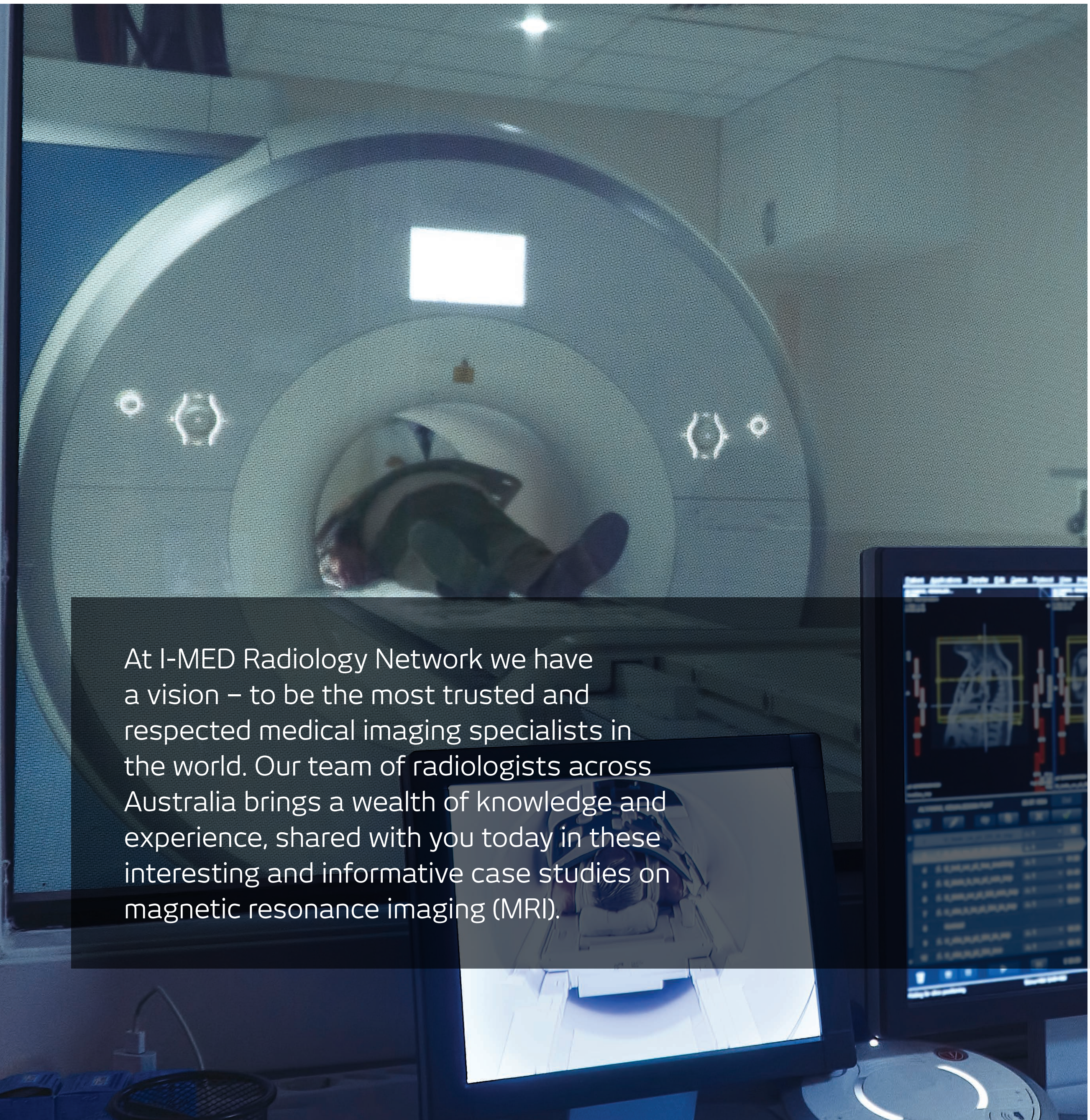
Adult MRI case studies

I-MED Radiology Network

Comprehensive care. Uncompromising quality.

Contents



At I-MED Radiology Network we have a vision – to be the most trusted and respected medical imaging specialists in the world. Our team of radiologists across Australia brings a wealth of knowledge and experience, shared with you today in these interesting and informative case studies on magnetic resonance imaging (MRI).

What is MRI?

Unlike x-rays, CT or Nuclear medicine, MRI does not use ionising radiation. It uses a combination of magnetic fields and radiofrequency pulses to obtain information about tissue structure and density. The magnetic fields are induced by superconducting 1.5 or 3 Tesla magnet, cooled by liquid helium. Much less-powerful gradient magnets are used to deliberately distort the main magnetic field in a predictable pattern, causing the resonance frequency of protons to vary as a function of their position. These hydrogen nuclei resonate with the applied radio pulses which when turned off give off radio signals (a process called relaxation). These are converted into cross-sectional images of the body.

Basic applications

The density and behaviour of water (protons) allows MRI to show detailed soft tissue structure. Multiple different pulse sequences can be used help characterise soft tissue composition. The superlative soft tissue detail of MR makes it the preferred modality for brain, spine, bone marrow and the internal structure of joints. CT continues to be the optimal modality for most general chest and abdomen imaging. Most of our CT scanners are low radiation dose, being an important consideration in paediatric patients. MRI may be the preferred modality for abdominal imaging for specific organs such as a liver, prostate and gynaecological conditions.   Some specific examples include MRCP for bile duct obstruction, prostate carcinoma, rectal carcinoma and breast screening in the very high risk.

Patient experience

Detailed clinical information and safety screening is necessary for MRI, so a comprehensive questionnaire is filled out. The patient wears a hospital gown for the study to avoid taking metallic objects into the room. The technical staff explain in detail what the patient will experience. The machines are very noisy, so headphones are worn. Very occasionally an intravenous (IV) injection of gadolinium contrast is required - this is fully explained and consented. The study usually takes around 15-45 minutes. Whilst most of our MRI machines are "wide bore", claustrophobia can still be an issue. A preceding oral sedative can be prescribed or occasionally IV sedation can be used if necessary.

Information needed from the referring doctor

1. Detailed accurate clinical notes

The type of study performed depends on the clinical problem. Many findings, such as in the spine, may be clinically irrelevant. A useful report depends on precise clinical information.

2. Safety detail

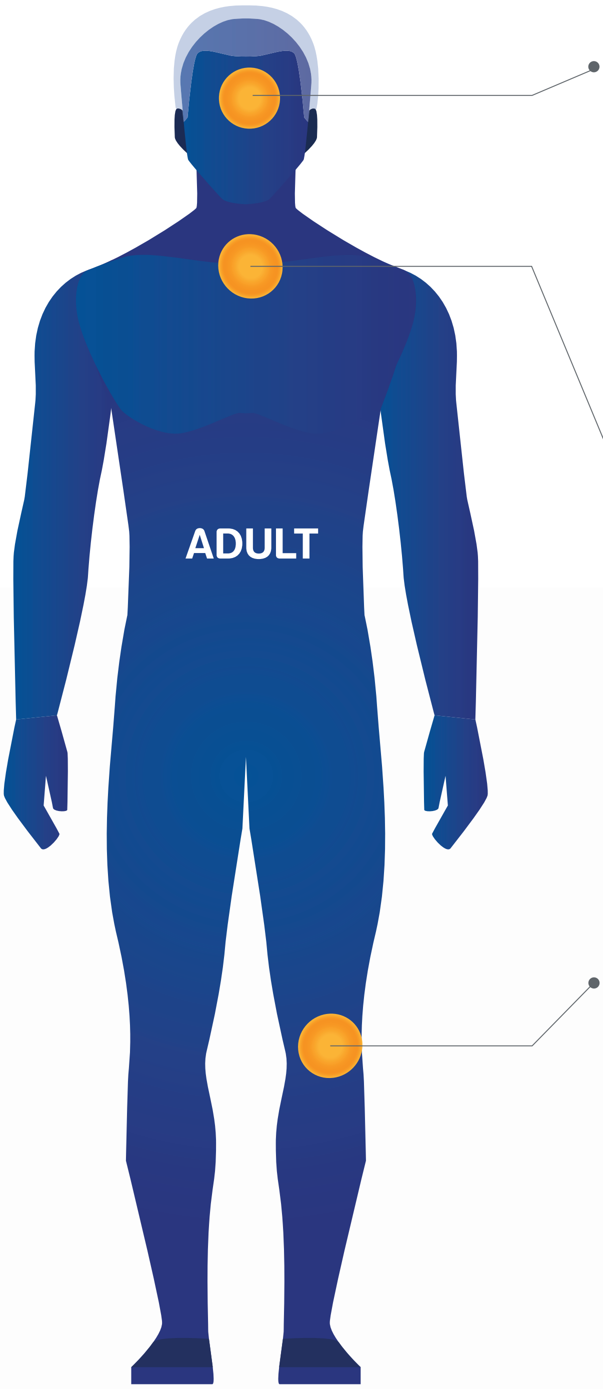
The powerful magnetic field can interact with metallic objects and hence can incite currents within them or cause them to move. Most implants are nowadays non-ferromagnetic and MRI-safe. Anchored devices such as orthopaedic implants are safe. MRI is contra-indicated in many very old-style ferromagnetic aneurysm clips. Most older pacemakers are not MRI-safe. Specific devices must be specifically questioned for by the referring doctor, and when necessary the make and model :

- Brain/spine implant, aneurysm clip, cochlear implant
- Pacemaker/defibrillator (MRI-safe pacemakers have been available only since 2011)
- Vascular stent
- Implanted pumps or leads
- Metallic eye, foreign body or welding, grinding, metalwork occupation

3. Pregnancy

There is no known adverse effect on the foetus by diagnostic MRI however as a precaution we generally avoid MRI in the first trimester. There are very few patients for whom MRI is contraindicated, however referring doctors must take their safety screening obligations seriously and advise us of any relevant concern. We will then assess the specific issue in detail and advise the patient and referring doctor.

Medicare-eligible MRI services for patients 16 years or older



Scan of head

For any of the following:

- Unexplained seizure(s)
- Unexplained chronic headache with suspected intracranial pathology

Scan of cervical spine

For suspected:

- Cervical spine trauma
- Cervical radiculopathy

Scan of knee

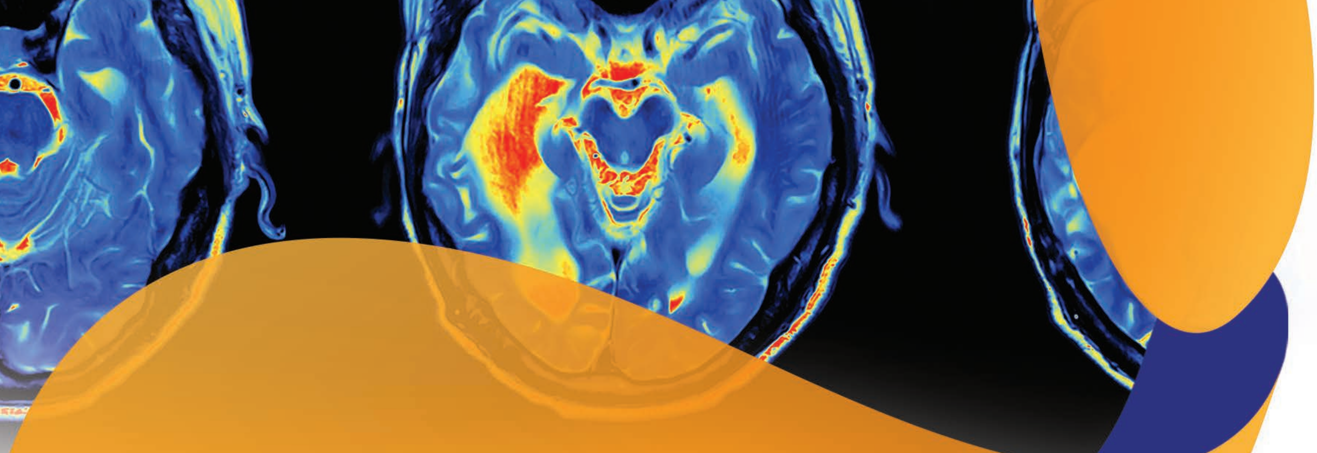
Following acute knee trauma with:

- Inability to extend the knee suggesting possibility of acute meniscal tear
- Clinical findings suggesting acute anterior cruciate ligament tear

***NB:** To be eligible for a Medicare Rebate, the referring doctor must specify one of the above clinical indications on the request / referral form. For example "Acute Knee Trauma - can't extend knee? Meniscal Tear".

*GPs will not be able to request more than three Medicare-rebateable knee MRIs per patient per annum for patients aged 16-49. In addition, GPs will no longer be able to refer patients aged 50 years and over for Medicare-rebateable knee MRIs. There will be no change to specialists requesting MRIs for any age group. Providers will need to use new item numbers for knee X-rays and knee CTs.

For persons 16 years or older



Unexplained seizure in patients 16 years and older

Dr Ian Cox MBBS MMed FRANZCR

In general, all patients with the diagnosis of new seizure will require an MRI, whether they have had a CT scan or not. A common practice in the past has been for the patient to have a CT scan and see a specialist, who then requests an MRI scan which is discussed at a second consultation. For those patients in whom there is a confident diagnosis of seizure, it saves them time, money and exposure to radiation to have an MRI rather than CT before seeing the neurologist.

Urgent investigation is required for new onset seizure in patients with a history of head injury, alcohol or drug abuse, decreased conscious state, persistent neurological signs, and signs, symptoms or biochemical evidence of systemic illness (e.g. fever). An expedited MRI appointment can usually be arranged if the GP phones and discusses the case with the MRI radiologist.

There are many causes for seizure that show up on MRI and not CT, including many tumours, mesial temporal sclerosis, vascular malformations and cortical dysplasias. The MRI is tailored specifically for this indication with selected sequences and planes, so it is important that the request makes it clear that the clinical problem is seizures, and includes other important clinical features such as evidence of systemic illness.

Unexplained chronic headache

Headache (HA) is one of the most common medical symptoms. Although the majority of headache disorders are benign, it is a crucial (and challenging) task to decipher the benign variants from conditions that threaten life and neurological function. Usually a clinical history and examination is sufficient to diagnose a primary headache disorder, but when there is clinical doubt, investigations are required to exclude serious and treatable causes. Deciding who needs investigation truly draws on a combination of the "science and art of medicine". There are no easy answers, but there are a number of "red flags" that increase the chances of a serious underlying cause. These include a new onset or new type or worsening pattern of existing headache, new level of pain (e.g. "worst ever), HA triggered by valsalva or cough, by exertion, by sexual activity (pre-orgasmic, orgasmic), HA during pregnancy and puerperium (venous sinus thrombosis), HA where there are associated neurological signs

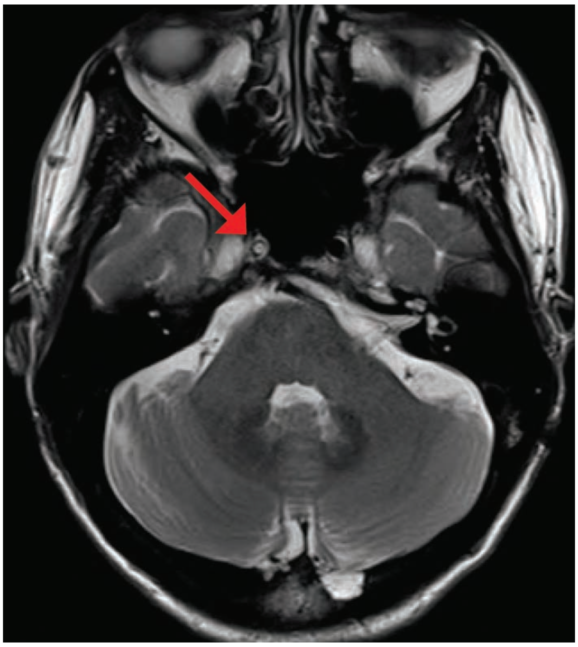


Figure 1(a) and (b): Arterial dissection
Figure 1(a) and (b): (left) T2 image of the skull base shows absent (normally black) flow in the right internal carotid artery (red arrow).

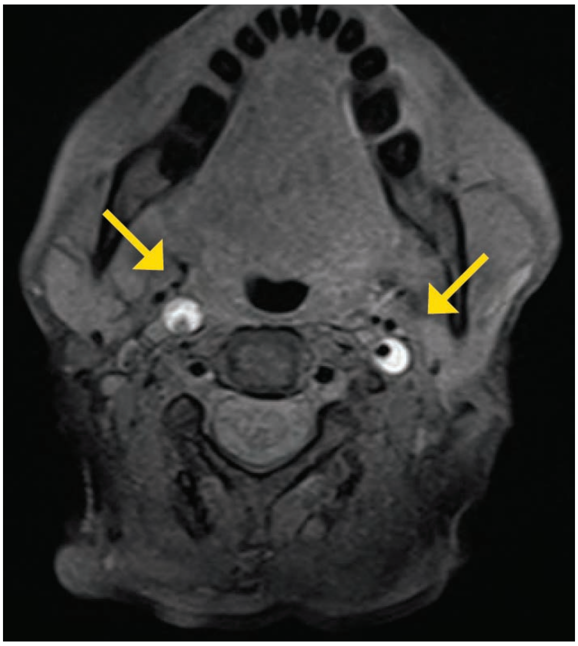


Figure 1(b): (right) Fat suppressed. T1 image below skull base shows blood in the wall of both internal carotid arteries narrowing the lumen (yellow arrows).

or symptoms, or evidence of systemic illness including features of sepsis, immunosuppression, weight loss and cancer. New onset side-locked HA can be a symptom of arterial dissection, and postural HA is a symptom of spontaneous intracranial hypotension.

CT or MRI?

MRI is superior to CT for diagnosing most of the serious causes of chronic headache. CT remains the investigation of choice in HA associated with recent trauma, and in "thunder clap" HA that raises the possibility of subarachnoid haemorrhage. CT and MRI are comparable in accuracy for diagnosing arterial dissection and venous sinus thrombosis, although dedicated CT angiography and venography (respectively) are necessary to make each diagnosis, and other causes of HA can easily be missed with these techniques. A "routine" MRI will detect a large number of causes of HA, and the sensitivity of MRI can be improved further by tailoring the examination to the patient. For this reason, it is even more important for MRI than CT that the request form contains the key clinical information. This is viewed by the radiologist before the MRI scan is performed, and the study is protocolled accordingly. As MRI does not involve ionising radiation, and most patients with HA do not require IV contrast, investigation for HA is a safe, non-invasive process. Whilst many scans performed for HA will return a normal finding, the cost benefit comes from the reassurance to the patient and their doctor when the study is normal, and the vital benefit of detecting those patients with a serious, treatable condition before serious complications (including death) have occurred.

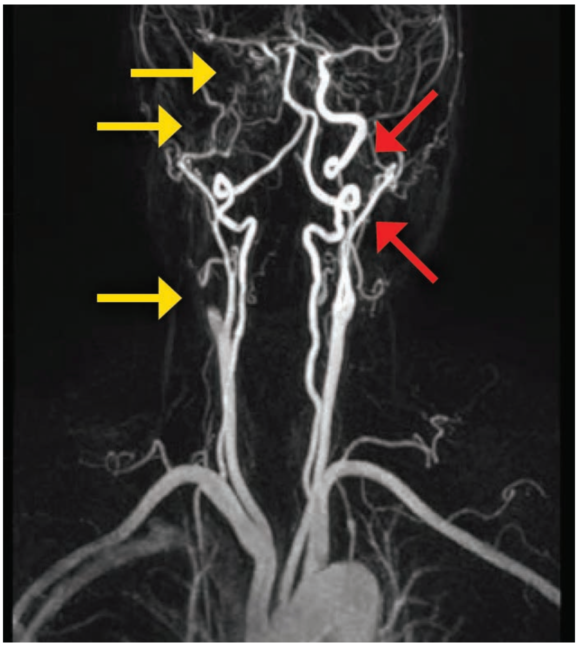


Figure 2: Arterial dissection. MR Angiogram shows absent flow in right common carotid artery (yellow arrows) and narrowed left common carotid artery (red arrow).

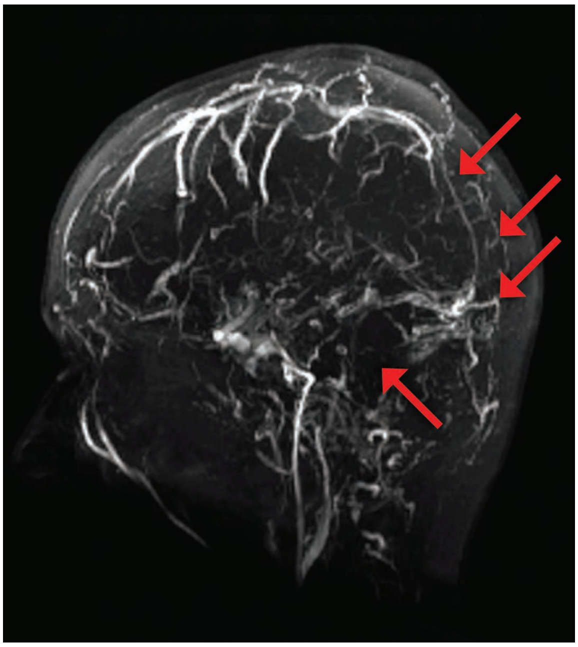


Figure 3: Venous sinus thrombosis.MR venogram shows absent flow in superior sagittal and transverse sinuses.

Raised intra-cranial pressure

Patients with clinical features of rapid onset raised intracranial pressure require imaging urgently, and CT may be appropriate to exclude a neurosurgical emergency (such as subdural haematoma or rapid onset hydrocephalus.) That said, a quick phone call to the radiologist can often secure an expedited MRI examination in an acceptable time period. MRI will show the cause of raised pressure with greater accuracy, and will also reveal other conditions that may mimic raised pressure.

Focal neuropathy

MRI is superior to CT in detecting the common causes of focal neuropathy; stroke and demyelination (multiple sclerosis), as well as the many rarer causes. The study will be tailored to the patient's potential clinical condition(s), so it is important that the MRI request contains detailed clinical information.

Familial history of aneurysm

MR angiography (MRA) and CT angiography (CTA) are comparable in accuracy and both are very good for detecting cerebral aneurysms. The advantages of MRA are:

1) it does not require intravenous contrast (CTA requires rapid IV bolus injection of iodinated contrast) and:
2) no ionising radiation. CTA may be more appropriate in patients who are claustrophobic, and who may have difficulty keeping still, as CTA is much more rapid to perform.

Figure 4: Aneurysms. MR angiogram shows bilateral internal carotid artery aneurysms.

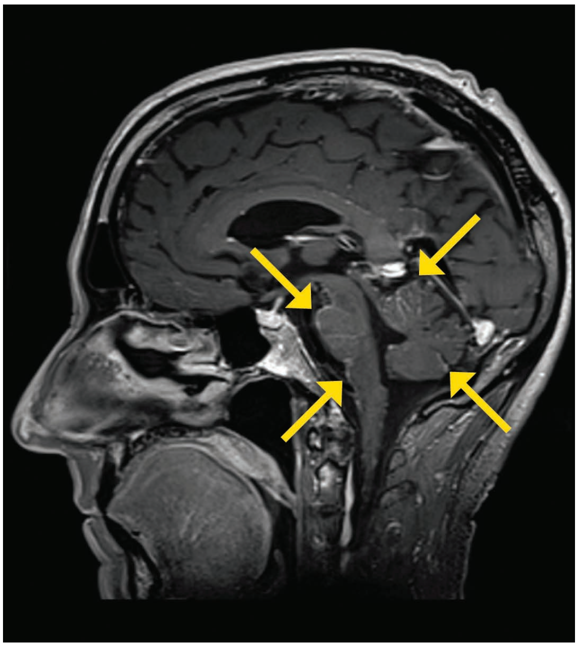


Figure 5: Meningeal metastatic disease. T1 post contrast image shows enhancing tumour coating brain stem and cerebellar folia.

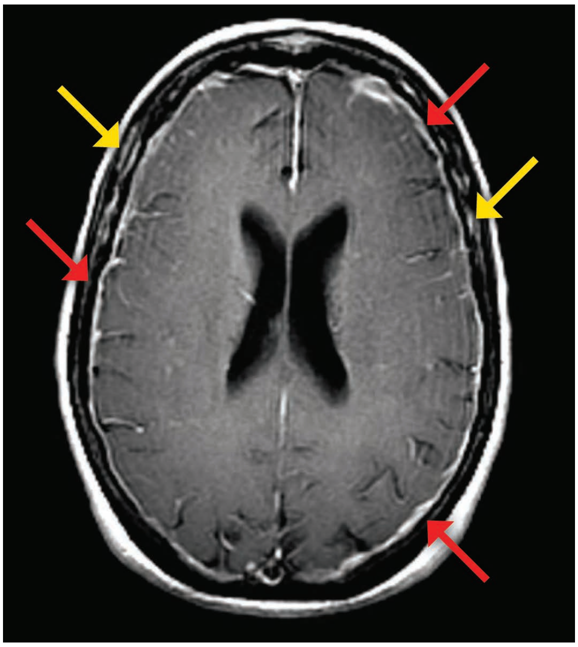


Figure 6: Meningeal metastatic disease. T1 post contrast images shows extensive enhancing tumour in the dura (red arrows). Bone metastases also enhance (yellow arrows).

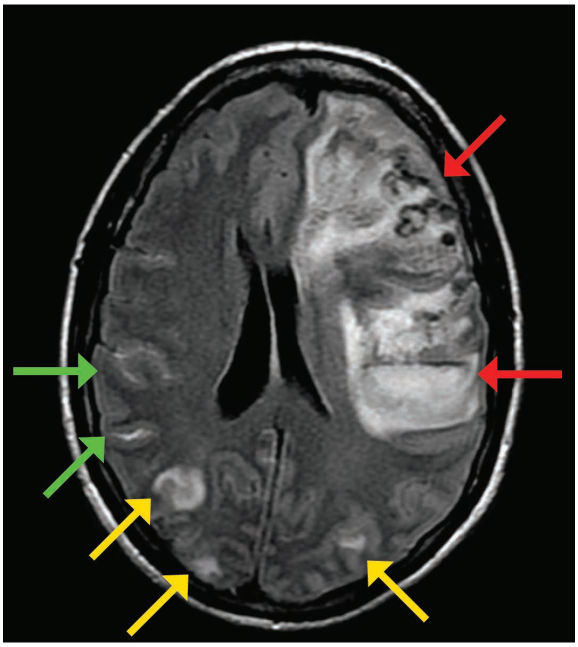


Figure 7: Posterior Reversible Encephalopathy Syndrome (PRES). FLAIR T2 image shows lesions of (PRES) (yellow arrows) complicated by cerebral (red arrows.) and sub arachnoid (green arrows) haemorrhage.

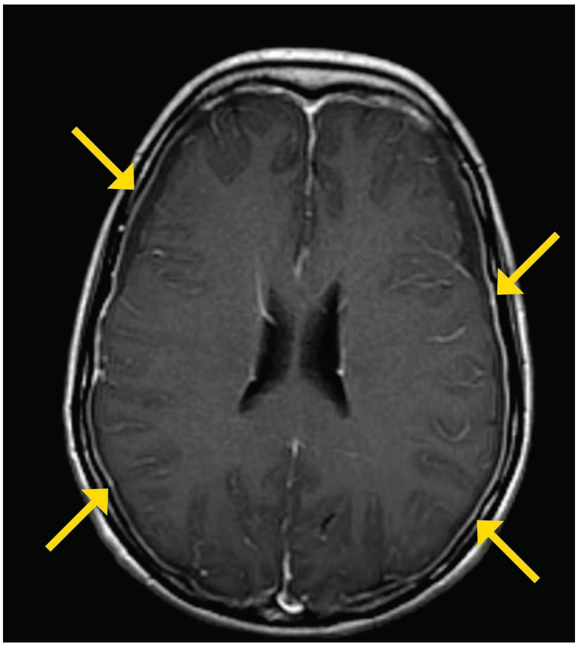


Figure 8: Spontaneous Intracranial Hypotension. Post contrast T1 image shows abnormal dural enhancement due to decreased intracranial pressure.

Figure 9: Spontaneous Intracranial Hypotension. PD image shows bilateral secondary subdural fluid collections.

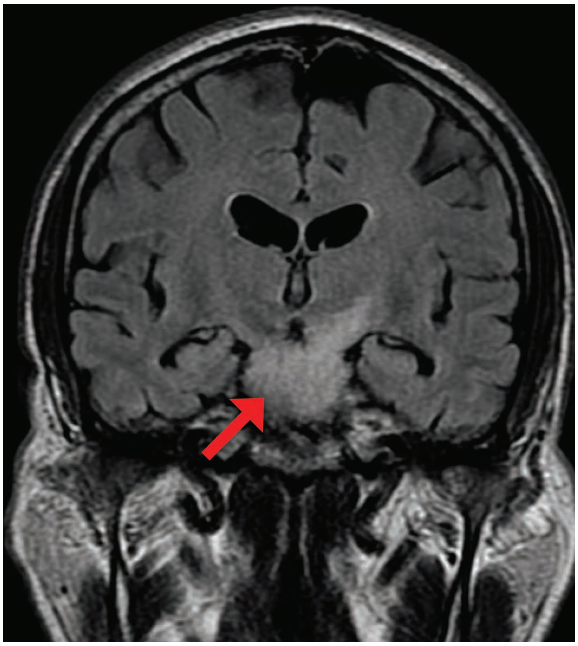


Figure 10: Coronal FLAIR T2 image shows brainstem encephalitis in a patient presenting with headache and fever.

Dr Ian Cox
MBBS MMed FRANZCR
Radiologist

After training in radiology at The Royal Melbourne Hospital, Dr Ian Cox undertook a one year Fellowship in body imaging and musculoskeletal MRI at the Medical College of Wisconsin, Milwaukee, followed by a two year Fellowship in diagnostic neuroradiology, including head and neck imaging and paediatric neuroradiology at the prestigious UCSF, San Francisco.

Concurrent with sessional appointments in MRI over many years at St. Vincent's Hospital, Melbourne, and then Monash Medical Centre, Dr Cox has been director of MRI at Cabrini Malvern for over twenty years.

Dr Ian Cox is an experienced general radiologist with a special interest in MRI. He has particular interest in neuroradiology and musculoskeletal imaging,and has experience in almost all facets of MRI.

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MRI for suspected cervical spine trauma

Dr Bob Dempster MBBS, BScHons, FRANZCR

The patient with moderate to severe cervical spine trauma will be evaluated in the A&E department with detailed CT and sometimes also MRI.

Those with mild to moderate trauma might be seen by their GP in the acute, subacute or delayed circumstance.

High resolution CT is the mainstay of cervical trauma imaging as it is optimal for displaying fractures, displacements and facetal dislocations, however CT does not show the cord and is very suboptimal for soft tissues including discs, ligaments and muscles.

MRI may be additionally useful in the following situations:

- Suspected cord injury with or without abnormal CT
- Neurological deficit with negative CT or out ofproportion to CT findings
- Persisting significant pain with normal CT e.g. whiplash injury
- Traumatic disc protrusion
- Suspected vertebral artery injury (MR or CT angiogram)
- Sub acute or chronic sequelae of trauma

Figure 1:
C4-5 Dislocation
Ruptured anterior and posterior longitudinal ligaments. Cord compression and oedema. Prevertebral haematoma. Ruptured interspinous ligaments. (Wikipaedia)

Figure 2:
Subluxation C5-6
Ruptured posterior longitudinal ligament. Cord oedema. Facetal dislocation.
(Kerr Seminars Musculoskeletal Radiology 2006)

Figure 2

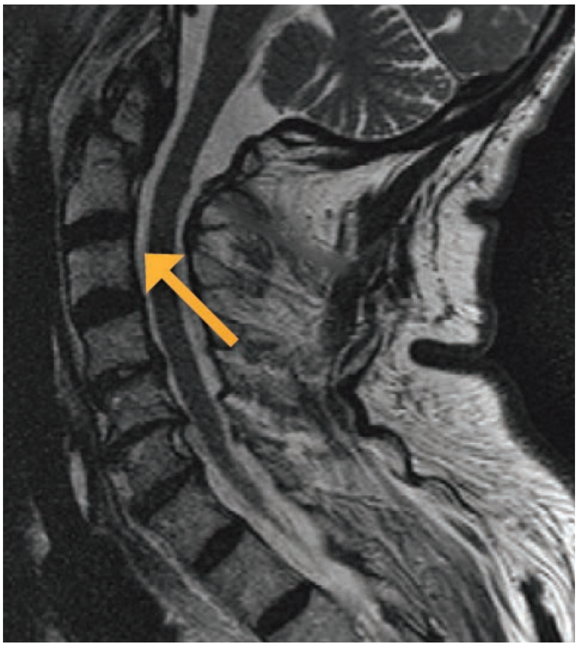

Figure 3a:
Displaced fractured odontoid posterior longitudinal ligament intact. Cord intact. (Looby Radiology Clinics Nth America 2011)

Figure 3b

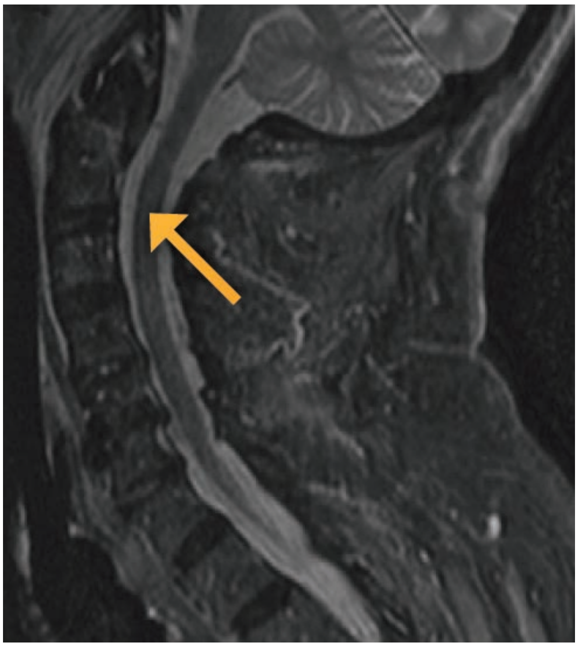

Figure 3c

Figure 4a:
Patient with neck pain after high speed collision: CT normal.

Figure 4b:
MR shows C5-6 subluxation, anterior longitudinal ligament, posterior longitudinal ligament and interspinous ligament disruption.

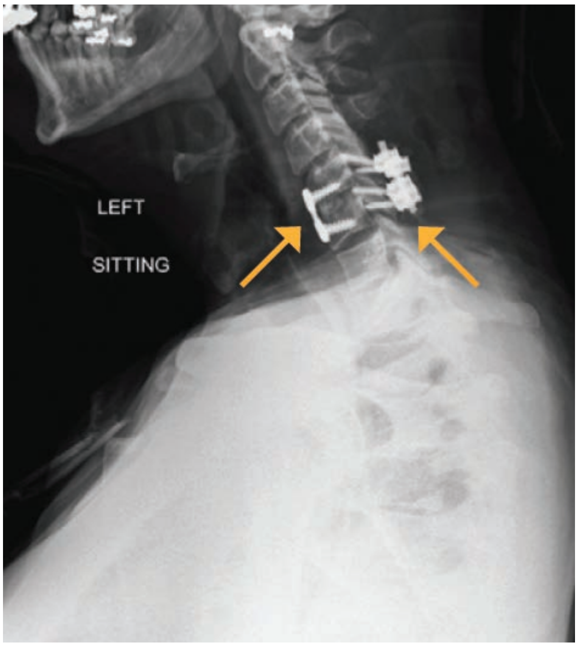

Figure 4c:
Post orthopaedic fixation.
(Looby Radiology Clinics Nth America 2011)

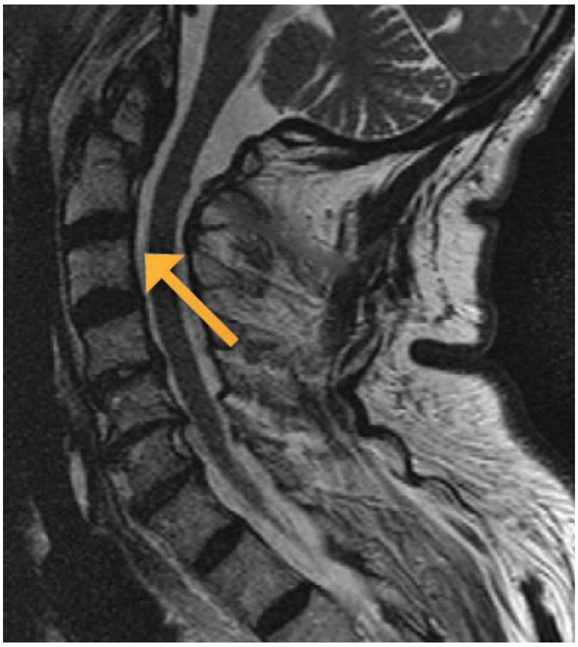

Figure 5a:
Whiplash Injury. Subtle compression fractures and oedema T1 and T2.(Anderson Radiology 2012)

Figure 5b

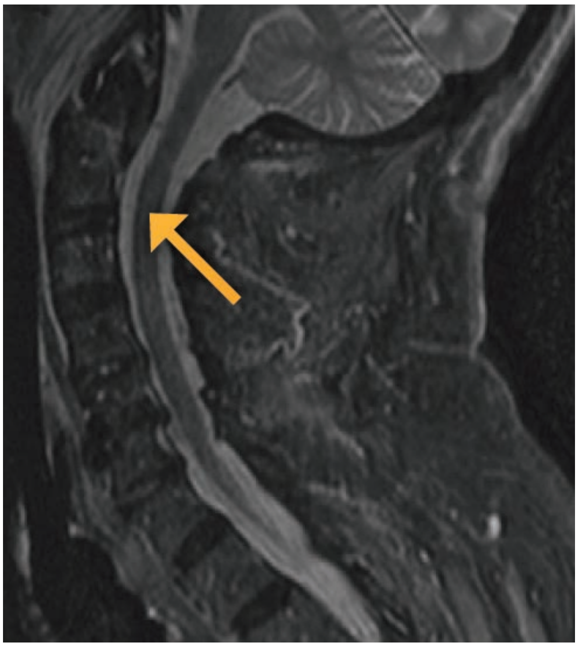

Figure 5c

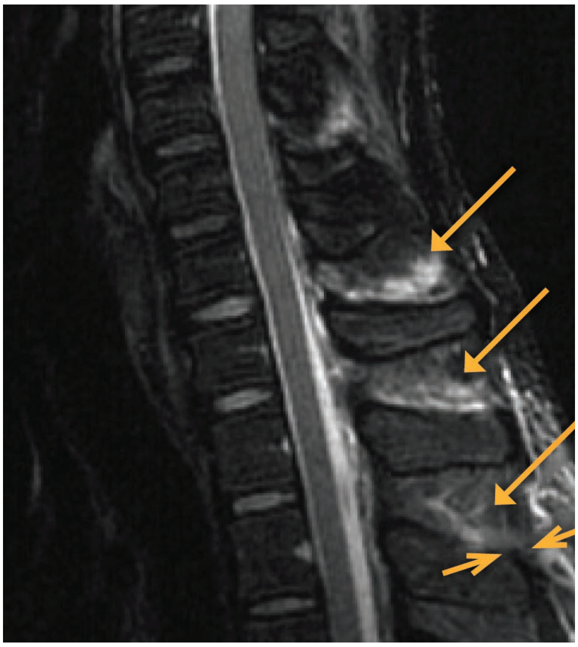

Figure 6:
Whiplash Injury
Torn interspinous ligaments C6-7-T1-T2.
(Minz Seminar Musculoskeletal Radiology 2004)

Figure 8:
Occluded right vertebral artery in a patient with a C1 fracture.
(Castillo Applied Radiology 2007)

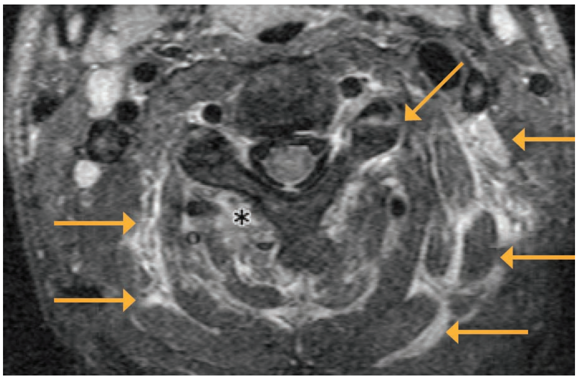

Figure 7:
Whiplash Injury. Extensive intermuscular haematoma. Damaged left C2-3 facetjoint.
(Anderson Radiology 2012)

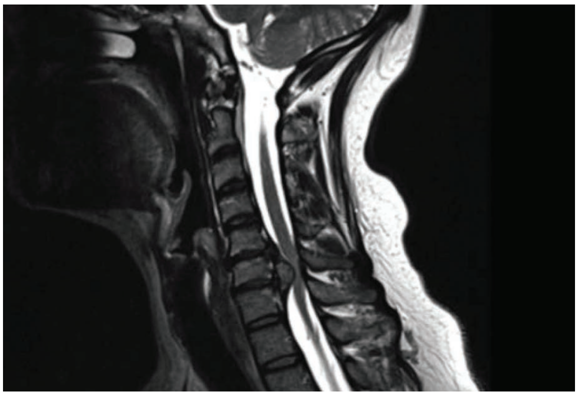

Figure 9:
Acute disc protrusion with cord compression.

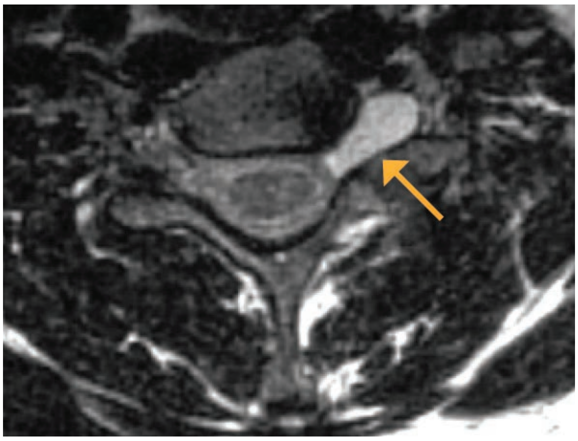

Figure 10:
Left T2 nerve root avulsion with pseudomeningocoele.
(Minz Seminar Musculoskeletal Radiology 2004)

Figure 11a:
Chronic post traumatic
syringomyelia following severe cord trauma with paraplegia 20 years previously.
(Kerr Seminar Musculoskeletal Radiology 2006)

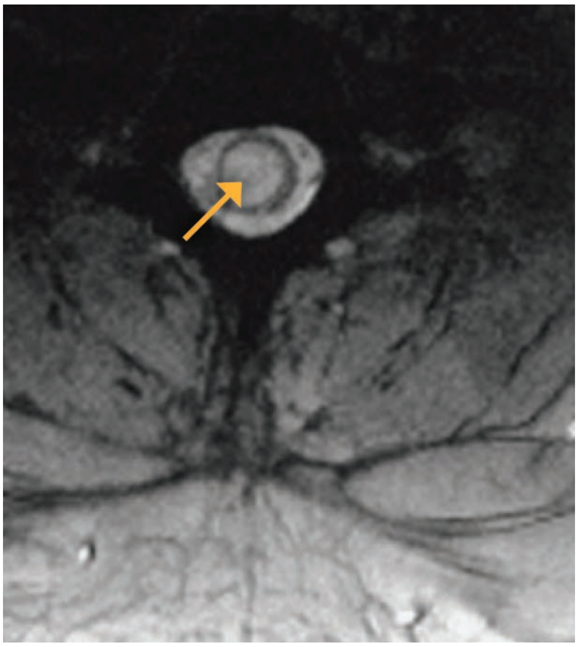

Figure 11b

Dr Bob Dempster
MBBS, BScHons, FRANZCR
Radiologist

Dr Bob Dempster is director of MRI and PET at I-MED Radiology, Frankston Private.

MRI lumbar spine for low back pain

Dr Steven Irons MBBS FRANZCR

Acute low back pain is one of the most common clinical presentations in general practice. In most cases, patients will respond to conservative treatment without initially requiring imaging investigations. However, there are a variety of symptoms and signs "red flags" that merit further investigation.

MRI is far superior to CT in assessing soft tissues including: bone marrow, discs, spinal cord, nerve roots, ligaments, epidural and leptomeningeal spaces.

Below are indications that warrant further imaging investigation with MRI, however do not attract Medicare benefits when referred by an allied health or general practitioner (GP).

Indications:

1. Suspected primary or metastatic disease

- Suspect in elderly, prior malignancy, pain at rest/ multiple sites, significant weight loss.

2. Discitis / osteomyelitis

- Back pain + fever or immunocompromised or local wound.

3. Fracture

- Minor trauma + high risk patient (elderly/ immunocompromised/chronic steroid use/known osteoporosis with significant new back pain).
- Major trauma.

4. Cauda equina syndrome

- Suspect in new onset: incontinence (urinary &/ or faecal) &/or bilateral leg weakness or sensory loss &/or saddle paraesthesia.

5. Non-infective inflammation / spondylitis

- Broad group of causes.
- Chief amongst this group are seronegative spondyloarthropathies, especially Ankylosing spondylitis (AS).
- Suspect AS in: Age less than 45, morning stiffness, improvement with exercise, not relieved supine, pain >3 months.

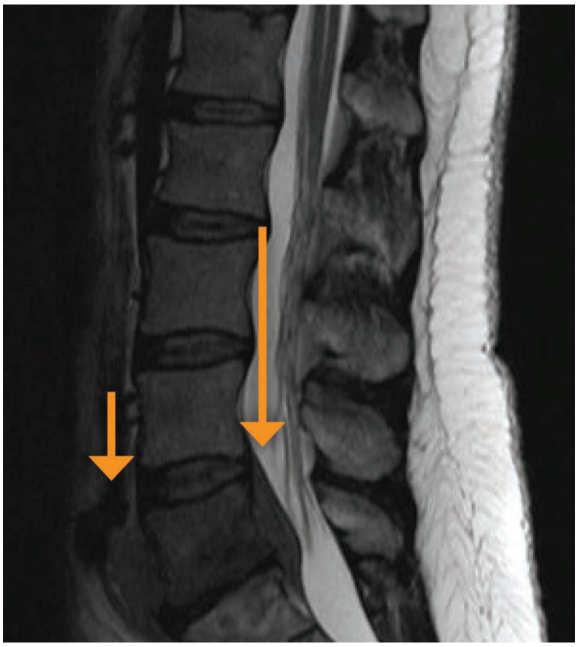

Figure 1:
Lymphoma infiltrating vertebral body, extending posteriorly into the epidural space as well as anteriorly into the prevertebral region.

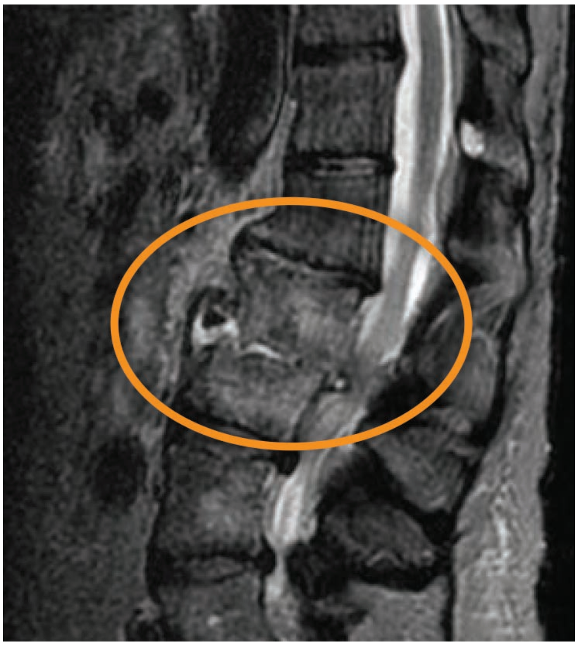

Figure 2:
Discitis/Osteomyelitis - L2/3 endplate and disc inflammation with destruction.

6. Sciatica that has failed conservative management

- Weakness or sensory disturbance down one or both lower limbs.
- Bilateral lower limb disturbance suggests central canal compromise.

For patients less than 16 years of age – GPs can order Medicare-rebatable MRI of any part of the spine for the following circumstances:

- Significant trauma.
- Unexplained neck or back pain with associated neurological signs.
- Unexplained back pain where significant pathology is suspected.

Figure 3:
Stress fracture. Fracture line (orange arrow) through bone marrow with greater than 50% height loss of vertebral body. Bone oedema indicates subacute insult.

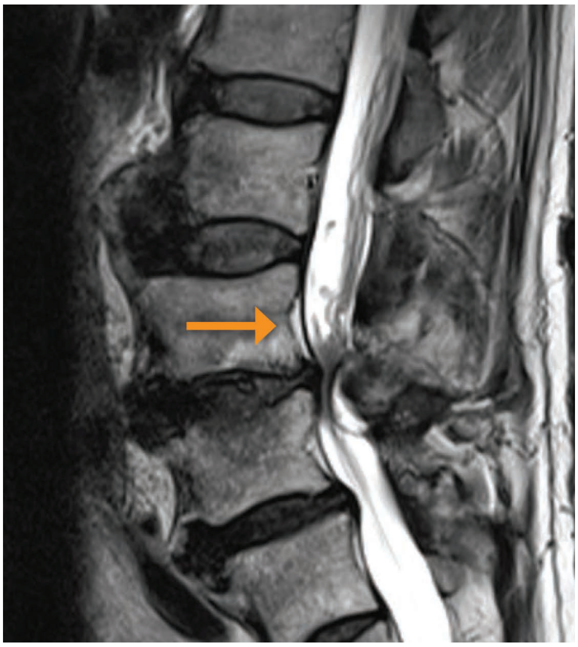

Figure 4:
Cauda equina syndrome from combination of disc and facet degenerative changes producing severe central canal stenosis.

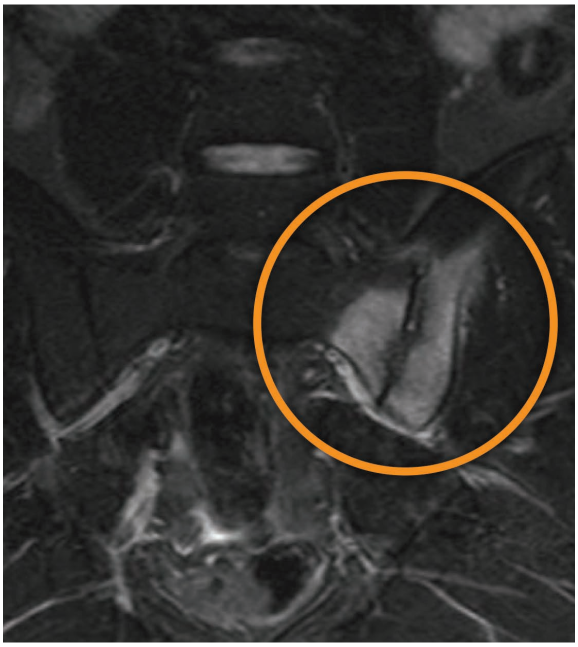

Figure 5:
Sacroiliac joint and bone marrow inflammation with probable early erosions in a patient suspected of having Ankylosing spondylitis(AS).

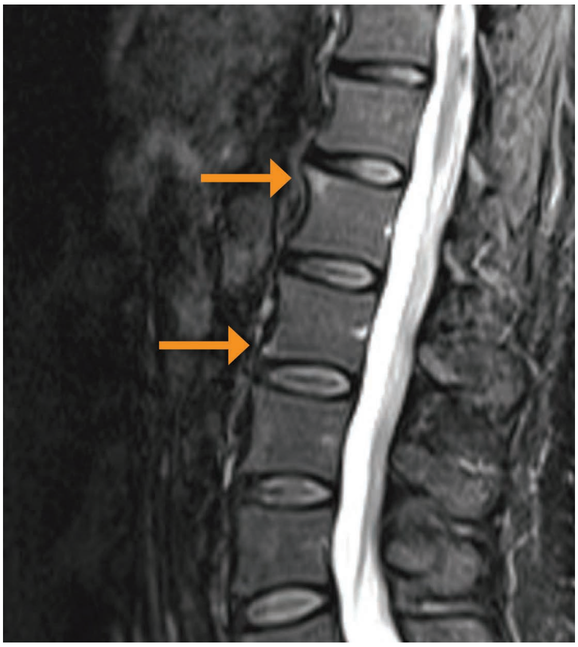

Figure 6:
Inflammation at the corners of vertebral bodies "shiny corner sign" at ligamentous attachments reflecting enthesitis in suspected AS.

Dr Steven Irons
MBBS FRANZCR

Dr Steven Irons is the Clinic Director at I-MED Radiology Frankston Private Hospital, and enjoys working with a variety of specialists and GPs in the region.

Dr Irons completed a Fellowship in MRI at The Alfred Hospital, Melbourne in 2005 and has been a part of the I-MED team since 2006. He is a general radiologist with special interests in a broad variety of MRI imaging and non-vascular interventions.

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Investigating shoulder injuries

Dr Tim Dunshea MBBS, FRANZCR
Radiologist, I-MED Radiology

Ultrasound and MRI can be complementary tests when imaging superficial shoulder structures such as the rotator cuff, subdeltoid bursa and biceps tendon. Rotator cuff tears commonly involve the supraspinatus tendon, and are seen on MRI as a fluid-filled defect within a normally black tendon. Subdeltoid bursitis is seen as fluid interposed between the deltoid and the rotator cuff.

MRI has the advantage over ultrasound when it comes to looking for deeper, intra-articular causes of shoulder pain. MRI provides great detail of many processes which may not be visible with other forms of imaging, including labral tears, paralabral cysts, intra-articular loose bodies, chondral damage, capsulo-ligamentous injuries and subtle Hill-Sachs lesions and other fractures.

The shoulder is a very mobile joint, with a large range of movement. The trade-off is that it is also potentially unstable. The fibrocartilagenous labrum deepens the shallow socket, however, it is prone to injury from a sudden injury or repetitive trauma. On MRI, the labrum is usually seen as black triangular structure around the rim of the glenoid fossa. When damaged, the labrum can develop a tear, become displaced or be associated with paralabral cysts. The MRI radiologist also needs to be aware of normal labral variants including normal fluid signal clefts that can mimic a tear making imaging of the shoulder very interesting and sometimes challenging.

There are two common types of labral tear. Firstly, the superior labral or SLAP (superior labral anterior to posterior) tear, which can be due to acute or repetitive trauma. Secondly the Bankart lesion (usually anteroinferior) which is commonly associated with anterior shoulder dislocation. Each of these have several variants, and give symptoms of pain and instability.

Figure 1:
Loose chondral body (arrow) within the inferior recess of the shoulder joint, surrounded by high signal joint fluid.

Figure 2:
Patient with previous anterior dislocation and a Bankart lesion. Cleft of high signal (arrow) indicating a tear at the antero-inferior corner of the labrum. Importantly there is no underlying glenoid fracture (bony Bankart lesion).

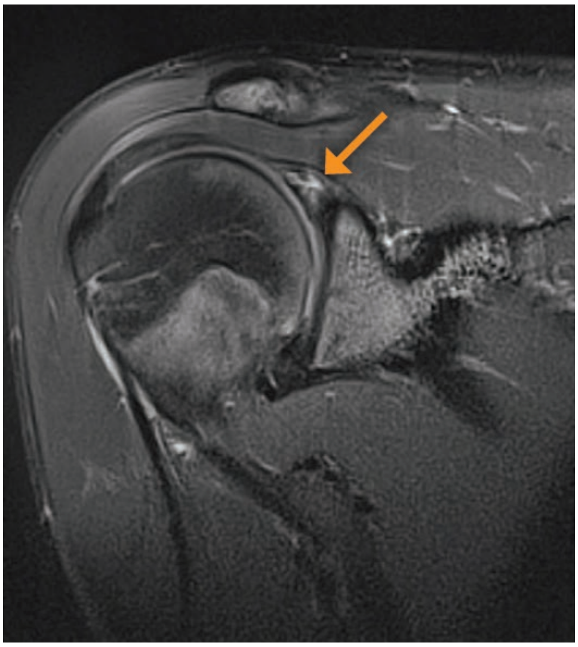

Figure 3:
Superior labral tear (arrow) in a patient with chronic shoulder pain.

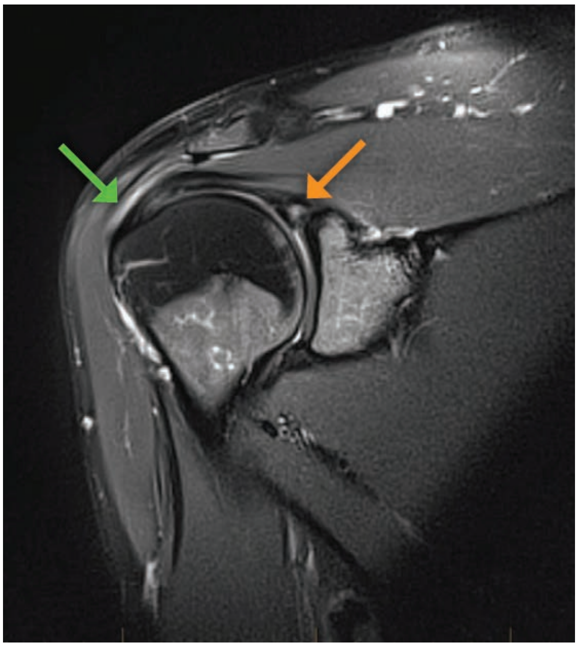

Figure 4:
Co-existing shoulder pathology. This patient has a SLAP tear (green arrow) and also has features of subacromial-subdeltoid bursitis (orange arrow).

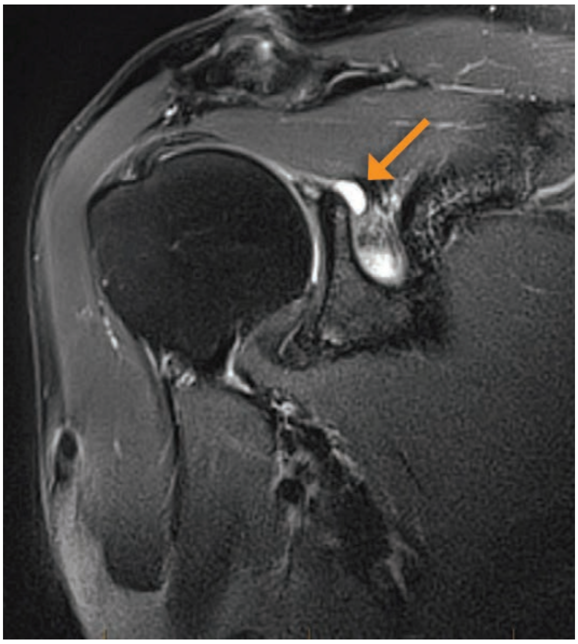

Figure 5:
SLAP tear with a small paralabral cyst.

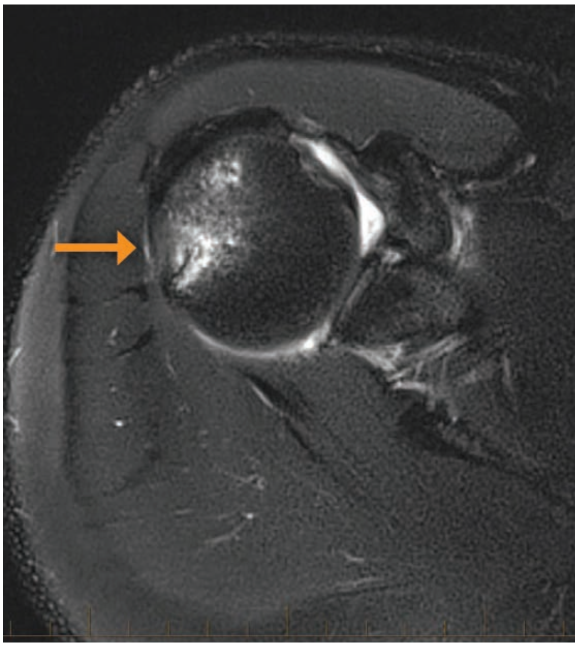

Figure 6:
Patient with a recent history of anterior dislocation. Here is a Hill-Sachs fracture and bone bruise.

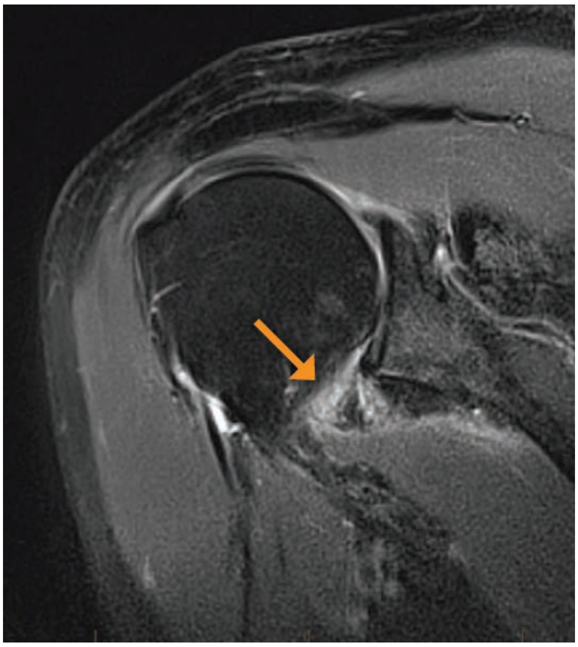

Figure 7:
This injury involves disruption of the humeral attachment of the inferior glenohumeral ligament which forms part of the shoulder capsule. This type of injury is known as a HAGL (Humeral Avulsion Glenohumeral Ligament).

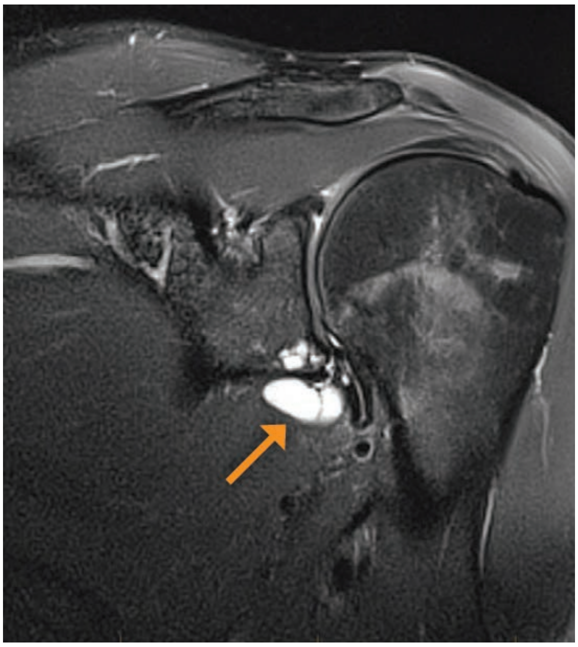

Figure 8:
Extensive inferior labral tear with a multilocular paralabral cyst and cystic bony change within the inferior glenoid.

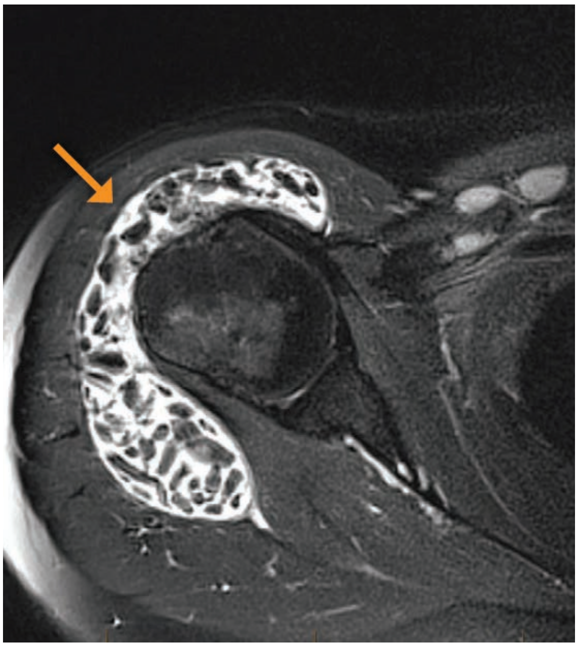

Figure 9:
Patient with rheumatoid arthritis with complex bursitis evident on US. Characteristic Rice Bodies are present in the bursa. These are small loose bodies which occur as a result of chronic inflammation. MRI showed that there was no associated intra-articular pathology in this patient.

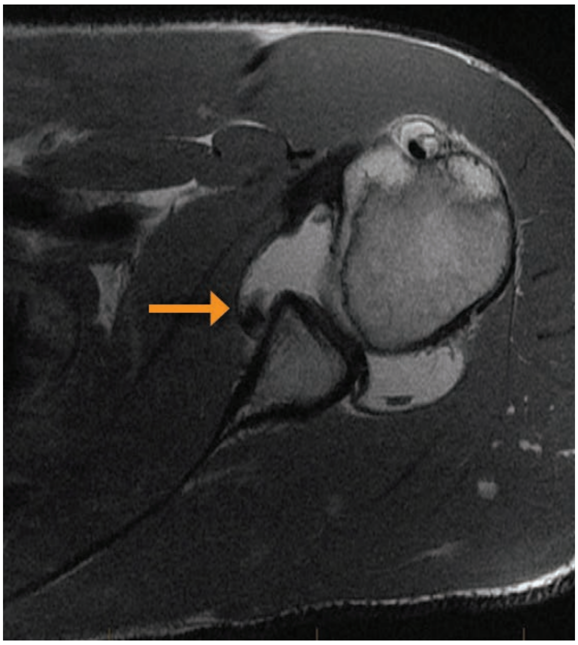

Figure 10:
ALPSA. This patient suffered a Bankart variant known as an ALPSA (Anterior Labral Periosteal Sleeve Avulsion), where the labrum is displaced medially, away from the glenoid rim. Unlike the Bankart lesion in which the labrum is avulsed from the underlying glenoid, in an ALPSA lesion the mobilised labrum remains attached to the periosteum which overlies the glenoid (thus sleeve). As a result it can heal (as opposed to Bankart which do not), however it can do so in an abnormal position requiring identification and early surgical repair.

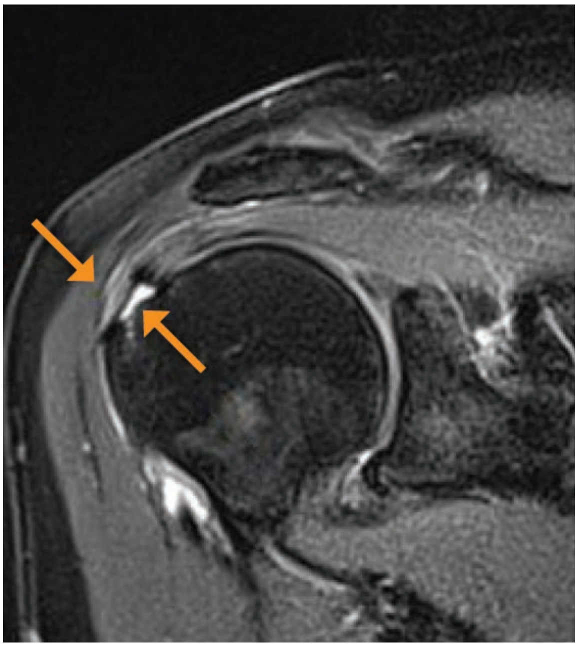

Figure 11:
There is a partial thickness tear, showing bright fluid signal where supraspinatus inserts onto the humeral head. This is a common site for rotator cuff tears. Incidentally there is some thickening of the overlying subdeltoid bursa.

Figure 12:
Thickening of the subdeltoid bursa, with bright fluid signal overlying the supraspinatus tendon which is intact.

Dr Tim Dunshea
MBBS (Hons), FRANZCR

Dr Tim Dunshea studied medicine at Monash University and completed radiology training at St Vincent's Hospital. Dr Dunshea then completed a musculoskeletal imaging Fellowship with I-MED Radiology Victoria House. He has extensive experience in cardiac imaging including coronary artery CTA (for which he has ANZCTCA Level 1 registration). Dr Dunshea has worked with I-MED Radiology since 2006 and has been Clinic Director at I-MED Radiology Warringal since November 2009. He is also Clinic Director at I-MED Radiology Heidelberg.

Dr Dunshea is an experienced general radiologist with special interests in MRI, cardiac CT, and ultrasound.

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Acute knee trauma

By Dr Andrew Rotstein MBBS, FRANZCR

The knee joint is the most commonly injured joint. Acute knee injuries can be caused by a direct blow, sudden twisting, an instability event or a fall onto the knee. Acute knee injuries often present clinically with a knee joint effusion, locking of the knee or focal knee pain. Acute knee injuries can occur to patients of any age.

Knee joint effusion

The clinical presence of a new knee joint effusion following trauma is an indication of internal derangement of the knee. It is important to determine how quickly the effusion has developed. A rapid onset effusion, within the first hour of injury, indicates a haemaethrosis.

The two most common and important causes for a rapid onset knee joint effusion are an ACL tear or patellar dislocation. These two diagnoses can sometimes be difficult for even an experienced musculoskeletal clinician to differentiate in the acute setting. A slowly developing effusion, next day onset, is more likely due to a meniscal or chondral injury.

The anterior cruciate ligament (ACL) is well visualised and assessed with MRI. In a complete ACL tear, ligament fibres are disrupted and hyperintense (Fig 1). Figure 1 demonstrates the knee of a 53-year-old patient who injured his knee while skiing. The secondary findings of an ACL tear include the classic anterior lateral femoral condyle and posterior lateral tibial plateau bone contusions due to impaction at the time of instability (Fig 2).

The patient was managed conservatively with physiotherapy and returned to skiing the following year with a customised knee brace.

The medial collateral ligament (MCL) is the most commonly injured ligament at the knee and injury to the ligament is accurately graded with MRI (Fig 3). MCL injuries are traditionally managed conservatively while lateral collateral ligament (LCL) injuries are traditionally managed surgically. Transient patellofemoral dislocation typically occurs in young patients and is well demonstrated with MRI. Patellofemoral dislocation is classically characterised by medial patella facet and lateral femoral condyle bone contusions (Fig 4). MRI is crucial for detecting unstable patellofemoral osteochondral lesions that require arthroscopy (Fig 5). MRI can also demonstrate predisposing factors for the patellofemoral dislocation such as patella alta (high riding patella), shallow femoral trochlear groove and tibial tuberosity lateralisation. These factors have implications for prevention and management.

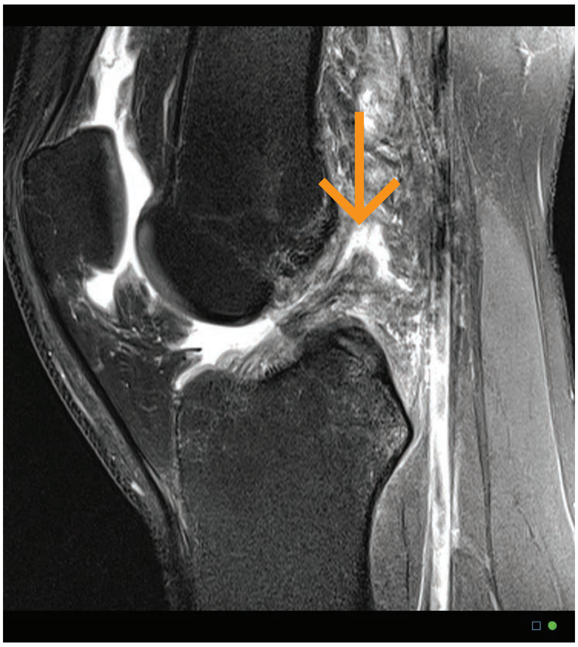

Figure 1:
ACL tear at the femoral attachment.

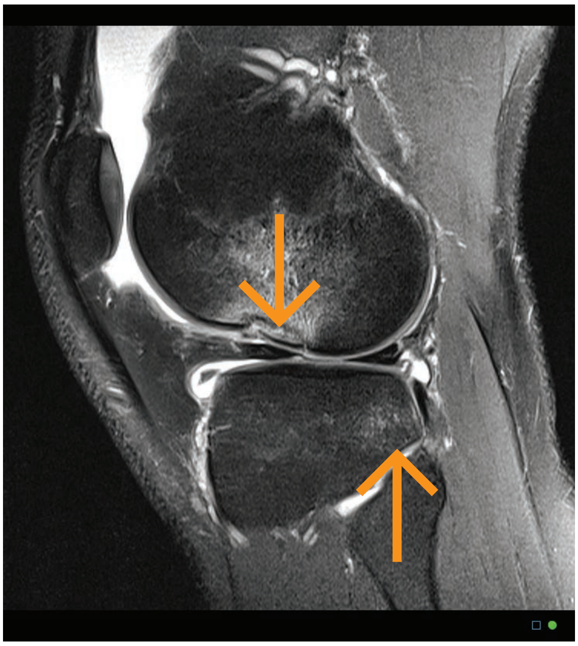

Figure 2:
Anterior lateral femoral condyle osteochondral impaction lesion and bone contusion. Posterior lateral tibial plateau bone contusion.

Knee joint locking

Acute knee injuries can present with locking of the knee. The locking can be fixed or intermittent. Locking can be due to meniscal tears or intra-articular cartilaginous or osseous bodies. A meniscal tear will often cause loss of end range extension. A loose body can cause locking in variable degrees of flexion.

MRI is the only radiology modality that can adequately assess the meniscus. A bucket handle tear of the meniscus occurs when the inner portion of the meniscus is torn and then flips into the center of the knee. This is like the handle of a bucket swinging from one side to the other. The bucket handle fragment of the meniscus is clearly shown within the intercondylar canal of knee adjacent to the ACL and PCL (Fig 6).

Figure 7 demonstrates a medial meniscal meniscotibial flap tear in a 54 year old woman who twisted her knee crossing the road. The patient experienced locking and medial joint line pain. The meniscal flap fragment is displaced inferiorly into the meniscotibial recess as shown on MRI (Fig 7). The patient was reviewed by an orthopaedic surgeon, aware that the meniscotibial recess is a blind spot at arthroscopy. At arthroscopy, the surgeon was able to remove the meniscal fragment. Following arthroscopy, the patient soon became pain free and her knee regained full range of movement.

Knee pain and fracture

For clinical suspicion of a fracture, x-ray is the first investigation.

If the knee x-ray is normal, fractures and bone contusions are very well identified with MRI due to MRI's tremendous ability to assesses the bone marrow (Fig 8).

Figure 3:
Distal MCL tear and ligament retraction.

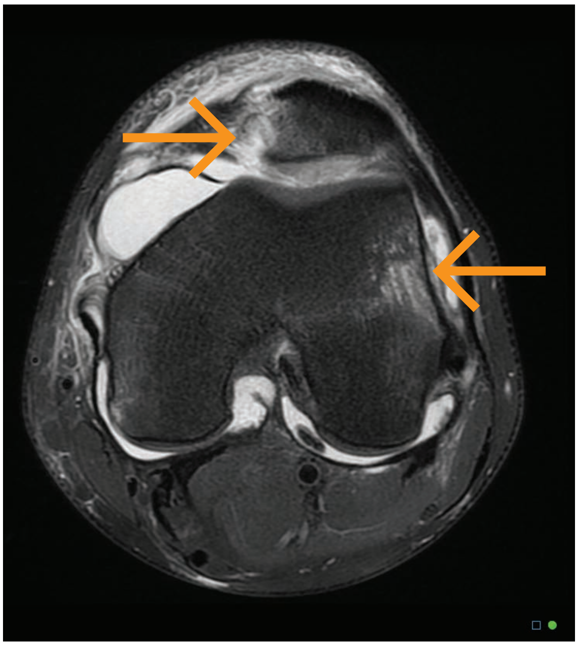

Figure 4:
Medial patellar facet osteochondral impaction lesion and bone contusion and lateral femoral condyle bone contusion following patellofemoral dislocation.

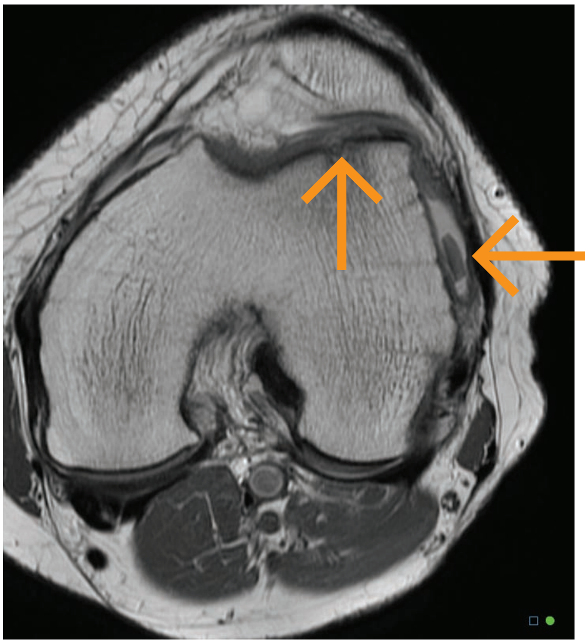

Figure 5:
Lateral femoral trochlear chondral lesion following patellofemoral dislocation. Chondral fragment displaced into the lateral patellofemoral recess.

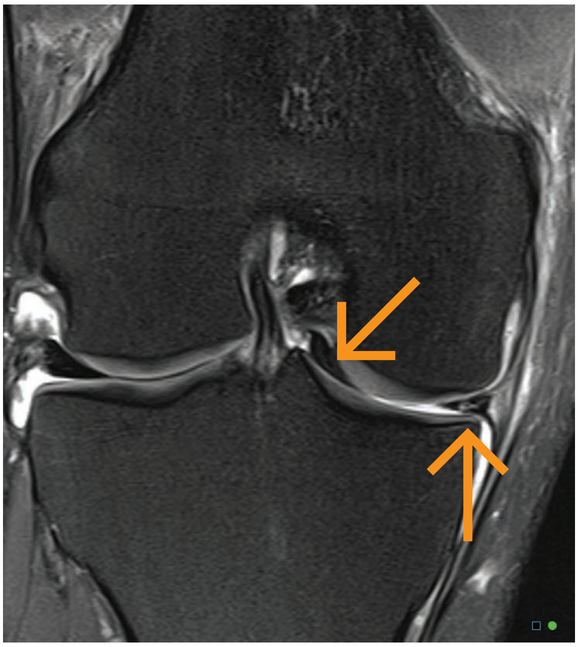

Figure 6:
Medial meniscal bucket handle fragment is displaced into the intercondylar canal. Small residual medial meniscal body with tear.

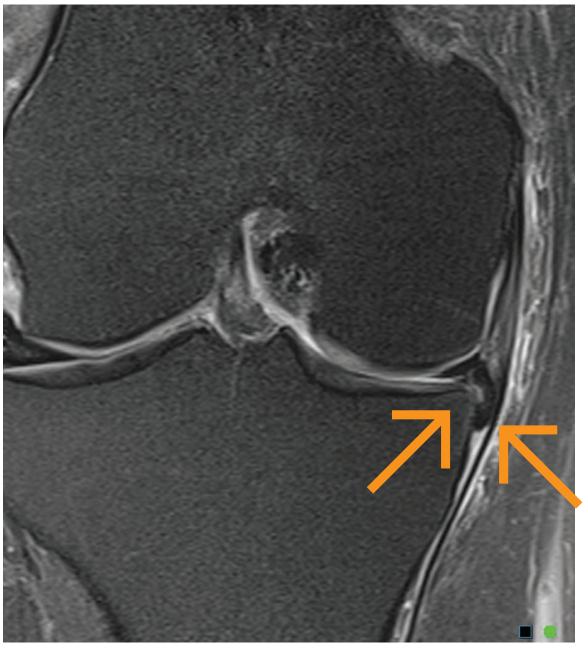

Figure 7:
Meniscal flap fragment is displaced inferiorly into the meniscotibial recess.

Figure 8:
Patellar trabecular fracture with surrounding bone contusion.

Dr Andrew Rotstein
MBBS, FRANZCR

Andrew is the Clinical Director of MRI, CT and Nuclear Medicine at I-MED's Victoria House clinic in Melbourne, Victoria. He is an experienced musculoskeletal radiologist, able to perform all musculoskeletal ultrasound and fluoroscopic injections as well as CT spinal interventional procedures. Dr Rotstein provides expert imaging for the AFL, professional athletes and their doctors. In 2006 he was radiologist for the Melbourne Commonwealth Games. Dr Rotstein lectures at Melbourne University, presents at national and international conferences and supervises musculoskeletal Fellowship training at the clinic. He is a pioneer of weight bearing CT for syndesmosis and lisfranc ligament injuries.

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MR imaging in cervical radiculopathy

Dr Nicholas Gelber MBBS, FRANZCR

There are many indications for imaging of the cervical spine including trauma, osteoarthritis, myelopathy, radiculopathy and pain but this article will be limited to the assessment of radiculopathy.

Contributing factors to patients who have radiculopathy include the following:

- Instability
- Posterior and postero-lateral osteophyte formation
- Neurocentral joint osteophyte formation narrowing the neural foramina
- Postero-lateral disc herniation
- Foraminal disc herniation
- Other unexpected causes such as tumour

In practice, the assessment of radiculopathy in the cervical region in the vast majority of patients is effectively an assessment of postero-lateral and foraminal osteophyte formation and disc herniation although it is very important to exclude the occasional unexpected cause such as tumour.

Readily available techniques include plain film, CT and MRI.

Table 1 outlines the basic advantages and disadvantages of each of these technologies.

Modality	Instability	Postero-lateral and neurocentral joint osteophyte formation	Postero-lateral disc	Foraminal disc	Non-compressive / other causes
Plain film including flexion and extension	++	+	–	–	–
CT	–	++	+/–	–	–
MRI	–	++	++	++	++

Advantages of MRI in the cervical spine include the following:

- Imaging in multiple planes.
- Zero radiation exposure.
- Ability to manipulate the image e.g. T1 and T2 and gradient echo imaging with different tissue intensity characteristics.
- Excellent soft tissue contrast enabling the advantages outlined in Table 1.

Figures 1-4 demonstrate normal appearances in the cervical spine and illustrate the advantages of MRI as outlined previously.

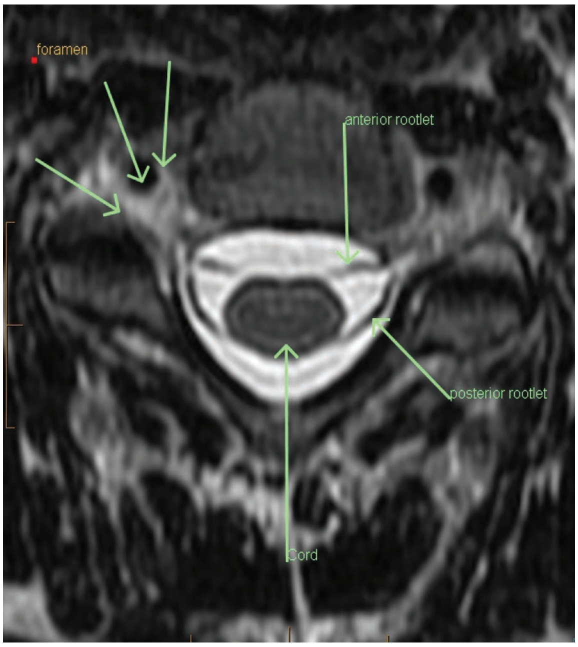

Figure 1:
Demonstrates axial T2 weighted imaging through the cervical spine. Note excellent visualisation of cervical rootlets (both anterior and posterior), and excellent foraminal detail. The cord is also well seen.

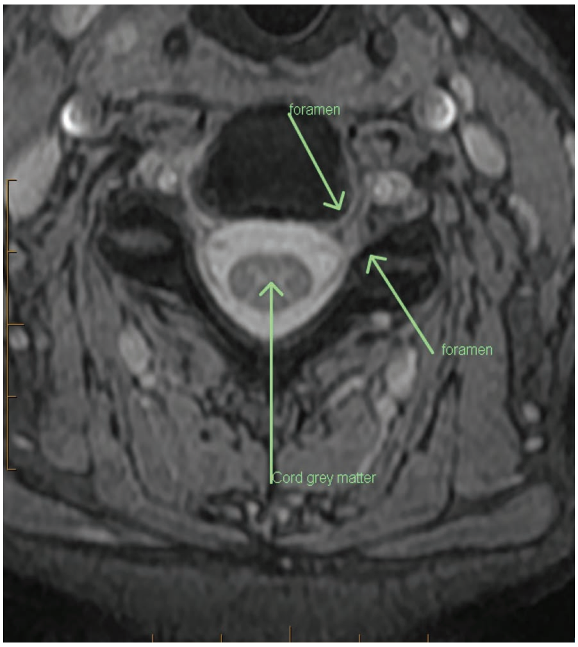

Figure 2:
Demonstrates axial gradient echo imaging through the cervical spine demonstrating similar soft tissue contrast with particularly good visualisation of the neural foramina containing nerve roots and surrounding CSF sleeves. The cord is particularly well seen and it is easy to differentiate between central grey and peripheral white matter.

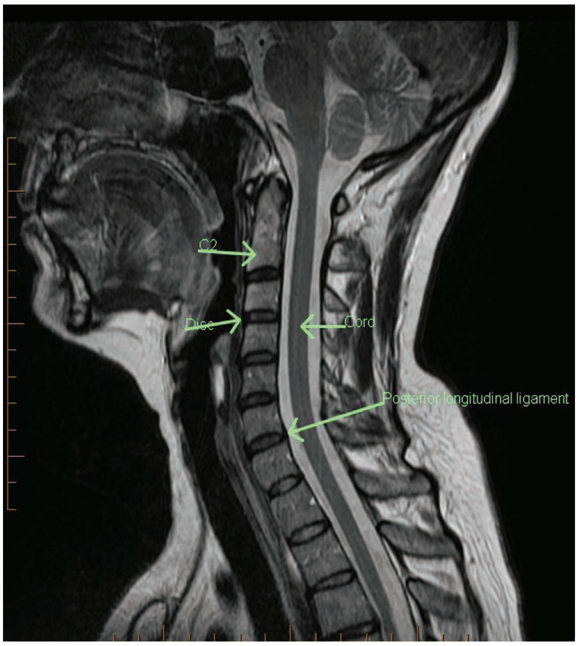

Figure 3:
Demonstrates sagittal T2 weighted imaging through the cervical spine demonstrating excellent visualisation of discs, CSF and cord.

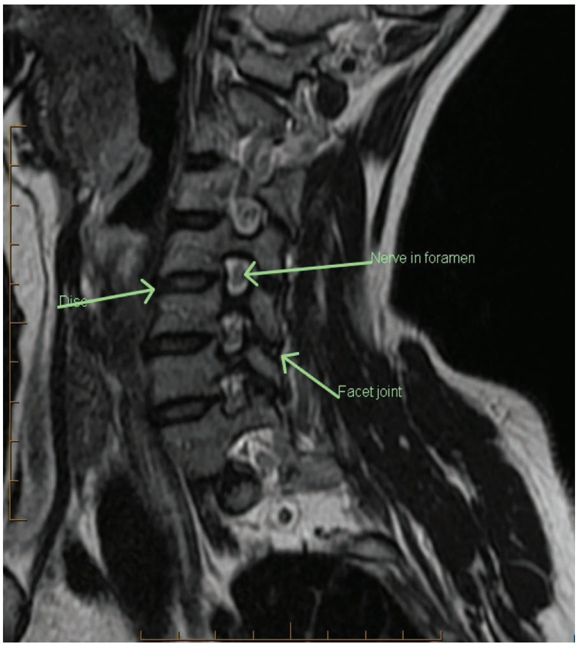

Figure 4:
Demonstrates oblique reconstruction showing excellent foraminal detail. Note excellent visualisation of nerve roots with no suggestion of compression.

Figures 5-11 demonstrate abnormal features in the cervical spine in patients with radiculopathy.

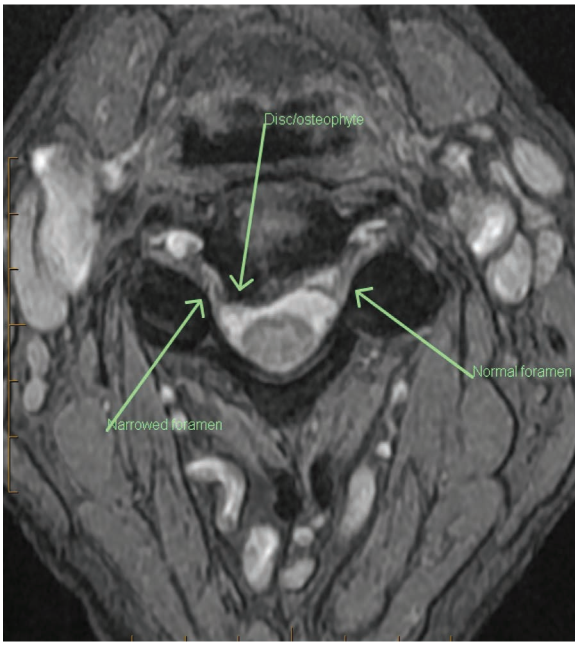

Figure 5:
Demonstrates substantial right postero-lateral disc and osteophyte formation narrowing the medial portion of the foramen. The opposite foramen is widely patent.

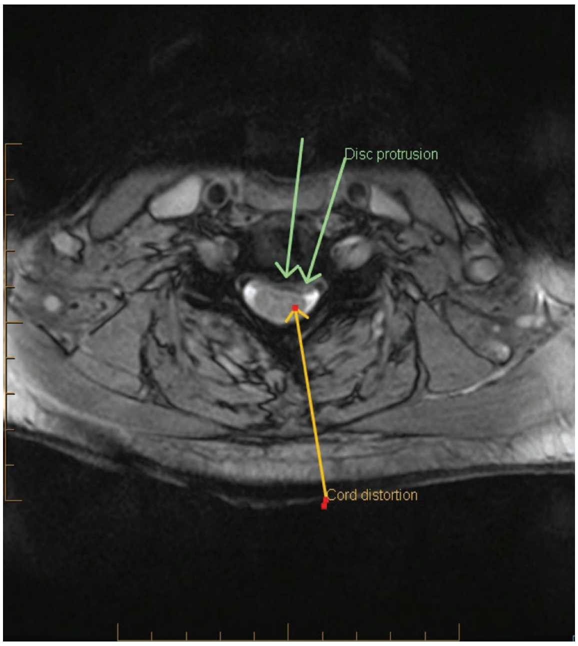

Figure 6:
Demonstrates moderate central and left postero-lateral disc protrusion minimally indenting the cord.

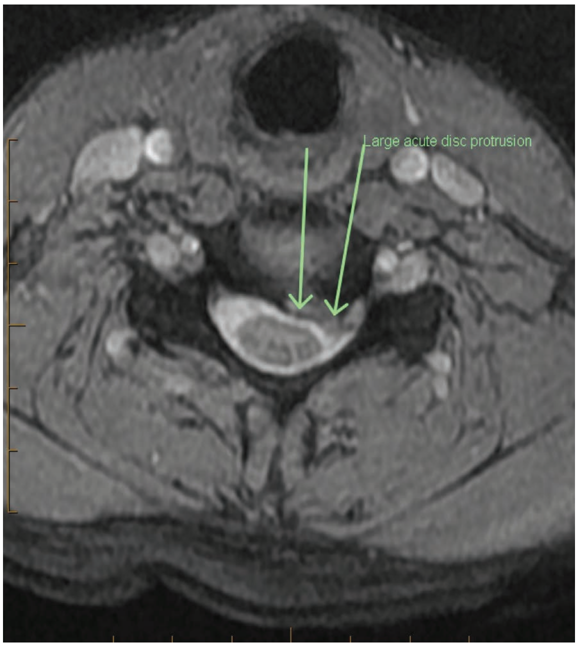

Figure 7:
Demonstrates substantial hyperintense acute left postero-lateral disc protrusion with medial foraminal narrowing and mild cord indentation.

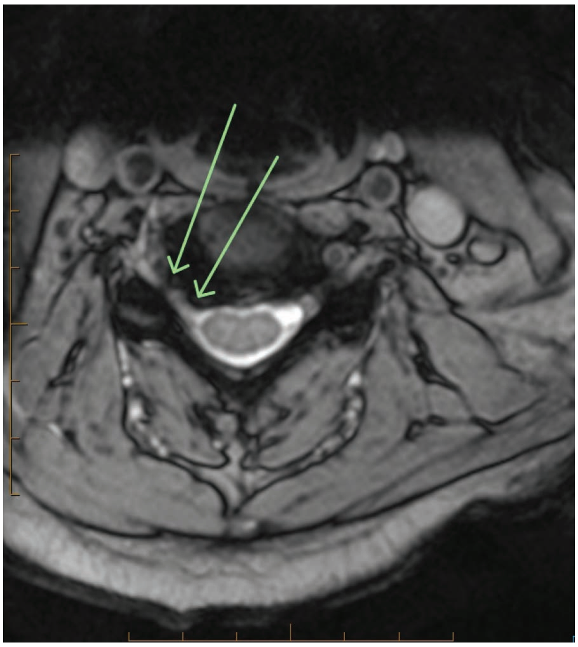

Figure 8:
Demonstrates right postero-lateral osteophyte formation and some neuro-central joint osteophyte formation resulting in significant bony foraminal compromise.

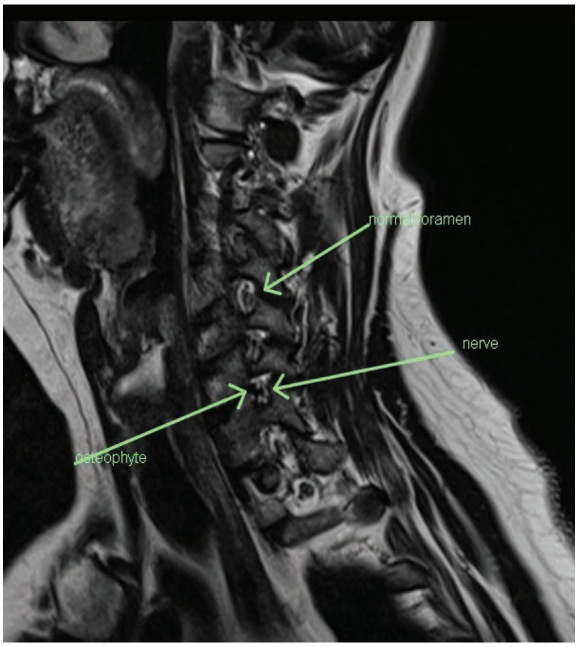

Figure 9:
Demonstrates an oblique reconstruction. The upper foramen is normal. The lower arrowed foramen demonstrates osteophyte formation anteriorly from the neuro-central joint resulting in nerve root compression.

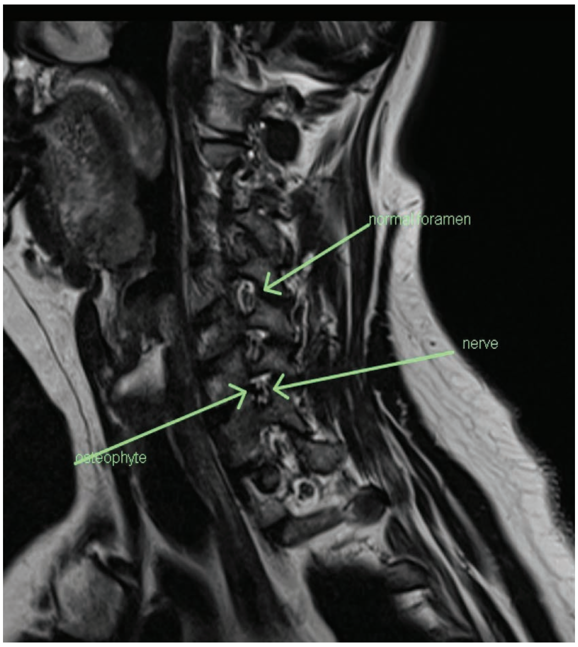

Figure 11:
Demonstrates significant central cord compression. This patient would not present with radiculopathy but clearly this is a very important diagnosis to make and MR is exquisitely sensitive for these changes.

Figure 10:
Demonstrates disc and osteophyte related lower cervical neural foraminal narrowing with a normal foramen above this. Two foramina are affected.

Summary

MR imaging is now reasonably widely available and is the examination of choice in patients who present with suspected cervical radiculopathy.

The reasons for this are outlined above but essentially, the modality demonstrates excellent soft tissue contrast with good visualisation of nerve roots and accurate assessment of all the common causes for nerve root compression, yielding appropriate pre-surgical information.

Dr Nicholas Gelber
MBBS, FRANZCR
Radiologist

Dr Nick Gelber has worked with I-MED since 2001, having previously worked at East Melbourne Radiology, mainly as clinic director at Mercy Radiology. He is an experienced general radiologist with a special interest in Neuroradiology and in particular MRI. He also does all general interventional procedures. Dr Gelber is on the RANZCR College Council.

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MRI of the hip

Dr Peter Smith MBBS, FRANZCR

Suspected hip fracture

Fractures about the hip are common particularly in the elderly. Prompt diagnosis and treatment have been shown to significantly reduce morbidity and mortality rates.

Investigation

Plain film is the first imaging test of choice. If a fracture is present then often no more imaging is required and appropriate orthopaedic treatment can commence. If a fracture is not found but is suspected the next test is an MRI. This is the most sensitive modality for diagnosis of fracture. Complete and partial fractures are diagnosed with confidence. Associated injuries of the pelvis and adjacent soft tissues can also be visualised. CT is less sensitive for femoral neck fractures, but may be used to further assess femoral neck and pelvic fractures prior to surgery.

Nuclear medicine is sensitive, but may take 2-3 days to become positive in the elderly, thereby delaying definitive treatment.

MRI findings

Typically coronal T1 and STIR sequences are used. The T1 shows normal fat as bright signal. A fracture will appear as a linear hypointensity in the femoral neck, or pelvis.

The STIR sequence highlights fluid as bright signal intensity. The signal from the fat is removed from the image to highlight areas of oedema. Bone bruises and fractures are therefore much easier to identify.

Axial sequences may be added to further clarify fractures.

In the younger age groups stress fractures of the femoral neck are associated with increased activity with exercise. Fractures in this age group may also have significant morbidity outcomes. Avascular necrosis and non-union of the fracture are the two main problems arising from stress fractures.

Differential diagnoses include:

- Transient Osteoporosis
- Labral tears
- Metastases
- Pelvic fractures
- Muscle and tendon tears

79 year old female with suspected hip fracture

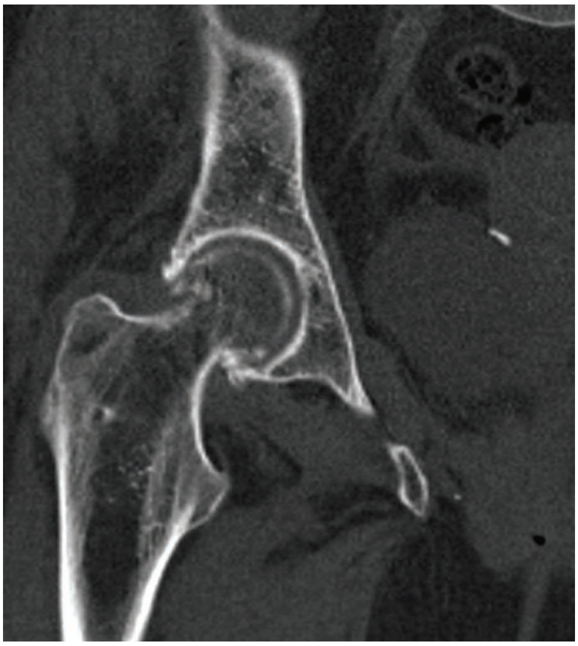

Figure 1a:
Bone scan showing abnormality right greater trochanter.

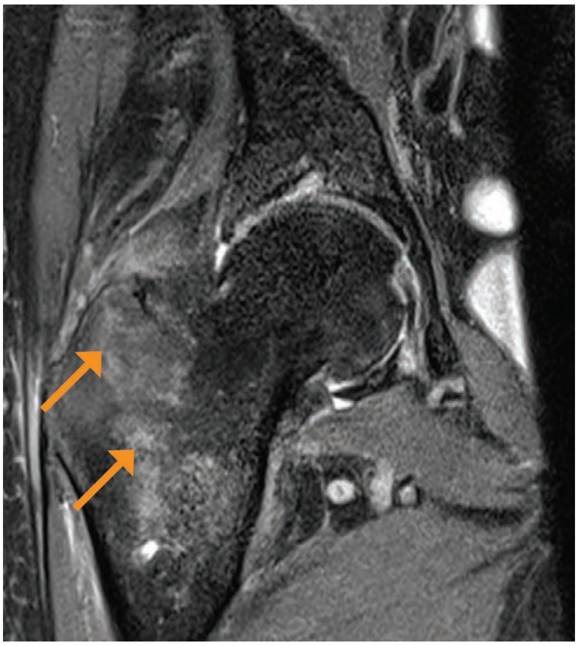

Figure 1b:
CT scan taken after the bone scan does not show the fracture line.

Figure 1c:
Coronal PD fat sat. Bright signal in the bone represents marrow oedema.

Figure 1d:
Coronal T1 irregular hypointense fracture line between trochanters.

Avascular necrosis – AVN

Causes of AVN include trauma, especially after femoral neck fractures, corticosteroids, alcoholism, fat embolism, sickle cell disease, coagulopathies, pancreatitis, thyroid disease, and Caisson's disease (the "bends").

Clinical findings include hip, groin or gluteal pain that is deep and throbbing and worse with activity. Hip motion is decreased.

Investigation:

X-ray is used in staging, but is not sensitive to the disease in the early stages.

CT is also used for staging, but again is not sensitive in the early stages.

Bone scans are sensitive to the early stage of disease but are not as sensitive as MRI scanning.

MRI is most sensitive. It can detect the disease from the very earliest stages. It is also able to differentiate other causes of hip pain that may present in a similar fashion. It is also important to exclude AVN in the contralateral femoral head.

MRI sequences: A coronal T1 or PD and Coronal STIR are preferred to assess both hips. Sagittal PD and PD FS are used to assess the extent of disease and the amount of subarticular bone that is involved.

MRI findings:

A hypointense band surrounding bone marrow represents the reactive margin of avascular bone marrow and the adjacent granulation tissue. In the early stages the femoral head morphology is preserved. With progressive or severe disease the subarticular bone collapses causing deformity of the bone and rapidly progressive degenerative joint disease.

Differential diagnoses include:

- Transient osteoporosis
- Insufficiency fracture
- Stress fracture
- Metastases

These diseases are all best assessed with MRI. Other imaging such as X-ray and CT may be further required for staging and sugical treatment planning.

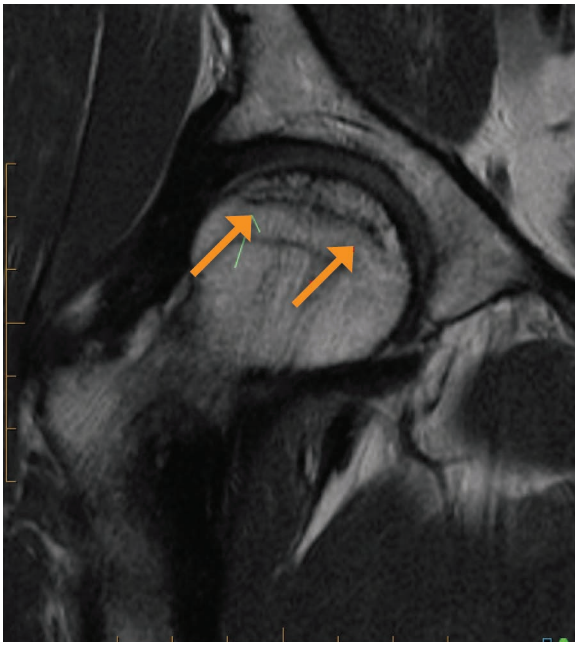

Figure 2a:
Coronal PD. Arrows point to the hypointense margin of the area of AVN.

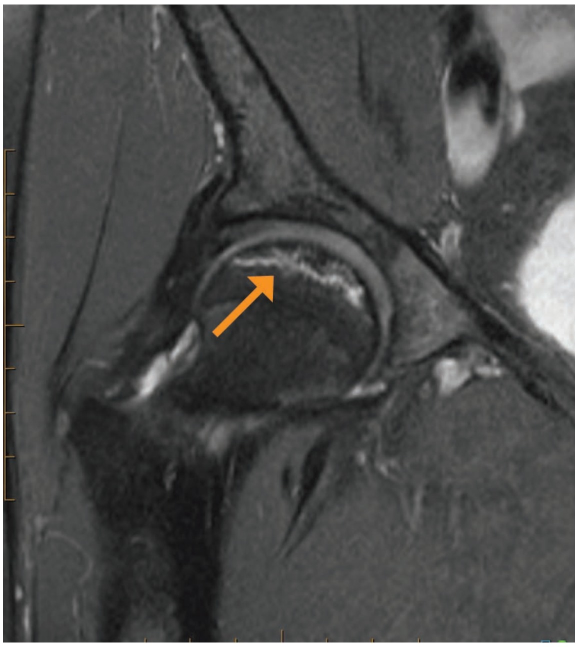

Figure 2b:
Coronal PD fat sat. Double line sign of AVN with a margin of bright and dark linear signal.

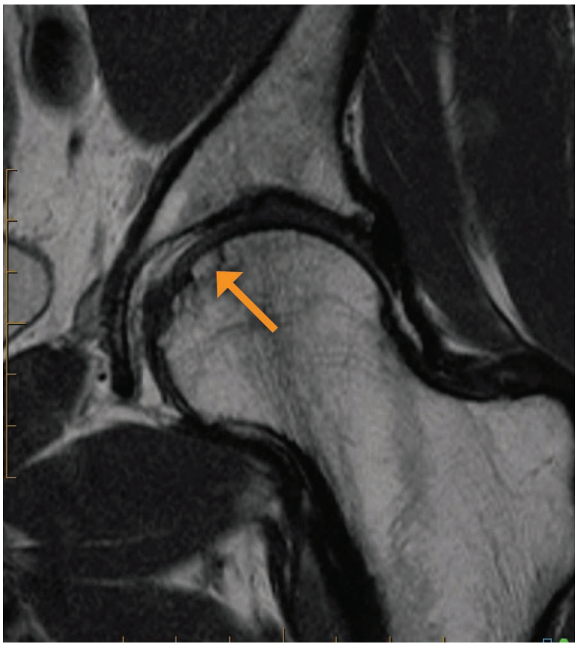

Figure 2c:
Cor PD. Contralateral side showing a small asymptomatic focus of AVN.

Dr Peter Smith
MBBS, FRANZCR
Radiologist

Dr Peter Smith has 20 years of MRI experience, specialising in musculoskeletal imaging. He is currently on the Medical Advisory Council for St Vincent's and Mercy Private Hospital.

Dr Smith is a specialist MR radiologist, with particular interest in musculoskeletal imaging including bone and soft tissue tumours.

Dr Smith is also interested in body and Neuro MRI. He performs specialist bone and soft tissue tumour biopsies, as well as all other MSK interventional procedures.

Dr Smith is an Honorary Fellow from the University of Melbourne.

Dr Smith is a member of Medical Advisory Council for St Vincent's and Mercy Private Hospital.

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