DISC DISEASE

INTRODUCTION

MRI has revolutionised imaging of disc disease, as so much more information is given than with myelography. With the latter, one can usually identify the site and severity of cord compression, guiding surgery. However, studies can be non-diagnostic, especially following cisternal injection of contrast medium, if cord swelling prevents outlining of the full extent of the lesion. With MRI not only is there information about the site and severity of cord compression but also the nature of the herniated material and the presence of cord oedema, haemorrhage or gliosis. In cases in which rupture of venous sinuses has occurred leading to extensive epidural haemorrhage, MRI will show the offending disc space whereas this information is unlikely to be provided by myelography. Most neurologists and radiologists who have become accustomed to using MRI would be of the opinion that they could no longer function adequately using myelography alone (even not considering the safety of the patient). However, a paper by Parry and others (2010) suggested that, statistically, the outcome following surgery was not influenced by the diagnostic imaging modality. This study is slightly biased by including only cases undergoing myelography at a referral centre where there was considerable experience in myelography, and in which myelographic morbidity was presumably low. Nevertheless, it remains an area of speculation! A recent study comparing MRI with non-contrast CT (Cooper and others 2013) concluded that MR imaging was more sensitive and accurate than non-contrast CT for diagnosis and characterisation of thoracolumbar myelopathy due to intervertebral disc herniation: something which seemed obvious but which needed validating!

The MRI appearance of disc disease varies widely and these can be some of the most challenging cases to scan. Whilst some are ‘classic’ and provide easy diagnoses, there are many variations which require high-quality images and experience in interpretation. It can be particularly difficult to decide on the clinical significance of certain lesions, for example the presence of multiple, mild, thoracolumbar Type II disc protrusions in a large breed dog such as a GSD whose clinical signs may equally well be due to degenerative myelopathy.

TYPES OF DISC DISEASE

Hansen originally considered two types of disc ‘prolapse’, both secondary to nuclear degeneration, namely Type I disc extrusions (usually chondrodystrophic dogs; chondroid degeneration and often calcified) and Type II disc protrusions (usually non-chondrodystrophic dogs; fibroid degeneration and often with a significant component of dorsal longitudinal ligament hypertrophy). To this we can now add non-degenerate disc extrusions, high-velocity/low-volume, traumatic extrusions (‘Type III’, although the neurologists hate this name!), intramedullary extrusions and ‘acute-on-chronic’ disc extrusions at sites where there appears to have been a pre-existing Type II disc lesion. Examples of all these will be shown.

MRI can also be used for follow-up studies to look for residual or recurrent cord compression after surgery if the clinical signs do not improve or if relapse occurs.
PULSE SEQUENCES FOR DISC DISEASE (HIGH FIELD)

T2W – often all that is required, at least with high field scanners. T2W in three planes can be obtained in less than 15’, allowing speedy transfer to the operating theatre for emergency cases. Dehydration of disc nuclei, compression of the subarachnoid space and cord changes are readily seen. 

T1W – not always required, but often good for detecting narrowing of disc spaces and vertebral endplate sclerosis. Comparison with identical T2W images allows differentiation between CSF and epidural fat. 

Post-contrast T1W – good for demonstrating reactive meningitis, and with added fat suppression gives a myelographic effect which is effective at delineating small extrusions. 

T2* gradient echo – excellent for demonstrating narrowing of disc spaces, calcification of disc material, changes in the dorsal annulus and dorsal longitudinal ligament, and haemorrhage.

IMAGE PLANES

Dorsal plane – excellent for lateralis ed lesions, and even if performed first will usually show which disc spaces are abnormal. Useful for identifying rib abnormalities, which is vital to know if thoracolumbar surgery is to be performed. A grossly under-used plane! 

Sagittal plane – usually identifies the site of pathology and its severity. Good for graphic demonstration of the craniocaudal length of a lesion such as haemorrhage from venous sinus rupture. It is important to scrutinise the parasagittal images as well as the midline image. 

Transverse plane – the most helpful plane for cord compression from the dorsolateral or ventrolateral aspect, which is not accurately depicted on sagittal scans. Transverse images must include the entire area of compression from normal cord in front of the lesion to normal cord behind it, and this may be several vertebral lengths. The neurosurgeons need to know exactly where to cut! 

Note that the degree of cord compression may appear different between the various planes and it is hard to know which is most reliable. Logically, there will be less partial volume averaging artefact on the transverse plane.

MRI FEATURES

Hansen Type I (degenerate) disc extrusions

Acute or recent clinical signs and usually painful. Arise mainly at disc spaces C2-3 to C7-T1 and T11-12 to the LSJ and much less commonly between T1 and T11 due to the presence of the intercapsular ligament between rib heads 2 to 11. However, German shepherd dogs may be predisposed to cranial thoracic disc extrusions between T2 and T5 and large breed dogs in general may show T1-9 disc extrusions; extrusion of calcified disc material between S3-Cd1 and Cd1-2 is also reported and causes tail base pain. It is therefore important that the entire area of neurolocalisation is scanned. Not all MRI features are seen with each case.

MRI features

- Evidence of prior disc degeneration: reduction in nuclear signal intensity on T2W (dehydration, mineralisation). Note that vacuum phenomenon can also occur with disc extrusion and on MRI this signal void cannot be differentiated from calcification (it can on CT); one case of pneumorrhachis (gas in the vertebral canal causing cord compression) has been reported.
- Narrowed disc space.
- Reduced residual nuclear volume.
- Abnormality of the dorsal annulus and dorsal longitudinal ligament (thickening, blurring, discontinuity).
• Extruded disc material: epidural material isointense with material still in the disc space, at any site around the cord. Calcified material is usually well-defined and ventral or ventrolateral; other material may lie anywhere and can be localised or dispersed
  - mineralised
  - non-mineralised: may be hard to distinguish from cord.
• Cord compression and attenuation of the subarachnoid space
  - focal or diffuse over several vertebral lengths
  - varying degrees of severity
  - ventral, ventrolateral, lateral, dorsolateral, dorsal, foraminal
Interestingly, the degree of cord compression on MRI does not seem to be associated either with the severity of clinical signs or with the outcome (Penning and others 2006).
• ‘Obstructive hydromyelia’; dilation of the central canal cranial to the compressive lesion, presumably due to impairment of CSF flow in the central canal.
• Cord signal changes e.g. oedema, myelomalacia, haemorrhage, intramedullary disc material. The presence and extent of intramedullary T2W hyperintensity in dogs with acute thoracolumbar disc extrusions has been shown to be predictive of outcome (Ito 2005, Levine and others 2009) although with marked compression this is often hard to assess.
• Contrast enhancement of or around the disc material. The pattern of disc material enhancement may be peripheral, homogeneous or heterogeneous and this does not seem to correlate with clinical presentation or pathological features. Contrast enhancement is often helpful for differentiating non-calcified disc material from the cord, where this is unclear.
• Epidural haemorrhage – usually extensive over several vertebral lengths. Best seen on T2* GE images as irregular signal void, but also detected on other sequences as epidural fat disruption; it may obscure the underlying disc lesion and a mixture of scattered disc material and haemorrhage is often found at surgery. More common in the caudal lumbar area. Interestingly, the presence of even quite extensive haemorrhage does not seem to affect the outcome.
• Local meningitis seen on contrast enhancement due to irritation of the cord by the disc material, which behaves like a foreign body.

Note that there is often found to be more disc material at surgery than there appears to be on the MRI scan, and so if there is uncertainty as to whether or not to operate, it is usually better to over-read the images!

Hansen Type II disc protrusions

Usually a chronic, progressive history of spinal dysfunction, which may have been diagnosed clinically as degenerative myelography, especially in GSDs. Pain may be absent. Typical locations are in the caudal cervical spine, often associated with ‘Wobbler syndrome’, around the thoracolumbar junction (often multiple) and at the lumbosacral junction. Not all MRI features are seen with each case.
**MRI features**

- Evidence of prior disc degeneration.
- Vertebral sclerosis and/or spondylosis, suggesting chronicity.
- Narrowed disc space.
- Thickened, bulging dorsal annulus and/or hypertrophied dorsal ligament; the latter is often very round when seen on transverse images.
- May reduce with traction.
- Cord elevation.
- Cord compression
  - focal above disc space
  - varying degrees of severity
  - ventral (ventrolateral)
  - dorsal compression from associated disease (e.g. Wobblers, DLSS).
- Cord atrophy: dorsal subarachnoid space remains patent.
- Cord signal changes
  - oedema, gliosis.

**Non-degenerate and ‘pulpy’ disc extrusions**

Not infrequently disc extrusions occur in which the extruded nuclear material does not appear to be degenerate and is isointense with disc material at other sites. This is seen in both chondrodystrophic and non-chondrodystrophic breeds, often following presumed trauma or exertion. The extruded material is of medium signal intensity on T1W; very similar to that of the spinal cord but helpfully outlined by hyperintense epidural fat. It is fairly hyperintense in T2W, in which it may be harder to detect due to its similarity in signal to both CSF and epidural fat. Other MRI features are as listed above.

A particular type of non-degenerate disc extrusion is known colloquially at the AHT as a ‘pulpy disc extrusion’ and by some others as ‘white discs’. These almost always occur at C3-4 or C4-5 in the cervical spine of small breed dogs, usually with a history of mild trauma and a peracute onset. The extruded material is completely normal in
signal intensity and forms a shallow mound over the disc space causing marked cord compression but over a longer craniocaudal length than is normal with a degenerate disc extrusion (presumably this soft nuclear material spreads out slightly). On transverse images the dorsoventral compression of the cord forms a characteristic shape, the ‘batman sign’ (another AHT expression). On T2W the material is hyperintense (isointense to CSF and epidural fat) and easily overlooked as being disc material; they have been wrongly described as ‘discal cysts’. At surgery the material is very soft and again not immediately recognisable as normal nuclear material. MRI features confirming the diagnosis also include the following:

MRI features
- Lesion centred immediately above a cervical disc space.
- Reduced residual nuclear volume.
- +/- narrowed disc space.
- Shallow-diffuse mound of compressive material ventral to cord on sagittal T2W.
- Characteristic ‘batman’ or ‘seagull’ shape of compressive material on transverse T2W.
- Abnormality of the dorsal annulus and dorsal longitudinal ligament (thickening, blurring, discontinuity).

A series of cases of pulpy disc extrusions seen at the AHT has been published under the more scientific title of ‘acute, hydrated, nucleus pulposus extrusions’, or AHNPE.

Acute, non-compressive nucleus pulposus extrusion (high-velocity, low-volume or ‘Type III’ disc extrusions)

Peracute onset of spinal dysfunction (tetra-, para- or hemi-paresis or -plegia) due to rapid extrusion of a small amount of normal nucleus pulposus during activity such as running or playing. The extruded material causes a focal cord contusion but no or minimal compression. The dogs often yelp at the time but subsequently the condition may be painless. There is usually some improvement in the deficits within a day or so. The clinical signs, management and prognosis are very similar to that of spinal infarcts (FCEs). Likewise, the MRI features have some similarities and without careful examination of the images an incorrect diagnoses may be made, although this is probably only of academic importance.

MRI features
- Focal spinal cord hyperintensity on T2W, immediately above or very close to an abnormal disc space (usually no signal changes on other sequences)
- Disc nucleus of normal signal intensity but reduced in volume
- Thickening, blurring and mild protrusion of the dorsal annulus
- Non-compressive epidural material isointense to disc nucleus; better seen on T1W in which it is hypointense to epidural fat
Intramedullary disc extrusions

Rarely, acute extrusions may enter or pass through the overlying spinal cord parenchyma. Interestingly, we have encountered this more frequently in cats than in dogs, and in the latter small breeds are usually affected. The clinical signs are again peracute and may be associated with trauma (often unwitnessed). MRI features include the following:

MRI features
- Lesion immediately above or slightly cranial to an abnormal disc space
- Narrowed disc space
- Reduced nuclear volume
- Disruption of dorsal annulus
- Cord mildly swollen, with T2W hyperintensity which may suggest a linear track
- Possible hypointensity on gradient echo (haemorrhage and/or calcified disc material; the latter may even be visible radiographically)
- No evidence of epidural material or cord compression.

Clearly, surgery is not indicated, but surprisingly many patients recover.
‘Acute-on-chronic’ or ‘Type I on Type II’

This is an AHT expression! Dogs present with recent clinical signs (usually pain or forelimb lameness due to impingement on a nerve root) in which a small, lateralised disc extrusion is seen at a site where there is evidence of pre-existing disc degeneration and Type II changes. Usually larger dogs.

Further Reading – disc disease


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**SPINAL TRAUMA**

**INTRODUCTION**

Patients with spinal trauma should be handled very carefully in case the spine is unstable or becomes so after induction of anaesthesia. Smaller patients may be given a body splint. It may be wise to scan the patient in lateral recumbency on a spinal board so as to minimise manipulation. Prior radiography may be helpful, and is to be recommended if there is any possibility of concomitant thoracic or abdominal injury. CT, if available, is complementary to MRI: it gives more information about the vertebrae but much less about the soft tissues.

Radiography and computed tomography (CT) have both been described in the veterinary literature for the assessment of vertebral fracture and subluxation. Computed tomography has been used as the gold standard for detection of fracture and subluxation with radiography only having 72% sensitivity for fracture and 77.5% sensitivity for subluxation detection. The use of MRI has only been anecdotally described in the evaluation of spinal fracture in dogs, although its use has been described in the literature in the assessment of atlantoaxial subluxation and spinal trauma without fracture. Penetrating spinal foreign bodies are also reported.

MRI has been extensively documented in the medical literature for the evaluation of spinal trauma patients, and has been utilised in the assessment of spinal stability and mechanical integrity. It has been found to be excellent at assessment of soft tissue trauma, such as ligamentous, discal, vascular and neural injury.

The detection of spinal instability is a key indication for surgical intervention. A three-compartment model has been utilised to assess stability of spinal fractures in both human trauma patients and veterinary patients. This system divides the vertebral column into dorsal, middle and ventral compartments and instability is present when
two or more compartments are disrupted. The dorsal compartment contains the vertebral arch, which is made up of the spinous process, articular processes, lamina and pedicles, as well as the dorsal ligamentous complex (DLC), which represents the supportive ligamentous structures including the facet joint capsule, interarcuate ligaments, interspinous ligaments, supraspinous ligaments and, when present, the intertransverse ligaments. The middle compartment contains the dorsal longitudinal ligament (DLL), the dorsal aspect of the annulus fibrosus and the dorsal vertebral body, which forms the floor of the vertebral canal. The ventral compartment contains the remainder of the vertebral body, the lateral and ventral aspects of the annulus fibrosus, the nucleus pulposus and the ventral longitudinal ligament (VLL). This model has been applied in the assessment of spinal instability by radiography and CT in dogs, despite the fact that it requires assessment not only of osseous but also of ligamentous and soft tissue supportive structures. The use of MRI for suspected vertebral instability associated with fracture or subluxation in a series of eleven dogs has been described (Johnson and others 2012).

**PULSE SEQUENCES FOR SPINAL TRAUMA**

As for disc disease, but STIR or fat-suppressed T2W images are particularly useful for demonstrating soft tissue changes (the hallmark of the site of a # or subluxation) and T2* gradient echo images are usually the best for demonstrating vertebral #s, ligamentar damage and cord haemorrhage.

**IMAGE PLANES**

All three planes are essential – the dorsal plane must be included as this is likely to show minor subluxation in the lateral plane most clearly.

**Fractures and subluxations**

*MRI features*

- Subluxation – loss of perfect alignment between vertebral bodies, facets or spinous processes on one, two or three planes. Remember that the degree of subluxation may have been worse at the time of injury and reduced since due to muscle spasm, so MRI probably shows the ‘best case scenario’.
- +/- Vertebral fractures (small chip #s may be missed).
- Alterations in intervertebral discs and disc spaces e.g. changed shape, width, signal intensity, appearance of annulus, nuclear extrusion.
- Altered or ruptured ligamentar structures.
- Spinal cord changes e.g. altered signal intensity (oedema, malacia, haemorrhage), compression, swelling, laceration, sectioning.
- Spinal nerve root avulsion (hard to see)
- Extramedullary haemorrhage.
- Epaxial and/or hypoaxial muscle changes e.g. hyperintensity on STIR, contrast enhancement, swelling, disruption.
- Lesions in body cavities e.g. pleural or (retro)peritoneal fluid, ruptured diaphragm.
Atlantoaxial subluxation

Minor spinal trauma may cause clinical signs when congenital atlantoaxial subluxation is already present. In normal animals, more marked trauma may cause rupture of the transverse ligament of the dens leading to subluxation +/- # of C2.

We have recognised a particular syndrome of ‘dens contusions’ in a few cats and small dogs which have fallen from a height resulting in tetraparesis or tetraplegia. Residual atlantoaxial subluxation is not demonstrated and the transverse ligament of the dens appears to be intact but there is a focal cord T2W hyperintensity +/- a spot of haemorrhage immediately above the tip of the dens. The hypothesis is that a transient flexion at the atlantoaxial junction has caused cord contusion by the impingement of the dens on the cord. Recovery is usual.
Further Reading – spinal trauma

