C. Imaging the spine in arthritis

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Learning objectives

Learning objectives:

1. To become familiar with the radiographic features of spinal involvement in rheumatoid arthritis (RA) and seronegative spondyloarthropathy (SpA).
2. To know the diagnostic advantages of MRI and CT.
3. To know the MRI and CT features in RA and SpA.

Images for this section:

Fig. 1
Main

The spine can be involved in most inflammatory disorders encompassing

- Rheumatoid arthritis
- Seronegative spondyloarthopathies
  - Ankylosing spondylitis
  - Psoriatic arthritis
  - Reactive arthritis
  - Enteropathic arthritis
  - Undifferentiated spondyloarthropathy
- Juvenile arthritides
- Rare disorders (gout, SAPHO etc.)

Inflammatory spinal changes are most frequent in rheumatoid arthritis (RA) and seronegative spondyloarthopathies (SpA). The presentation will therefore focus on these disorders, which display somewhat different imaging features.

Rheumatoid arthritis (RA)

Involvement in RA is usually located to the cervical spine where erosive changes are predominantly seen in the atlanto-axial (C1-C2) region. Pannus formation around the odontoid process (dens) (Fig. 1) may cause bone erosion and destruction of surrounding ligaments; most seriously if the posterior transverse ligament is involved.

The diagnosis of cervical RA changes is important [1]. The changes can cause instability, potentially risking spinal cord injury. Radiography of the cervical spine is therefore mandatory in RA patients with neck pain. It should always include a lateral view during flexion compared with neutral position in addition to a special view of the dens (Fig. 2) to detect any lesions and/or instability.

Arthritis of apophyseal joints with instability in the C2-Th1 region may also occur, but less frequently. It may progress over time, especially if the C1-C2 region is stabilized surgically [2](Fig. 3).

Cross sectional imaging in the form of computed tomography (CT) and magnetic resonance imaging (MRI) can improve the detection of RA changes in the atlanto-axial region resulting in the following advantages:

- Elimination of overprojecting structures.
- Detection of signs of involvement before they are visible by radiography.
- Clear delineation by CT of osseous structures - erosions etc.
- Visualization by MRI of:
• Soft tissue structures - pannus; spinal cord etc.
• Signs of disease activity.
• Sequels of inflammation - fibrous pannus and fat deposition in the bone marrow.

The advantages of CT and MRI are demonstrated in Figures 4-6. Radiography (Fig. 4) shows erosion at the base of dens (arrow) and instability with a distance between the dens and the anterior arc of C2 exceeding 3 mm (normal upper limit). CT (Fig. 5) demonstrates extensive erosion not only at the base of dens, but also at the tip and at the atlanto-axial and atlanto-occipital joints. MRI, post-contrast sagittal T1 weighted fat saturated (T1FS) sequence (Fig. 6) demonstrates enhancing pannus tissue surrounding the dens, which is a sign of active inflammation.

MRI visualization of the spinal cord is important to detect cord injury or risk of injury. It is recommended that MRI should be performed in all RA patients with neck pain and neurological symptoms [3;4]. Risk of cord compression/injury occurs especially in patients with flexion instability accompanied by erosive changes in the atlanto-axial and/or atlanto-occipital joints causing dens to protrude into the occipital foramen (basilar impression). Figure 7, sagittal and axial images show erosion of the dens and protrusion of the tip into the occipital foramen causing cord compression (white arrows). There is a mixture of fibrotic end enhancing pannus tissue (black arrow) in the widened space between the dens and the anterior arc of C2.

MRI also gives the possibility of detecting signs of arthritis before the occurrence of erosive changes [4]. Figure 8 illustrates MRI of a RA patient with neck pain and normal radiography. There are signs of active arthritis with synovial contrast enhancement (synovitis) at the left atlanto-axial joint in addition to enhancing pannus tissue at the left side of the dens (white arrows) and a subchondral enhancing area in the axis (black arrow).

**Seronegative spondyloarthropathy (SpA)**

According to the European classification criteria [5] SpA is divided into:

• Ankylosing spondylitis (AS)
• Psoriatic arthritis
• Reactive arthritis
• Arthritis associated with inflammatory bowel disorders (enteropathic arthritis)
• Undifferentiated spondyloarthropathy.

Inflammatory changes at the sacroiliac joints always occur in AS and is part of most other forms of SpA. Spinal changes are also a feature of SpA, especially in late stages of AS.
**Radiographic features**

Manifest structural sacroiliac and spinal changes can be diagnosed at radiography. It is, however, not possible to differentiate between the different forms of SpA based on radiography of the sacroiliac joints although symmetric involvement is more frequent in AS than in other forms of SpA [6].

Spinal changes are more specific. Syndesmophytes and involvement of apophyseal joints are more frequent in AS than in the other forms of SpA [6]. Vertebral squaring, syndesmophytes and ankylosis of apophyseal joints are characteristic of AS whereas voluminous paravertebral new bone formation occur in psoriatic and reactive arthritis. The features of enteropathic arthritis often resemble those of AS.

Figure 9 illustrates the slim ossification (named syndesmophytes) at the periphery of annulus fibrous characteristic in AS. Figure 8 illustrates the voluminous paravertebral new bone formation (parasyndesmophytes) characteristic in psoriatic and reactive arthritis.

**Ankylosing spondylitis (AS)**

The most frequent and usually the most disabling form of SpA is AS. It is therefore important to know the radiographic features characteristic of AS. According to the Modified New York Criteria [7] the diagnosis of definite AS requires the following:

- Positive radiography: Grade ≥2 bilateral sacroiliitis or unilateral grade 3-4 sacroiliitis.
- At least one of the following clinical criteria:
  - Low back pain and stiffness for more than 3 months which improves by activity.
  - Limited movement of the lumbar spine in both the sagittal and frontal plane.
  - Reduced chest expansion.

These criteria are still used in the diagnosis of AS despite the increasing use of CT and MRI in the diagnosis of SpA.

Figure 11 illustrates typical definite bilateral AS sacroiliitis (grade 3) in the form of bilateral moderate joint erosion, especially at the iliac side of the joints, accompanied by subchondral sclerosis and focal widening of the joint space. Accompanying initial spinal changes are illustrated in Figure 12. They consist of vertebral squaring due to bone apposition at the anterior aspect of the vertebral bodies (arrowhead) and erosion of vertebral corners which can appear condensed (shiny corners (arrow)). Initial development of syndesmophytes (curved arrow) is also seen.

The spine gradually fuses due to syndesmophytes crossing the intervertebral spaces in addition to fusion of apophyseal joints (Figure 13). Also the interspinous ligaments...
posteriorly may ossify and be visible at frontal radiographs as a slim ossified streak (Figure 14, arrows).

Erosive changes within intervertebral spaces occur in about 10% of patients with AS and are sometimes accompanied by subchondral sclerosis. Such changes can heal with ankylosis (Fig. 15), but there may occasionally be persisted movement at single intervertebral spaces. This can result in pseudo-arthritis like changes with the formation of reactive osteophytes due to excessive mechanical load at single movable areas. The diagnosis of such changes may require CT for adequate visualization (Fig. 16).

Advantages of CT and MRI

- CT gives a clear delineation of osseous structures - posterior joints, fracture, pseudo-arthritis etc.
- MRI can visualize:
  - Signs of disease activity.
  - Signs of previous inflammation - fatty depositions in bone marrow.
  - Chronic structural changes.

CT is the modality of choice to detect fractures and is superior to MRI in detecting osseous lesions such as erosion and ankylosis of costo-vertebral and costo-transversal joints (Fig. 17, arrows). CT is not able to detect signs of disease activity in the form of inflammatory edema. This can be visualized by MRI which has gained a central role in the evaluation of disease activity [8].

The most frequently used MR sequences are:

- Sagittal STIR or T2FS and T1 weighted sequences of the entire spine.
- Supplementary axial slices can be necessary for visualizing involvement of apophyseal, costo-vertebral and costo-transversal joints [9;10].
- T1FS sequences after intravenous Gadolinium can be advantageous and may provide a better anatomic delineation [11].

Early activity changes mainly consist of edema at vertebral corners and/or costo-vertebral joints (Fig. 18). However, during the course of disease signs of activity can also be seen at syndesmophytes (A), apophyseal joints (B) and interspinous ligaments (C)(Fig. 19).

Chronic AS changes detectable by MRI mainly consist of fatty marrow deposition at vertebral corners (Fig. 20), erosion which may be surrounded by signs of active inflammation and/or fatty marrow deposition and vertebral fusion in advanced disease. Syndesmophytes may not always be visible by MRI (Fig. 21) [8].

Complications in AS
One of the feared complications in AS is spinal fracture. Non-fatal fractures have been reported to occur in up to 6% of AS patients and especially in patients with long disease duration [12;13]. Fracture may occur after minor trauma due to the spinal stiffness and a frequent accompanying osteoporosis. Fractures often occur at intervertebral spaces, but usually involve the ankylosed posterior structures and are thereby unstable. Obvious fractures can be diagnosed by radiography (Fig. 22), but fractures may be obscured. It is therefore mandatory to supplement a negative radiography with CT if fracture is suspected (trauma or change of spinal symptoms) (Fig. 23). Cervico-thoracic fractures may cause spinal cord injury which can be visualized by MRI (Fig 24, arrow). The fractures may be lethal even after minor trauma [14].

Other forms of SpA

In psoriatic and reactive arthritis the spinal changes are often characterized by voluminous paravertebral new bone formation (parasyndesmophytes) or coalescing ossification of the paravertebral ligaments (Fig. 25). However, in psoriatic arthritis the changes may also present as erosion of vertebral plates often accompanied by subchondral sclerosis and sometimes signs of multiple osseous inflammation by MRI. Such osseous lesions are especially seen in patients with pustular psoriasis or pustulosis palmoplantaris (Fig. 26). In patients with reactive arthritis and HLA B27 the spinal changes may progress to changes indistinguishable from those seen in AS (Fig. 27). In patients with enteropathic arthritis the spine is often osteoporotic with various accompanying features characteristic of SpA, most often AS-like features. However, by MRI there is usually more pronounced inflammation in the posterior ligaments than seen in the other forms of SpA (Fig. 28).

Grading of SpA changes

The purposes of grading inflammatory spinal changes are to:

Achieve a quantitative value for

- Disease activity.
- Chronic changes.

This is important for

- Therapeutic decisions.
- Monitoring the disease/therapy.

Grading by radiography can either be done using the Bath Ankylosing Spondylitis Index (BASRI) (Fig. 29) [15] or Modified Stoke Ankylosing Spondylitis Spine Score (mSASSS) (Fig. 30) [16] both developed by rheumatologists.
Grading of activity by MRI has become important after the introduction of anti-tumor necrosis factor alpha (anti-TNF#) agents that have proven promising for alleviating inflammatory symptoms of AS and possibly preventing structural damage [17]. There is no accepted universal grading method, but one of the three following methods are commonly used:

- The SPARCC MRI spinal index (Spondyloarthritis Research Consortium of Canada) - six most involved discovertebral units scored dichotomously for activity (Fig. 31) [18].
- ASspiMRIa (Ankylosing Spondylitis Spine MRI Activity Score) with modifications - all discovertebral units (Fig. 32) [19;20].
- The Aarhus method - all discovertebral units (Fig. 33) [8].

It is possible to gain a quantitative value for the effect of anti-TNF# using one of these methods.

Chronic changes can also be quantified using the Aarhus method (Fig. 34) [8].

**Conclusion.**

- Radiography is still valuable in the diagnosis of spinal inflammatory disorders.
  - Is necessary for visualizing instability.
  - Is superior to MRI for detecting syndesmophytes.
- MRI can add information on:
  - Signs of activity; soft tissue changes.
  - Fat deposition - a sign of chronic disease.
- MRI is widely used to monitor disease activity during anti-TNF therapy.
- CT is especially valuable in the detection of fracture.
- MRI and CT can detect changes before they can be visualized by radiography.

**Images for this section:**
Fig. 2

Fig. 3
Fig. 6

Fig. 7
Fig. 8

Fig. 9
Fig. 10
Fig. 12
Fig. 19
Bath Ankylosing Spondylitis Index - Spine
Based on lateral radiograph of cervical spine (C1-C7) and frontal + lateral radiographs of lumbar spine (Th12-S1); grade 0-4:
Grade 0: Normal findings.
Grade 1: Dubious changes.
Grade 2: Slight changes, including erosion, vertebral squaring or sclerosis, with or without syndesmophytes on ≤ 2 vertebrae.
Grade 3: Syndesmophytes on ≥ 3 vertebrae, with or without fusion involving 2 vertebrae.
Grade 4: Fusion involving ≥ 3 vertebrae.

Usually addition of sacroiliac joint grade according to the New York criteria, grade 0-4.

Modified Stoke Ankylosing Spondylitis Spine Score
Lateral radiographs of the cervical and lumbar spine assessed for anterior changes (C2-Th1 and Th12-L5).

Divided in 3 grades:
Grade 1: Erosion, sclerosis and/or squaring.
Grade 2: Syndesmophyte.
Grade 3: Bony bridge.

Maximum total score 72

Recommended by OMERACT.
Fig. 30

**SPARC MRI SPINAL INDEX**

6 most involved disco-vertebral units

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<tr>
<th>Left Slice 1</th>
<th>MAIN SLICE 2</th>
<th>Right Slice 3</th>
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Max./unit: 6 + 6 + 6

Max. patient score: 108

Fig. 31

**ASspiMRIa**

Activity changes original

Activity changes modified

Max. patient score 69
THE AARHUS METHOD - Activity changes

Three dimensional oedema scores for vertebral units:
0:  Normal.
1:  Minor <25% of subchondral area.
2:  Moderate 25 - <50% of subchondral area.
3:  Major ≥50% of subchondral area.

Additional scores for:
➢ Oedema at costo-vertebral joints: dichotomously: (0/1).
➢ Apophyseal joints and other posterior elements: (0/1).
Max. patient score: 81
**THE AARHUS METHOD - Chronic changes**

Chronic scores for vertebral units:
- **0:** Normal.
- **1:** Minor <25% of subchondral area.
- **2:** Moderate 25 - <50% of subchondral area.
- **3:** Major ≥50% of subchondral area.

Fig. 34
References


**Personal Information**

The author has for the last 20 years worked within the field of imaging seronegative spondyloarthropathies using the available imaging modalities.

During 6 years participated in international OMERACT (Outcome Measures in Rheumatology Clinical Trials) analyses and member of Assessment of Ankylosing Spondylitis (ASAS) working groups.