Spinal infections: typical and atypical imaging features.

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Learning objectives

While the imaging features of established spondylodiscitis are well known, other presentations may be misleading. The aim of this work is to review the typical imaging features of spondylodiscitis as well as some more atypical and unusual imaging features (septic spondylitis, septic arthritis of facet joints, primary epidural abscess, unusual germs) [1]. Besides, some authors consider intramedullary abscess as a form of spinal infection particularly in tuberculosis [2].
Background

Infectious spondylodiscitis is an uncommon disease with increasing incidence which is estimated to be around 0.4 to 2.4 per 100,000 per year and tend to increase with increasing age. Many authors expect these numbers to increase because of better diagnostic techniques, increasing numbers of immunocompromised patients patients, growing IV drug use in young people, increased use of intravenous access devices, and increasing prevalence of genitourinary surgery in the elderly [1].

Spondylodiscitis is the most common and best known form of spinal infection.

Septic spondylodiscitis, septic arthritis of facet joints, primary epidural abscess and unusual germs are the atypical form. Intramedullary cord abscess are uncommon and considered by some authors as a rare form of spinal infection particularly in spinal tuberculosis [2].

1. INFECTIOUS SPONDYLODISCITIS

It is an infectious process involving two adjacent vertebral bodies and the intervening disk.

Hematogenous spread of septic emboli is generally accepted as the most common mechanism by which infection is seeded into the vertebrae. The most common source of infection is thought to be the urinary tract.

Classically, pyogenic spondylodiscitis presents with lesions in to adjacent vertebral bodies and the corresponding intervertebral disk. This is thought to be due to the segmental nature of the supplying arteries that bifurcate to supply two adjacent vertebral bodies.

In children, the presence of vascular channels that directly feed the disk allows for direct hematogenous infection seeding for the disk. In adults, the direct blood supply to the disk is reduced and thus disk infection usually arises via direct spread from the vertebral body after the end-plate have been destroyed.

Spinal infection (SI) can be pyogenic or non-pyogenic in nature and involve any anatomical area around the spine, including but not limited to infection of the disc, vertebral body, paravertebral soft tissues and the epidural space. The most common form include: discitis, vertebral osteomyelitis, septic arthritis, muscular involvement (psoas abscess or paraspinal abscess), paravertebral, and epidural abscess. Treatment can vary considerably depending on the type of spinal infection.

Epidemiology
Spondylodiscitis, also referred to as spinal or vertebral osteomyelitis (VO) septic discitis, or disk-space infection is a common result of a pyogenic vertebral infection. This infection involves the disc space as well as the adjacent vertebral bodies and account for 2-4% of all bone and joints infections. The most common microorganism responsible for pyogenic vertebral osteomyelitis (PVO) is Staphylococcus aureus. Non-pyogenic sources of infection include: Mycobacterium and a variety of fungal organisms such as Candida or Aspergillus. Hydatic cysts can also be a source of SI.

Three mechanisms of spinal infection dissemination have been identified. The most common route of spread is via hematogenous dissemination. Direct inoculation from iatrogenic sources is considered to be the next most common route followed by dissemination from an adjacent contamination [3].

The incidence of spinal infection increase with age. Several studies confirm that those individuals aged 50 to 80 years are the most susceptible.

Spinal infection such as vertebral osteomyelitis appears to have a predilection for the lumbar spine. The extensive lumbar spine anastomosing veins and arteries, which favour infectious seeding via the hematogenous route of spread, offer some explanation for this observation. The thoracic spine (30%), cervical spine (11%) and sacrum (0.1%) are all less common sites for spinal infections.

**Clinical presentation**

The clinical presentation of patients with early stage spinal infection varies widely among individuals, and the condition can be difficult to differentiate from other diagnoses. Patients in the sub-acute stage may present with vague symptoms often mimicking other common conditions. Atypical symptoms of chronic chest, abdominal, or hip pain may be present and often mask or overshadow the the underlying back pain. Back pain and fever are the most common symptoms reported. The presence or absence of fever alone is insufficient to rule in or rule out spinal infection. Paraspinal muscle spasms are also very common. Neurological impairment is also common, but similar to fever its presence varies widely, ranging from 14.3% to 51.7% of cases.

**Imaging features**

When spinal infection is first suspected, baseline conventional radiographs are indicated. Radiographs are relatively easy to access, are cost effective and give good visualization of bone tissue, which provide rationale for their use. However clinicians must be aware of the 2-3 week latent period rarely exhibit diagnostic clues.

Typically the earliest radiographic sign is narrowing of the disc space. Blurring, irregularity and even destruction of the adjacent endplates tends to occur later (Figure 1,2).
Magnetic resonance (MR) imaging is currently the modality of choice for the evaluation of potential spinal infection. Advantages of MR imaging include the capability of multiplanar imaging, direct evaluation of the bone marrow, and simultaneous visualization of the neural structures.

**Signal intensity alterations in Infected Disks**

- Disk height is classically described to be decreased in patients with disk infection. More than one-third of patients with proven disk infection had normal height of the involved disks. And more than 10% had increased disk height of the intervertebral space due to disk abscesses or apparent increased disk height due to collapse of adjacent vertebral bodies (Figure 3).

- On T1-weighted MR images, typical signal intensity alterations of infected disks have been reported as mostly isointensity or hypointense when evaluated with 1.5-T MR imagers (Figure 3).

- On T2-weighted MR images, infected disks are typically considered hyperintense compared with normal adjacent disks. It is important to realize that disk iso- or hypointensity on T2-weighted MR images does not exclude disk infection but may instead represent early infection (Figure 4).

- After contrast material administration, infected disks almost invariably enhance. Lack of enhancement of infected disks was reported to occur rarely. Enhancement of the disk can increase reader confidence for the diagnosis of infection when there are equivocal findings at nonenhanced MR imaging. Enhanced patterns of infected disks include broad, patchy linear, thin, or thick enhancement either in the center or peripherally (Figure 5).

- Non visualization of the nuclear cleft was reported to be indicative of spinal infection (Figure 4). As was already pointed out, the nuclear cleft is rarely visible in the cervical and thoracic spine, and its clinical use is therefore limited [4].

**Vertebral Bodies and Paraspinous Tissue**

- Vertebral bodies adjacent to infected disks are typically described as hypointense on T1-weighted MR images and hyperintense on T2-weighted MR images, with signal intensity increase on contrast-enhanced images (Figures 3, 4, 5).

- To improve conspicuity of early bone marrow edema, STIR sequence is advocated instead of fast spin-echo sequences (Figure 6).

- Abnormal signal intensity in the vertebral bodies was described to usually involve the whole vertebral body on T1-weighted, T2-weighted, and contrast-enhanced MR images (Figures 5, 7), partial involvement of the adjacent vertebral bodies was seen in more than one-third of cases, and rim enhancement or heterogenous enhancement was reported in more than one-fifth of cases in the study of Lederman and al [4].
Destruction of the vertebral endplates is considered typical for disk infection. Most authors evaluate erosion or destruction of the endplates on T1-weighted MR images, but others find T2-weighted MR images better suited for evaluation of erosion of the endplates. Other reports have also described preserved endplates in proven disk infection. Lack of endplate involvement on T1-weighted MR images can therefore not be used as a reliable sign to exclude spinal infection.

Presence of paraspinal inflammatory tissue is often described in spinal infection, and its presence may help considerably in establishing the diagnosis. Previous reports state that spinal infection is almost invariably associated with some paraspinous or epidural inflammatory tissue (Figures 7,8). Absence of inflammatory paraspinal or epidural tissue may therefore be valuable sign to exclude spinal infection.

Although typically described as a feature of tuberculous spondylodiscitis, involvement of adjacent or even distant disks can also be observed in nonmycobacterial infections (Figures 10,11).

We conclude that criteria with good to excellent sensitivity include evidence of either paraspinal or epidural inflammatory tissue, contrast enhancement of the disk, hyperintensity or fluid-equivalent signal intensity on T2-weighted MR images, and erosion or destruction of the vertebral endplates on T1-weighted MR images. In atypical manifestations of spinal infections, some classically reported signal intensity alterations considered typical of spinal infection at MR imaging may not be observed. Spinal infection may rarely involve only one vertebral body, a vertebral body and the adjacent disk, or exclusively the epidural space. Pyogenic hematogenous infections frequently involve several spinal levels [4].

The final diagnosis is a combination of clinical, imaging and biochemical findings. In the acute/subacute phase conventional radiographs should be ordered. Laboratory analysis, including C-Reactive Protein (CRP), and WBC is often ordered and may, in some cases be normal. Blood cultures should be retrieved preferably during a fever spike to identify the causal microorganism. It should be emphasized, however, that the accuracy of blood cultures to identify such organism varies. MRI and CT imaging should follow, including CT guided biopsy of the vertebral body or disc to successfully identify the causal organism and thus guide an appropriate antibiotic treatment regimen.

2. Spondylitis

Most studies on spondylodiscitis report classic finding of involvement of two adjacent vertebrae in the majority of cases. The fact that only a single vertebral body showed abnormalities on MRI lead to diagnostic confusion [1]. Anterior cortical disruption of the
vertebra and upward subligamentous spread of the infection are the two most prevalent features that can aid in earlier diagnosis of single segment spondylodiscitis.

Early imaging tended to show atypical MR presentations. A signal intensity alterations involved single vertebral body initially (Figure 9,10) which later progressed to include the disk and the adjacent vertebral body (Figures 11,12).

3. SEPTIC ARTHRITIS OF FACET JOINT

Septic arthritis of facet joints (SAFJ) is a very rare condition and is thought to represent 4-20% of cases of hematogenous pyogenic spinal infection [5,6]. Its diagnosis is probably becoming more common with the increasing availability of more sensitive imaging techniques. The lumbar region is more frequently affected by this condition, particularly the L4-L5 level. Infection affects the facet joints bilaterally only rarely.

Underlying immunodepressive states and simultaneous infectious processes can be documented at the time of diagnosis. SAFJ manifests as an acute-subacute lateralized inflammatory back pain and fever, and is difficult to differentiate from spondylodiscitis without the help of imaging techniques. Extension to the epidural space and/or paraspinal structures is common, and degrees of neurological impairment are observed during its course in some cases [6].

Staphylococcus aureus is, by far, the organism most frequently responsible for this condition, and the most common form of dissemination is hematogenous. Potential sources of propagation are the skin, intestinal catheters, and more rarely, respiratory and urinary tract infections, although cases of direct inoculation (therapeutic joint infiltration, epidural catheter, mesotherapy, and acupuncture procedure) have been reported. Etiologic diagnosis is established on the basis of blood cultures; guided percutaneous aspiration or surgery is only necessary when these are negative.

MRI is both sensitive and specific and is the technique of choice in the diagnosis of SAFJ. It showed signal changes and alteration of the structure at the level of the interapophyseal joint (Figure 13). An adjacent collection may be also seen associated with infiltration of the surrounding soft tissues, with extension to the epidural space (Figure 14,15).

Treatment of SAFJ consists primarily of antibiotics, and in selected cases of severe neurological compromise, surgical decompression is needed [6].

4. SPINAL EPIDURAL ABSCESS (SEA)

SEA is a rare, but serious condition with multiple causes. Its outcome is often poor and sometimes fatal. So-called primary SEA is due to the hematogenous spread of pathogens from distant focus of infection into the spinal epidural space. The risk of SEA is higher in
immunocompromised persons, e.g., persons who have the acquired immune deficiency syndrome (AIDS) or are under immunosuppressive treatment after organ transplantation. The source of infection remains unclear in many cases of primary SEA.

The most common pathogen in primary SEA is *Staphylococcus aureus* [7].

MR imaging has emerged as the modality of choice for imaging of these entities.

Precontrast T2-weighted images often fail to demonstrate an abscess because both cerebrospinal fluid and an abscess have high signal intensity (Figure 16).

Post-contrast MR imaging delineates the extent of an abscess and the degree of compression of the thecal sac. Two basic patterns of enhancement of SEA have been described:

- The first pattern is homogeneous or heterogeneous enhancement, which represents cellulitis or granulomatous tissues with embedded micro-abscesses, indicative of the phlegmonous stage of infection.

- The second pattern is of an unenhancing central region representing a collection of liquid pus surrounded by thin or thick rim enhancement (Figure 17,18,19).

There are two additional important patterns of contrast enhancement:

- Linear enhancement along the dura mater

- Engorgement of the epidural or basivertebral veins.

Sea often causes significant spinal cord compression that necessitates decompression (Figure 19). A complete neurologic deficit may be fully reversible with early aggressive treatment. Nonoperative medical treatment is also justified for poor surgical candidates [8].

5. INTRAMEDULLARY CORD ABSCESS

Intramedullary cord abscesses are uncommon. Forty percent of abscesses occur in the first two decades of life, with 27% occurring before the age of 10 years.

The symptoms of spinal cord are indistinguishable from those of epidural abscess. Most are of hematogenous origin, and the primary source is usually the respiratory tract. Intramedullary abscess may also complicate congenital dermal sinuses or bacterial endocarditis. *Staphylococcus* and *Streptococcus* organisms have been the most commonly microorganism found in intramedullary abscesses.
It has been suggested that the development of this process may be associated with focal venous infarcts that are complicated by bacterial colonization.

Sequential imaging findings suggest that development of abscess within the spinal cord may be similar to the pathologic evolution of abscess in the brain.

- At the early stage of infectious myelitis, T2-weighted MR images show high signal, with poorly defined enhancement on post-contrast T1-weighted images.

- Approximately 1 week after the initiation of treatment, the region of myelitis became less diffusely hyperintense on T2-weighted sequences, with more clearly defined marginal enhancement on post-contrasts T1-weighted images (Figures 20,21). The surrounding edema continues to be more extensive than the margins of enhancement. This phase is termed the late stage of myelitis, and corresponds to capsular formation. This finding is thought to represent the beginning of intramedullary cord abscess formation.

- The central cavitory portions of the intraaxial necrotic areas are seen on T1-weighted non-contrast images as areas of low signal intensity and as hyperintense foci on T2-weighted sequences (Figures 22,23).

The differential diagnostic considerations of an intramedullary abscess includes cord ischemia, Guillain-Barré syndrome, acute disseminated myelitis, multiple sclerosis, hemangioblastoma, or other cavitating cord tumors.

In summary, the diagnosis of septic myelitis needs to be considered in any patient with intramedullary high signal intensity and abnormal contrasts enhancement on T2-weighted images [9].
Fig. 1: Lateral lumbar radiograph shows erosion and destruction of the inferior endplate of the L2 vertebral body and superior endplate of L3 without disc space narrowing (black arrow). These findings consistent with spondylodiscitis at L2-L3.

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Fig. 2: Lateral lumbar radiographs. Spondylodiscitis L2-L3 at advanced stage with disk space narrowing and irregular endplates.

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Fig. 3: Sagittal T1-weighted MR images shows apparent increased disk height between lumbar vertebrae L2-L3, which is related to disk abscess and destruction of the inferior endplate of L2 and decreased height of the body of L3. We note that the signal intensity of the disk at L2-L3 is slightly hypointense.

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**Fig. 4:** Sagittal T2-weighted MR images reveals an oval collection of fluid-equivalent signal intensity in the enlarged disk space and effacement of the nuclear cleft in comparison to the other lumbar disks.

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**Fig. 5:** T1-weighted fat suppressed contrast-enhanced reveals rim enhancement of the disk space at L2-L3 with a nonenhancing center indicative of a large intradiskal abscess.

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**Fig. 6:** Sagittal T2-weighted STIR MR image reveals an oval collection of fluid-equivalent signal intensity in the enlarged disk space and effacement of the nuclear cleft in comparison to the other lumbar disks.

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**Fig. 7:** Coronal T1-weighted fat-suppressed contrast-enhanced MR image shows diffuse contrast enhancement of the L2 and L3 bodies. Note extensive collection in the left iliopsoas muscle with rim enhancement with non-enhancing center. Note also inflammatory tissue in the contralateral iliopsoas muscle with micro-abscesses.

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**Fig. 8:** Axial T1-weighted fat-suppressed contrast-enhanced MR image shows extensive epidural phlegmon.

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Fig. 9: Sagittal T2-weighted STIR MR image showing high signal intensity of the entire L3 vertebral body without involving the adjacent disks.

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Fig. 10: Corocal T1-weighted post-gadolinium contrat MR image with fat suppression showing L3 vertebral body enhancement without involving the adjacent disks. A huge collection is noted in the right ilio-psoas muscle.

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**Fig. 11:** Sagittal T1-weighted MR image shows a low signal intensity of the entire vertebral body of L5 and S1 without involving of the adjacent disk.

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Fig. 12: Sagittal T1-weighted post-gadolinium contrast MR image with fat suppression showing diffuse enhancement of L5 vertebral body and the superior part of the S1 body. Note the disk is not involved and the extensive epidural abscess.

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Fig. 13: Sagittal T2-weighted STIR MR image shows a fluid in the interapophyseal C7-T1 joint with infiltration of the surrounding soft tissues.

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**Fig. 14:** Sagittal T2-weighted STIR MR imaging demonstrating a fluid collection adjacent to the interapophyseal T1-T2 joint.

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**Fig. 15:** Sagittal T1-weighted post-contrast MR image demonstrating signal changes at the left interapophyseal L5-S1 joint associated with infiltration with the surrounding soft tissues, which extends to the epidural area and paraspinal musculature.

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Fig. 16: On the T2-weighted MR image the SEA is indistinguishable from cerebrospinal fluid.

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**Fig. 17:** Precontrast sagittal T1-weighted MR image exhibits diffuse abnormal signal intensity in the spinal canal, obscuring the entire subarachnoid space in the cervico-thoracic regions.

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Fig. 18: Post-contrast sagittal T1-weighted image shows linear enhancement along the dura mater. The unenhancing region anterior to the dura matter represents a collection of pus. Note subarachnoidal space is totally compressed with the epidural mass.

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Fig. 19: Axial T1-weighted post-contrast MR image demonstrating the medullary cord compressed by the anterior epidural collection (arrow).

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Fig. 20: Sagittal T1-weighted post-contrast MR image shows widened anteroposterior dimensions of the spinal cord with solid intramedullary contrast enhancement.

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**Fig. 21:** Axial T1-weighted post-contrast MR image (T6 level) shows widened of anteroposterior and transverse dimensions of the spinal cord with solid intramedullary contrast enhancement.

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Fig. 22: Sagittal T1-weighted MR image shows widened anteroposterior dimensions of the spinal cord with central cavitary portion.
**Fig. 23:** Sagittal T2-weighted MR image exhibits spinal cord expansion, central edema extending from T6 to T9 with central cavitory portion

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Findings and procedure details

A 1.5 tesla MRI is used to perform exams.

A dedicated cervical spine coil was used for patients who underwent imaging of the cervical spine.

Transverse and sagittal MR examinations of the spine were performed with a phased array coil.

T1-weighted spin-echo, T2-weighted MR images by using a fast pin echo technique, and contrast-enhanced T1-weighted MR images were obtained.

Gadopentetate dimeglumine at a dose of 0.1 mmol per kilogram of body weight was used as the intravenous contrast agent.

For T2-weighted and contrast-enhanced T1-weighted MR sequences, fat suppression was accomplished by using selective presaturation of lipid resonant frequency.

Fast spin-echo short inversion time inversion-recovery (STIR) MR images were also obtained.

The coronal plan is used to detect the abscess localised far from the initial site of the spinal infection (e.g. in the psoas muscle.)

CT is also used when MRI is not available.

Plain radiographs are performed when spinal infection is first suspected.
Conclusion

MR imaging is a powerful diagnostic tool that can be used to help evaluate spinal infection and to help distinguish between an infection and other clinical conditions. In most cases of spinal infection, MR images show typical findings such as vertebral endplate destruction, bone marrow and disk signal abnormalities, and paravertebral or epidural abscesses. However, it is not always easy to diagnose a spinal infection, particularly when some of the classic MR imaging features are absent or when there are unusual patterns of spondylitis. It is necessary to be familiar with atypical MR imaging findings of spinal infection and features that may mimic spinal infection to avoid misdiagnosis and inappropriate treatment.
1- Ziegelbein J, El-Khoury G.Y. Early spondylodiscitis presenting with single vertebral body involvement: A report of two cases. The Iowa Orthopaedic Journal 31:219-224


