Chapter 12.
Advanced imaging in spinal pathologies

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For sources in this article see list of literature (chapter 19).

Despite the great advancements in imaging, clinical and neurological examination remain the cornerstones of diagnosis of spinal problems. No complementary test replaces accurate neurolocalization and thorough clinical examination. Remember, we treat animals, not images. Nonetheless, diagnostic imaging can help us reach a specific diagnosis, localize a lesion and provide a realistic prognosis.

The most important imaging techniques are x-ray, computerized tomography (CT) (or CT myelography) and magnetic resonance imaging (MRI). CT and MRI are both far superior to x-ray. However, the latter is still widely used and recommended for general purposes, due to its ready availability.

Nonetheless, an x-ray can show only very apparent lesions, such as hemivertebrae, bone tumours or discospondylitis. Therefore, we usually need either a CT or an MRI to make a confident diagnosis.

Fig. 12.1 CT scanner

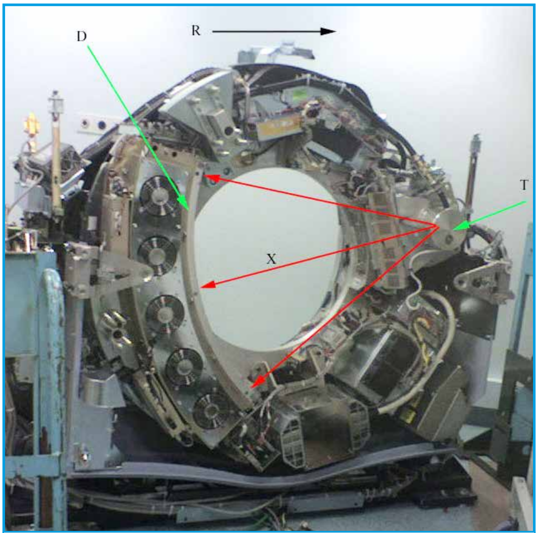

Fig. 12.2 CT scanner with cover removed to show internal components. Legend: T: X-ray tube, D: X-ray detectors, X: X-ray beam, R: Gantry rotation. https://en.wikipedia.org/w/index.php?title=CT_scan&oldid=931133973 (accessed 30 December 2019).

12.1 MRI and CT fundamentals

Both MRI and CT images are computer generated. The computer acquires and processes data to create a picture of a "slice" of the patient.

In a CT scan, the data is acquired by means of an x-ray tube that rotates around the patient. The tube is connected to detectors of the radiation passing through the patient's body. As in conventional radiology, x-rays that pass through the patient are attenuated according to tissue thickness and density. The computer uses the information provided by the detectors to create a black and white image (figure 12.1 and 12.2).

The attenuation coefficient (or radiodensity) of each tissue is represented in grey tone scale. This attenuation coefficient of radiation within the different tissues is expressed in Hounsfield units (HU). Thus, water has a value of 0 HU, the cortical bone of +3000 HU and air -1000 HU.

MRI, in contrast, generates images using magnetic fields and radio waves. A strong magnetic field causes all the protons in a patient's body to spin parallel to the field direction. If the magnetic field is disrupted, the nuclei recover their normal spin direction, producing radio signals which decrease over time as the result of two processes, known as T1 and T2 relaxation. These parameters differ depending on tissue composition. Soft tissue produces a wide range of radio signals, while bone generates very little differentiation. Computers use this variety of emitted signals to build an image, exploiting these differences to differentiate tissue.

There are two basic types of MRI: low-field and high-field. The difference relates to the magnet. Low-field MRI machines are usually open design and range from 0.2 to 0.6 Teslas (T) whereas high-field scanners are at least 1.5 T. Low-field MRI equipment is far more affordable, and positioning patients is easier. High-field MRI yields images of much greater quality, with thinner slice acquisition and faster scan times, thanks to the signal to noise ratio.

12.2 CT or MRI?

In general, CT renders a better view of bone tissue, whereas MRI provides more information on soft tissue. Apart from its superior bone detail, CT can depict slices of the body as thin as 0.6 mm. Moreover, the data can be manipulated to see specific tissues. Today's CT machines can use the data acquired to create axial images on any plane, or even volumetric (3D) representations of the body. These last are especially useful where bone problems are concerned.

CT is also cheaper than MRI, and because it is quicker it can usually be done with just mild sedation (as long as no intravenous or intrathecal contrast medium is used).

CT combined with myelography provides optimal information about spinal cord compression, as changes in the spinal cord's contours are shown in fine detail. However, CT myelography provides little information about the nature of a mass, and its use brings the risk of complications.

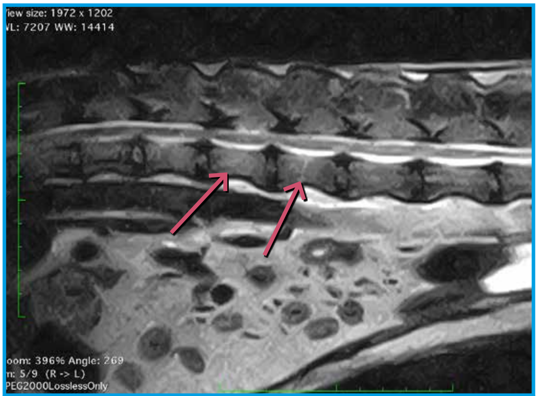

Fig. 12.3 MRI of a multiple disc herniation in a dog. Courtesy of Dr María Ortega.

MRI provides a better contrast resolution, so it is better for imaging soft tissue. It provides more information about intervertebral discs, nerve roots and intramedullary changes.

Overall, MRI is considered better for spinal disorders (and the nervous system at large) due to its ability to discriminate soft tissue (e.g., nerve tissue). However, for some spinal conditions CT might be the first choice imaging technique.

The following sections present a variety of pathologies with pros and cons of each imaging technique.

12.3 Disc disease

Hansen Type I

- Usually affects chondrodystrophic breeds, with the affected discs usually calcified.
- A CT scan shows herniation of calcified discs better than MRI (figures 12.4, 12.5 and 12.6). CT is therefore the best imaging choice.
- In severe disease, with a lack of nociception, MRI can aid in prognosis, due to its ability to detect intramedullary changes (e.g., oedema, haemorrhage) that may affect the chances of recovery (figure 12.3).

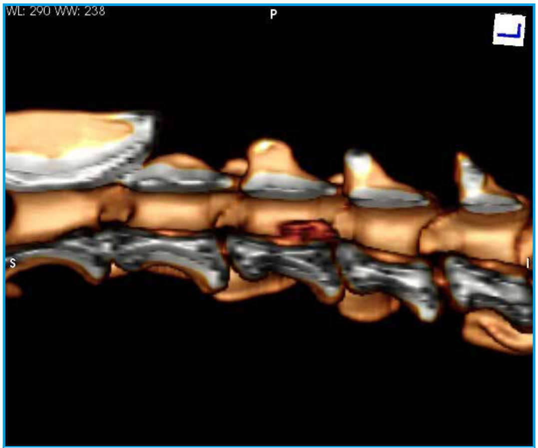

Fig. 12.5 CT 3D reconstruction of a cervical disc extrusion.

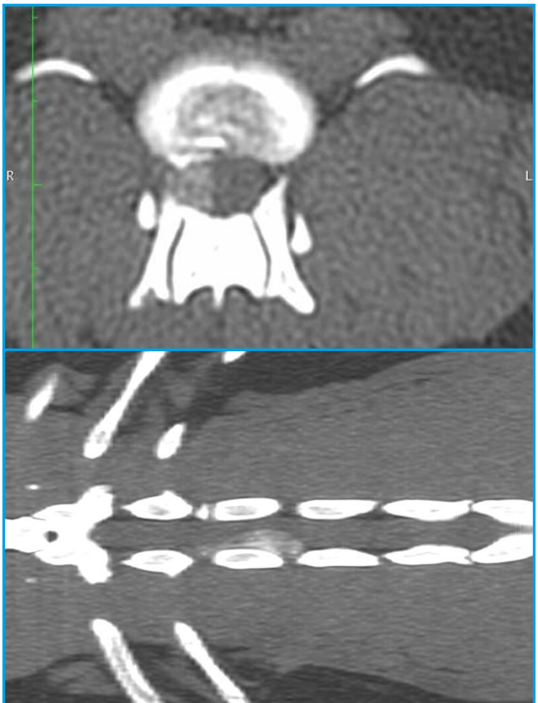

Fig. 12.4 Hansen type I - Thoracolumbar disc disease.

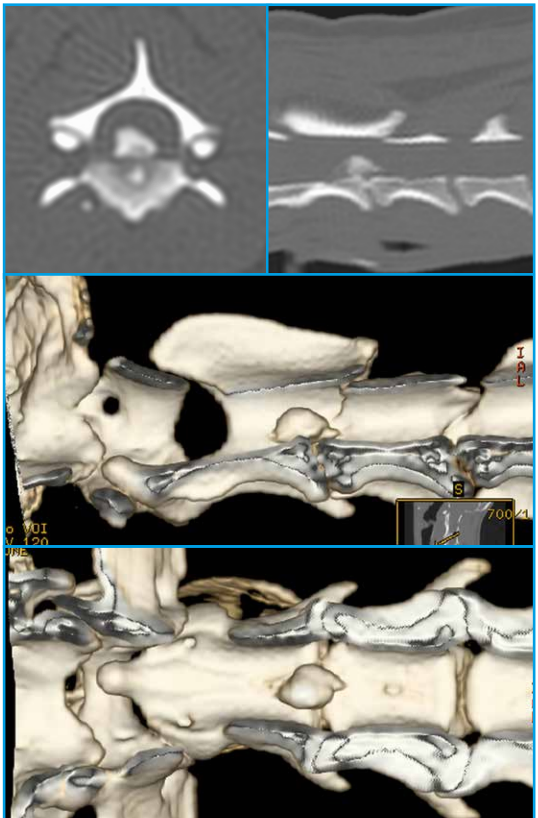

Fig. 12.6 Hansen type I - Calcified with 3D view.

Hansen Type II

- In this type of disc disease, the herniated material is seldom clacified so CT scan will not usually show changes.
- With a 3D CT scan, misalignments (for example, in the lower back) may be very visible.
- CT myelography can provide extremely good information about the area and type of compression, perhaps as good or better than information from MRI (figures 12.7 to 12.11).
- According to orthomanual principles, chronic IVDD is usually associated with vertebral misalignments. On these, CT could potentially provide optimum information.

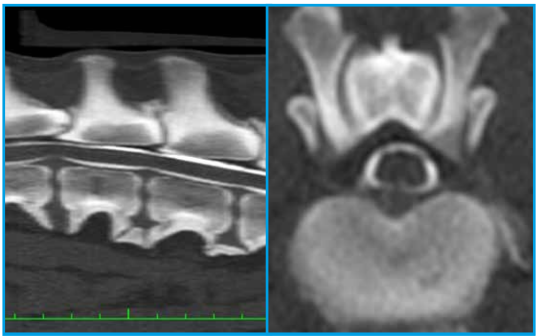

Fig. 12.8 Hansen type II - Disc disease myelogram.

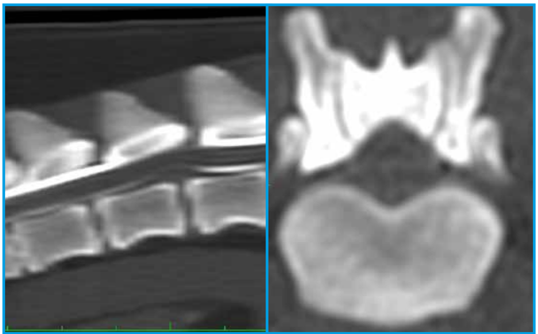

Fig. 12.9 Hansen type II - T13-L1.

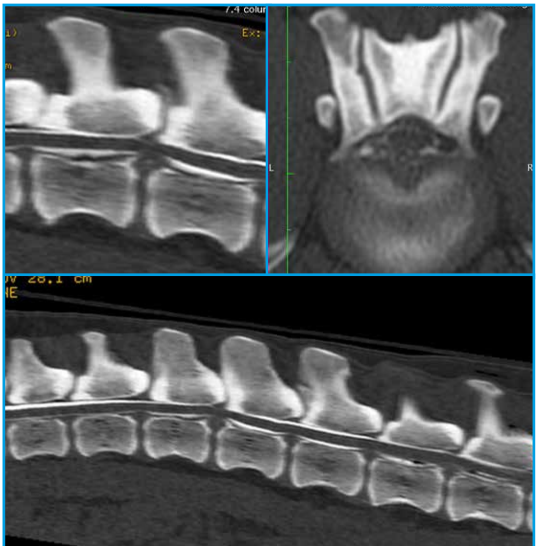

Fig. 12.7 Hansen type II - Disc disease myelogram.

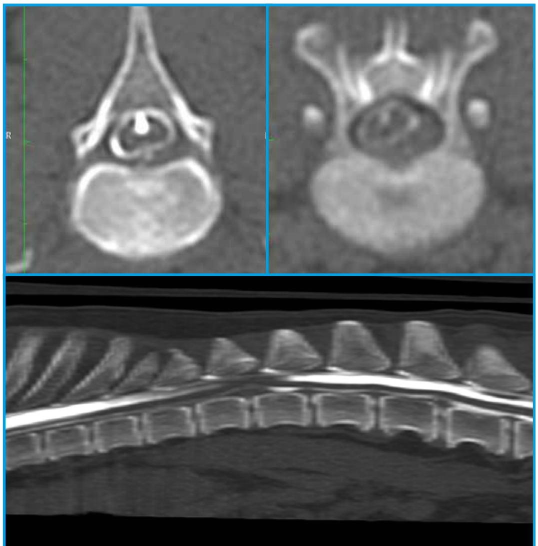

Fig. 12.10 Hansen type II - With syringomyelia.

Acute non-compressive disc disease, or high-velocity low-volume IVDD. Also commonly, though erroneously, called Hansen type III

- This disease is neither compressive nor does it involve calcified disc material. Therefore, MRI is the superior imaging technique, as it shows intramedullary changes and the involved discs.
- Nevertheless, the changes that can be seen using CT myelography will usually be enough to rule out compressive disorders; although with a CT scan, acute non-compressive disc disease would be impossible to differentiate from from ischemic disease (i.e., a fibrocartilaginous embolism). Treatment is similar in both cases (physical rehabilitation). The prognosis would, in both cases, greatly depend on clinical findings rather than imaging (figures 12.12 to 12.15).

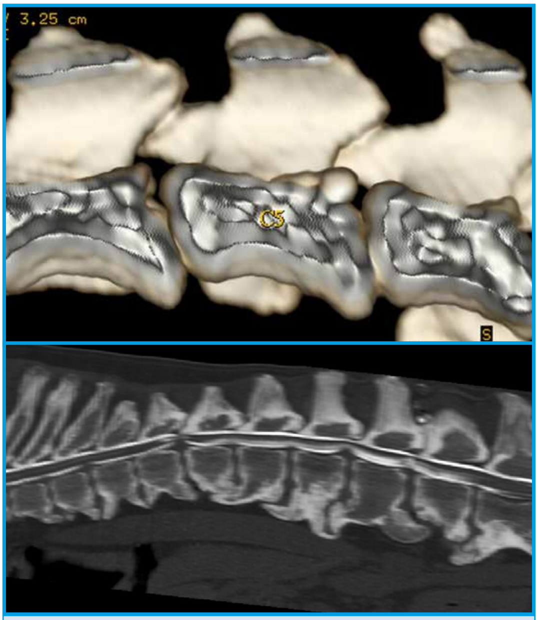

Fig. 12.11 Thoracolumbar disc disease.

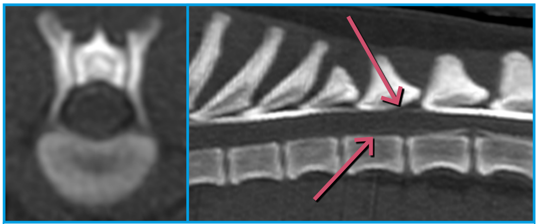

Fig. 12.12 Hansen type III - Reduction of subarachnoid space.

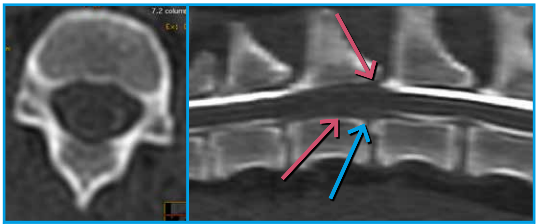

Fig. 12.13 Hansen type III - Reduction of subarachnoid space. *Blue arrow points to the disc herniation (tiny).*

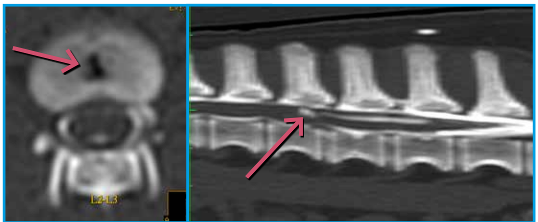

Fig. 12.14 Hansen type III - This is a type III with disc material that has gone through the spinal cord. Described in the ECVN meeting poster (page 290). In the transverse view, gas effect in the disc can be seen, beside the trajectory of disc material.

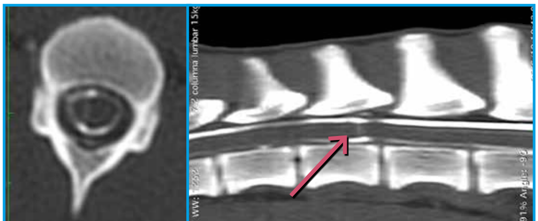

Fig. 12.15 Hansen type III, like fig. 12.14. This is a type III with disc material that has gone through the spinal cord. Described in the ECVN meeting poster (page 290). In the sagittal view, gas effect in the disc can be seen, beside the trajectory of disc material.

12.4 Spinal tumours

Vertebral tumours

- Due to its superior ability to show bone, CT is the best choice for diagnosing vertebral tumours (figure 12.16).
- MRI, however, will usually provide enough information to reach the diagnosis with a high degree of precision.

Spinal cord tumours

- MRI is definitively better. It shows not only where a tumour is (extra- or intramedullary), but also gives information about the nature of the mass.
- CT (with myelography and/or intravenous contrast) in most cases provides enough information to locate a mass.

Fig. 12.16 CT scan of a vertebral osteosarcoma. Sagittal and transverse views.

12.5 Caudal cervical spondylomyelopathy or Wobbler syndrome

- Wobbler syndrome is a combination of several different possible conditions: disc protrusion, vertebral anomalies, vertebra subluxation, ligament hypertrophies and articular facet degenerative changes that either alone or in combination compress the spinal cord.
- Like any compressive disc disease, CT myelography is as good as MRI for describing the compression, or even better if bone tissue is involved. CT myelography is especially useful when planning surgery (figures 12.17 to 12.20).
- However, in the presence of more than one compression, MRI can show spinal cord changes and thereby help in identifying the precise location of the primary cord lesion that is causing neurological deficits.

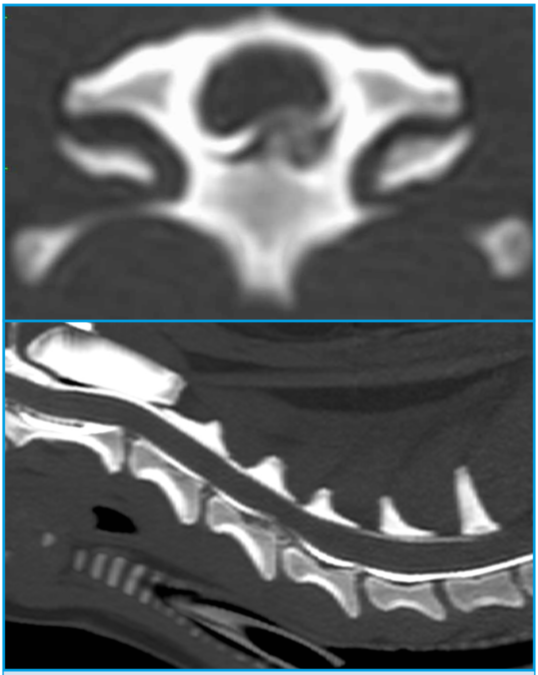

Fig. 12.17 CT myelogram C4-C5.

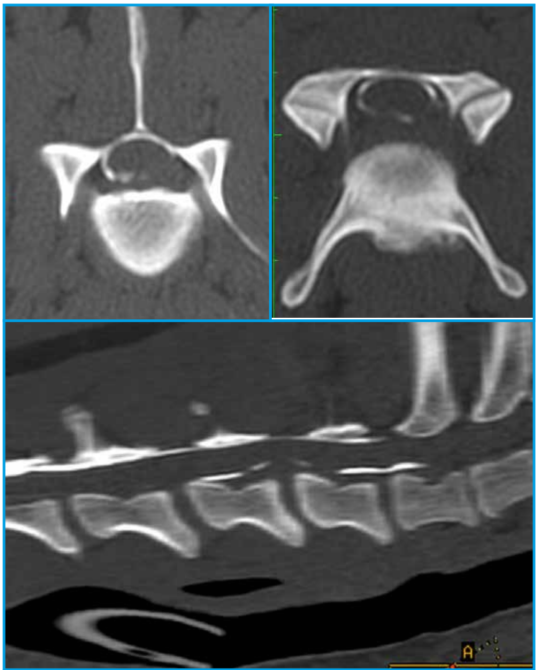

Fig. 12.19 Wobbler disc herniations and subluxation.

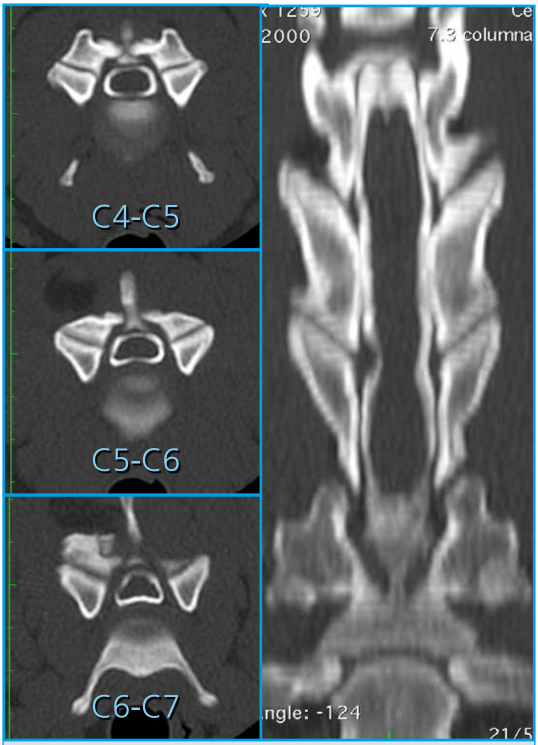

Fig. 12.18 Wobbler vertebral malformation.

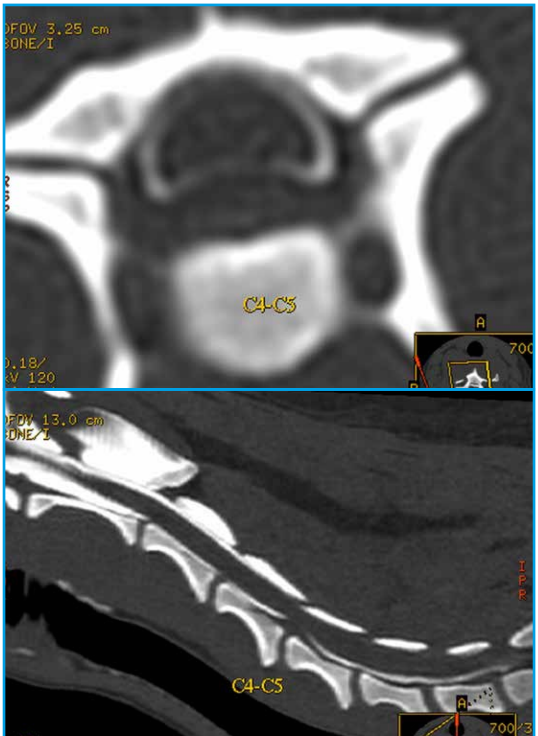

Fig. 12.20 Disc disease, acute C4/C5.

12.6 Lumbosacral stenosis/cauda equina syndrome

- Both MRI and CT give detailed information for the diagnosis of lumbosacral stenosis/ cauda equina syndrome. However, MRI gives information about nerve roots that, in some cases, may be necessary to reach an accurate diagnosis.
- The importance of good clinical examination is especially great for cauda equina syndrome, as there is little relation between lumbosacral compression as seen on imaging and the severity of clinical signs. In my opinion, the diagnosis of lumbosacral stenosis/cauda equina syndrome is basically a clinical one, though imaging is instrumental to determine the precise cause (figures 12.21 to 12.26).

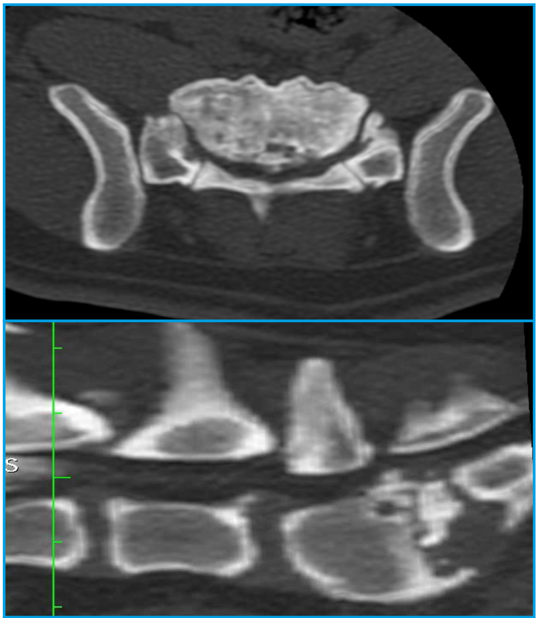

Fig. 12.22 Severe lumbosacral disease, with spondiloartrosis, L6-L7 subluxation and L7-S1 discospondylitis.

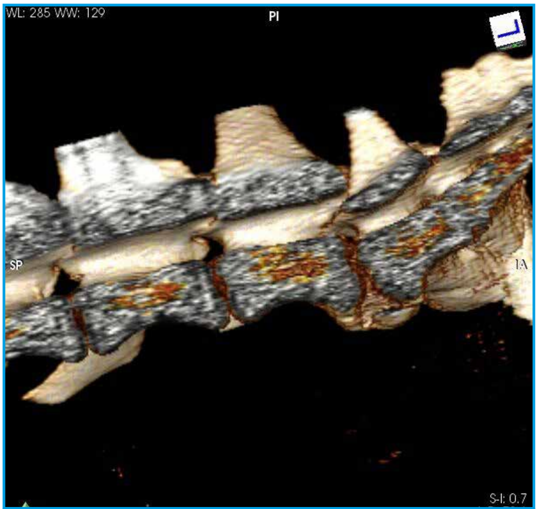

Fig. 12.21 3D reconstruction of a fusion of L7 and sacrum, causing L6-L7 subluxation.

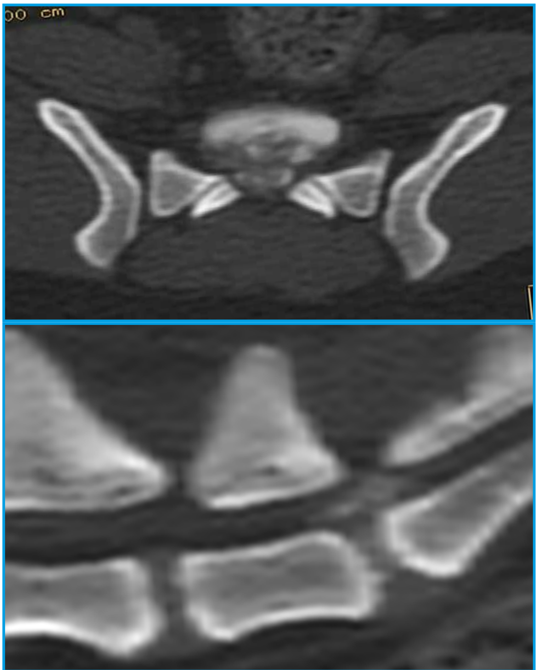

Fig. 12.23 Lumbosacral extrusion.

Fig. 12.24 Combination of LS protrusion and entrapment of left L7 nerve root.

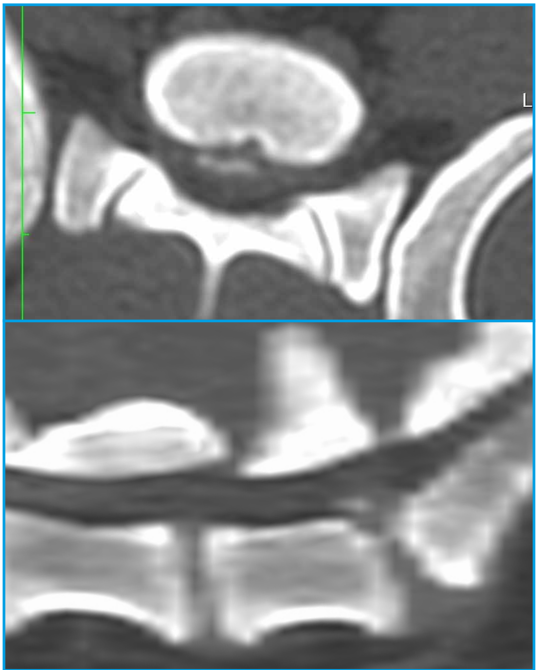

Fig. 12.26 Lumbosacral disease.

Fig. 12.25 Protrusion L7-S1.

12.7 Other

- Ischemic myelopathy
  - This is basically an intramedullary disorder, so MRI provides better information.
  - Though CT will show few changes, if any, it would rule out spinal cord compression. Combined with a peracute onset of clinical signs, many times asymmetrical, CT is often sufficient to confirm the diagnosis (figure 12.28).
- Hemivertebrae and other congenital vertebral malformations
  - This is common in screw-tail dog breeds, like the French Bulldog and Pug. Here, CT is clearly preferable, as these are basically congenital alterations in vertebral bone (figure 12.29).

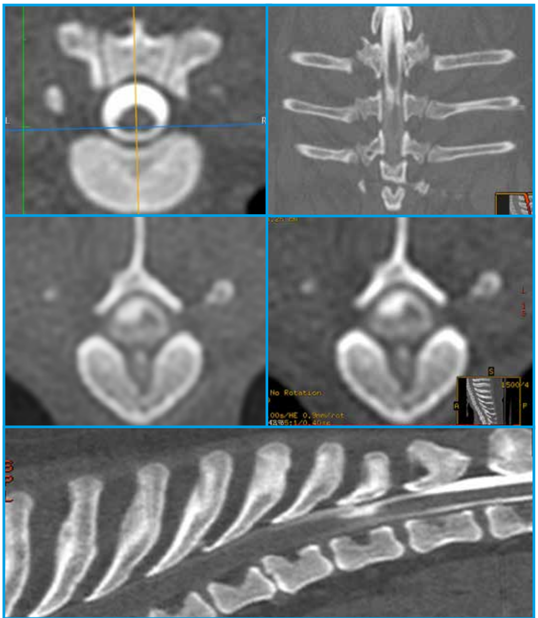

Fig. 12.27 Arachnoid diverticula.

- Arachnoid diverticula
  - CT myelography and MRI both provide enough information to diagnose these outpouchings of the subarachnoid space (figure 12.27).
- Syringomyelia
  - CT myelography will usually provide valid information. However, as an intramedullary disorder, MRI is preferable to a CT scan (figure 12.10).

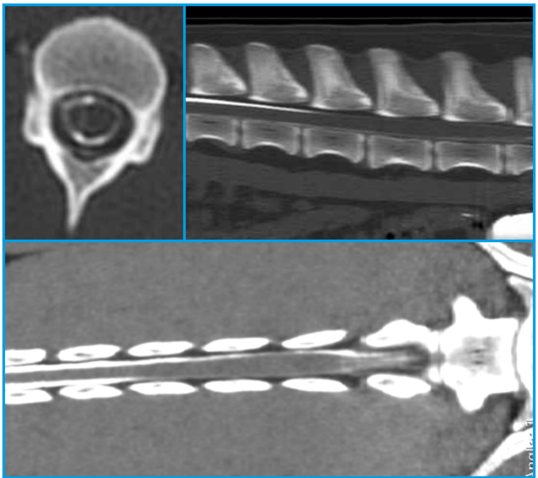

Fig. 12.28 Fibrocartilaginous thromboembolism.

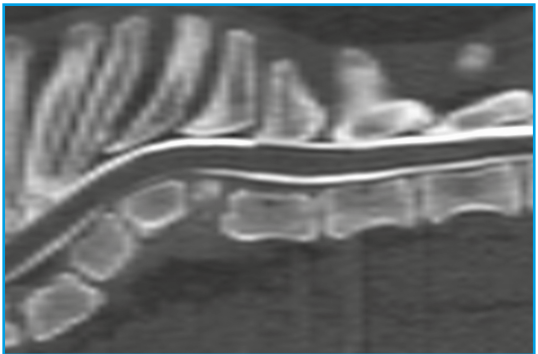

Fig. 12.29 Hemivertebra in a Pug.

12.8 Orthomanual therapy

- The orthomanual approach is based on the understanding that the spine is symmetric and the joints are congruent. Problems arise from small changes in the bones. The main treatment goal is to bring misaligned vertebrae and joints into alignment. Manipulation is used to correct vertebral and joint misalignments, allowing the spine and joints to regain a more optimal anatomical position. Adjusting misalignments of the spine also enables the nervous system to recover and leads to relaxation of muscular spasms.
- Bone imaging is useful both to diagnose and confirm small deviations in vertebral position as well as to confirm the effects of treatment. So CT scanning is the best imaging technique.
- Three-dimensional CT scans may be useful to corroborate clinical findings. In reality, however, the small size of misalignments means that they will likely be less evident on imaging, at least initially. Some research has been done in this regard, but much remains to be investigated about how CT scans might be used in identification of vertebral misalignments and in corroborating the effects of manual adjustments. Clinical signs and findings before and after treatment remain the most important indicator.

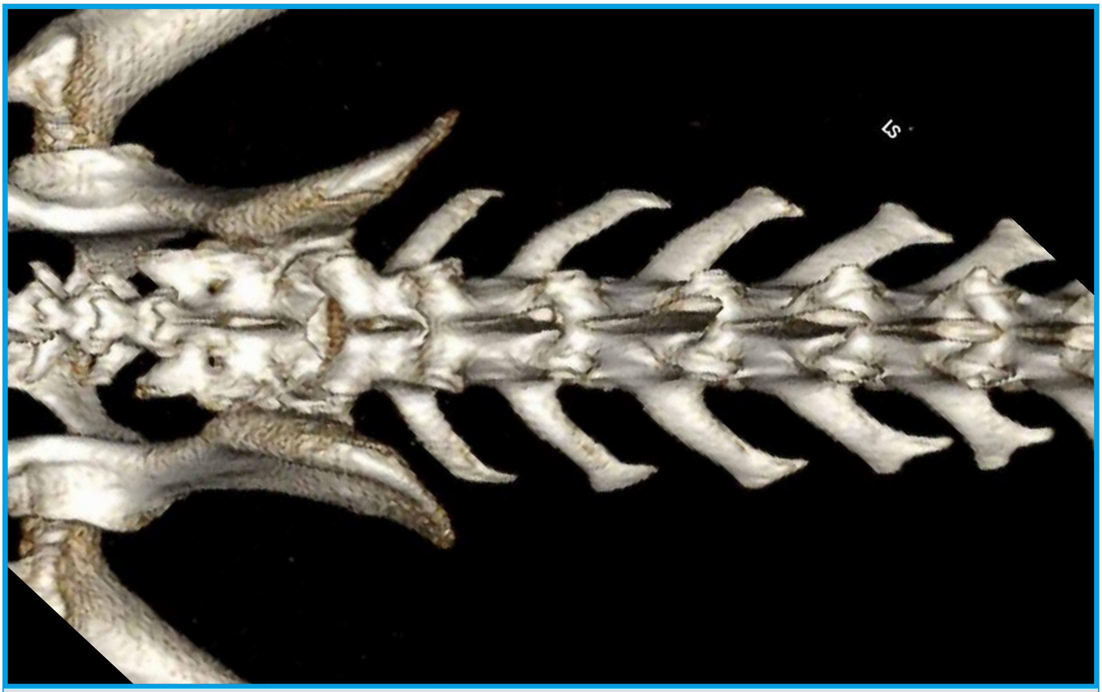

Fig. 12.30 Misalignment and its neurological consequence.