Ankylosing spondylitis: A Pictorial Review

Poster No.: P-0009
Congress: ESSR 2012
Type: Scientific Exhibit
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Keywords: Musculoskeletal spine, Musculoskeletal joint, Conventional radiography, CT, MR, Education, Arthritides
DOI: 10.1594/essr2012/P-0009

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Purpose

To provide an educational and pictorial review of ankylosing spondylitis (AS) based on their radiological imaging features using plain radiography, CT and MRI.

Methods and Materials

Sacroiliitis is the sine qua non of AS.

The primary site of pathology is the enthesis. The osteitis caused by the inflammatory process leads to bone edema and subsequently to ossification of the ligaments. The synovial joints are also affected by inflammation, with erosions followed by bone production and ankylosis.

Radiography should be the initial technique despite its relatively high false-negative rate in early disease. At this stage, MRI is useful.

Results

SACROILIITIS

A commonly used radiographic protocol for evaluating the sacroiliac joints includes anteroposterior and Ferguson views of the sacroiliac joints Fig. 1 on page 21. CT and MRI have also been used in an attempt to identify sacroiliitis for early diagnosis of AS.

Sacroiliitis is the sine qua non of AS. It is an integral part of the modified New York diagnostic criteria for AS. The sacroiliitis grading system associated with the modified New York criteria is as follows:

-Grade 0: normal findings.
-Grade 1: suspicious changes.
-Grade 2: minimum abnormality, defined as small localized areas with erosion or sclerosis without alteration in the joint width.
-Grade 3: unequivocal abnormality (severe erosions, pseudo-widening of the joint space and partial ankylosis).
-Grade 4: complete ankylosis.

Based on the modified New York clinical criteria, grades 0 or 1 are not sufficient for the diagnosis of definitive AS.

The first radiographic sign in 99% of cases of AS is sacroiliitis. The classic sacroiliac joint involvement is bilateral and symmetric but in approximately 10% of cases the initial radiographic evidence of sacroiliitis is unilateral with eventual bilateral involvement.

The radiographic findings of AS in the sacroiliac joints start as a loss or blurring of the subchondral cortex Fig. 2 on page 22. This finding is followed by the development of small erosions (rat bite erosions) along the iliac side of the joint, as well as subjacent mild sclerosis Fig. 3 on page 23. As the disease progresses, the erosions become larger and include the sacral side; the joint space widens; and sclerosis about the joint becomes more prominent Fig. 4 on page 24. If the disease continues to progress, ankylosis of the joint occurs, with resolution of the sclerosis Fig. 5 on page 25.

The late appearance of radiological changes in AS patients often results in a delay in diagnosis, which may be avoided by the use of MRI. Early signs of inflammation on MRI have been consistently found in the inferior iliac portion of the joint. Pericartilage osteitis is an important feature of AS that is well demonstrated by MRI as bone marrow edema. T1-weighted spin echo sequences may be performed to examine articular cartilage for the presence of erosions, while T2-weighted sequences with fat suppression or STIR sequences demonstrate the increased signal of bone edema, which will also be seen as reduced signal on T1 Fig. 6 on page 26 Fig. 7 on page 19. In chronic sacroiliitis or fused sacroiliac joints, the subchondral bone may show a high signal on T1 due to the increased yellow marrow often associated with osteoporosis of adjacent bone with fused joints Fig. 8 on page 18. The use of dynamic post-contrast imaging with Gd-DTPA has been advocated, as in active disease there is a linear rise in the signal at the point of maximal enhancement in the joint cartilage and periarticular tissue in the first 1-2 minutes. However, contrast enhancement is only required if the STIR sequence is equivocal.

CT is more sensitive than radiographs in identifying sacroiliitis and the findings are similar to those seen on radiographs, such as erosions Fig. 9 on page 17, sclerosis, and eventual ankylosis if the disease progresses Fig. 10 on page 16. Studies indicate that CT is more sensitive than radiographs in identifying sacroiliitis, leading to an earlier diagnosis. Nonetheless, the sensitivity of CT in the detection of acute inflammatory lesions is poor compared to that of MRI.

**AXIAL SKELETON**
The primary site of pathology is the enthesis, where the longitudinal ligaments and the annulus fibrosis collagen merge directly with bone. The osteitis caused by the inflammatory process leads to bone edema and subsequently to ossification of the ligaments. The synovial joints are also affected by inflammation, with erosions followed by bone production and ankylosis.

Disease involvement of the spine typically starts at the thoracolumbar or lumbosacral junctions. As the disease progresses, the remainder of the thoracic and lumbar spine as well as the cervical spine become involved.

The first radiographic evidence of spine involvement occurs in the enthesis where the annulus fibrosus outer fibres merge directly with the vertebral body. Small erosions (Romanus lesions) Fig. 11 on page 15 occur with the development of adjacent sclerosis (shiny corner) Fig. 12 on page 14. Next, either new bone formation occurs along the anterior aspect of the vertebral body, or the corner erosions progress leading to a barrel-shaped or square vertebral body on the lateral radiographic view of the spine Fig. 13 on page 13. As the disease continues to progress, syndesmophytes form along the anterior fibres of the annulus fibrosus Fig. 14 on page 12 Fig. 15 on page 6, leading to the bamboo spine appearance. The interspinous ligaments can ossify, causing the dagger sign. Ankylosis of the facet joints occurs, described as the tram track sign. In addition, in the fused spine, there may be dystrophic calcification of the intervertebral discs Fig. 16 on page 7.

Radiographic scoring methods have been developed for the evaluation of inflammatory changes in the spine. The modified Stoke ankylosing spondylitis score (mSASSS) is based on an analysis of the anterior cervical and lumbar vertebral spinal unit, which is graded as:

-Grade 0: normal.
-Grade 1: erosions/squaring/sclerosis.
-Grade 2: syndesmophytes.
-Grade 3: total bone bridging.

MRI can detect active enthesitis in the spine before the development of Romanus lesions on radiographs. The MRI finding is an abnormal signal at the vertebral rim in a pattern similar to the shiny corner sign on radiographs. The signal characteristics of this active enthesitis are T1-weighted low signal intensity, T2-weighted high signal intensity, and postcontrast enhancement Fig. 17 on page 8. In chronic lesions, the edema pattern may disappear and be replaced by yellow marrow at the enthesis and adjacent vertebral body, with high signal on T1-weighted sequences and low signal on STIR and T2-
weighted FS sequences. Where fusion is extensive, multiple triangular fat accumulations are seen and high signal may be present in the intervertebral discs on T1-weighted sequences due to the presence of fine calcification.

Syndesmophytes are not well-demonstrated by MRI due to the low signal of the normal longitudinal ligament and annulus, but involvement of the costovertebral and facet joints is readily seen on the axial studies, which show joint-line erosion adjacent to bone edema, effusions, and eventually fusion. Sagittal MRI studies should be sufficiently wide to include the facet and costovertebral joints, to ensure that inflammatory lesions are not overlooked.

Anderson type A lesions resemble Schmorl nodes and have a rim of edema in the vertebral body. Erosion or destruction of the subdiscal bone may become extensive and resemble a spondylodiscitis, referred to as an Anderson type B lesion Fig. 18 on page 9. These lesions are due to increased mobility at a level between fused segments or to posterior-element pseudoarthrosis in solidly fused spines. The changes induced by Anderson-type lesions are well-demonstrated on CT and MRI. CT demonstrates sclerosis and the state of the posterior elements; pseudoarthrosis will be easily identified on sagittal reconstructions Fig. 19 on page 28. MRI shows the irregular destruction of the endplates and extensive vertebral-body edema but with limited visualization of paravertebral inflamed soft tissue Fig. 20 on page 10. Posterior-element pseudoarthrosis is highlighted as low signal across the lamina on T1-weighted sequences, with adjacent edema on STIR.

The main spinal complications of AS are osteoporosis, trauma and cauda equina syndrome.

Fractures of the cervical spine may occur after minor trauma to the head and neck. The typical appearance on plain radiographs is of a chalkstick break across either the disc or the vertebral body and the posterior elements. These fractures are best evaluated by CT using axial and reconstructed sagittal and coronal reconstructions Fig. 21 on page 11 Fig. 22 on page 20. MRI is essential to assess whether there has been associated cord injury.

Cauda equina syndrome occurs in the later stages of AS. CT and MRI may show thecal diverticular erosion of the lamina, peripheral clumping of nerve roots and dural calcifications.

**APPENDICULAR SKELETON**
In the appendicular skeleton the hips, shoulders, and knees are the most common sites of involvement, typically bilateral and symmetric.

When the hips are involved, one sees axial migration, concentric joint space narrowing, cufflike femoral osteophytes, acetabular protrusion, and eventually ankylosis Fig. 23 on page 27.

At the shoulder, in addition to typical joint space narrowing of the acromioclavicular and glenohumeral joints, a hatchet deformity can form on the humeral head. This defect is a large erosion at the greater tuberosity.

At the knee, the radiographic manifestations of involvement are tricompartmental joint space narrowing and erosions.

The small joints of the hands and feet as well as the wrists are affected less frequently than large joints. The findings include asymmetric involvement, small erosions, and osseous proliferative changes.

**Images for this section:**
Lateral and frontal radiograph of the cervical spine show syndesmophytes formation at C5-C6 and C6-C7 levels (arrows). There are also cysts, erosions, and sclerosis at the atlantoaxial joint (asterisk).
Ankylosis of the spine. (a) Lateral radiograph of the thoracic spine reveals the bamboo spine appearance and discal mineralization (arrows). (b) Anteroposterior radiograph of the lumbar spine demonstrates ossification of the interspinous ligament, known as the dagger sign (arrowhead).
Sagittal MRI study of the lumbar spine demonstrates an erosion at the anterior corner of the L5 vertebral body (arrows) and adjacent vertebral inflammatory response with bone marrow edema pattern (asterisk). There are also endplate erosions with surrounding edema at L1-L2 and L3-L4 levels (arrowhead).

Fig. 17
Fig. 18

**ANKYLOSING SPONDYLITIS**

Anderson type B lesion. Lateral and anteroposterior radiographs of the lumbar spine demonstrate endplate erosions and adjacent vertebral sclerosis at L2-L3 level (arrow). There is also left sacroiliitis (asterisk).
**Anderson type B lesion.** Sagittal MRI study of the lumbar spine demonstrates endplate erosions with extensive surrounding edema at L2-L3 level (arrows). There is also a small erosion at the anterior corner of the L1 vertebral body (asterisk).
Fig. 21

AP and lateral radiographs of the cervical spine in a patient with advanced ankylosing spondylitis after suffering a minor trauma show spinous process fractures of C3 and C4 vertebrae (asterisk). NOTE THAT LATERAL VIEW DOES NOT INCLUDE ALL SEVEN CERVICAL VERTEBRAE.
Syndesmophyte. Lateral radiograph of the thoracic spine demonstrates a syndesmophyte in the T11-T12 intervertebral space (arrow). There is also a Romanus lesion (arrowhead).

Fig. 14
**Fig. 13**

**Ankylosing Spondylitis**

_Squaring of vertebral bodies._ Lateral radiograph of the lumbar spine shows flattening of the anterior surface of the L2, L3 and L4 vertebral bodies (arrows).
“Shiny corner”. (a) Lateral radiograph of the lumbar spine demonstrates a small erosion (Romanus lesion) at the anterior corner/tip of the L1 vertebral body (arrow). There is also adjacent sclerosis or a shiny corner (arrowhead). (b) Anteroposterior radiograph of the lumbar spine reveals early bilateral sacroiliitis (asterisks).
ANKYLOSING SPONDYLITIS

Romanus lesion. Lateral radiograph of the thoracic spine demonstrates erosions at the anterior corner rim of the T11 and T12 vertebral bodies (arrows).

Fig. 11
ANKYLOSING SPONDYLITIS

Bilateral sacroiliitis. CT image of the SIJ shows total ankylosis of the sacroiliac joints (arrows)

Fig. 10
Unilateral sacroiliitis. CT image of the SIJ shows widened joint space (asterisk), periarticular erosions (arrow), blurring of the cortical white line (arrowhead), and subtle subchondral sclerosis in the left sacroiliac joint.

Fig. 9
Bilateral sacroiliitis. MRI study of the SIJ shows erosions (arrow), subchondral fat accumulation (asterisk), and intra-articular fluid signal (arrowhead) in the sacroiliac joints. Fat accumulation and sclerosis are signs of chronic disease and best visualized in short repetition time/echo time pulse sequences.
Unilateral sacroiliitis. MRI study of the SIJ shows an erosion (arrow), subchondral edema (arrowhead), and intra-articular fluid signal (asterisk) in the right sacroiliac joint. The left sacroiliac joint is normal.
Sagittal CT reconstructions of the cervical spine demonstrate the chalkstick fracture through the disc anteriorly and the posterior elements at C6-C7 level with angulation and anterolisthesis > 50%.

Axial CT image shows bilateral facet dislocation and the "double vertebral body" sign.
Fig. 1

Anteroposterior (AP) radiograph of the sacroiliac joints (SI). The joint have a uniform width and cortical white line along its margins is intact (arrows).
Grade 1 sacroilitis (using the modified New York criteria). AP radiograph of the SIJ demonstrates suspicious changes in the left sacroiliac joint (arrows).

Fig. 2
Grade 2 sacroilitis (using the modified New York criteria). AP radiograph of the SIJ demonstrates bilateral sclerosis without alteration in the joint width (arrows).

Fig. 3
Grade 3 sacroilitis (using the modified New York criteria). AP radiograph of the SI demonstrates bilateral erosions and bilateral periarticular sclerosis. Note that the changes are more severe on the iliac sides of the joints (arrows).

Fig. 4
ANKYLOSING SPONDYLITIS

Grade 4 sacroiliitis (using the modified New York criteria). AP radiograph of the SIJ demonstrates total ankylosis of the sacroiliac joints (arrows).

Fig. 5
Fig. 6

Bilateral sacroiliitis. MRI study of the SIJ shows erosions (arrows) and subchondral edema (asterisk). Note that the changes are more severe on the iliac sides of the joints. There is also an erosion at the anterior corner of the L5 vertebral body and adjacent bone marrow edema pattern (arrowhead).
Coronal and axial MRI study of the pelvis show symmetric narrowing of both hip joints with a small erosion at the right acetabular roof (arrows) and joint fluid in both hip joints.

Fig. 23
ANKYLOSING SPONDYLITIS

Anderson type B lesion. Sagittal and coronal CT reconstructions of the lumbar spine demonstrate endplate erosions and adjacent vertebral sclerosis at L2-L3 level (arrows).

Fig. 19
Conclusion

The AS commonly involve the entire axial skeleton. The initial examination should be radiographic. MRI can be useful in the early stages of disease.

References


Personal Information