Inflammatory Arthropathy – Ankylosing Spondylitis
Anne Grethe Jurik, Department of Radiology, Aarhus University Hospital, Noerrebrogade 44, DK-8000 Aarhus C, Denmark.

Introduction
Ankylosing spondylitis (AS), also known as Pierre-Marie Strumpell’s disease and, more commonly, as Bechterew’s disease, is nowadays a well-recognized inflammatory disease entity with a prevalence about 0.5%. AS primarily involves the sacroiliac joints (SIJ) and the spine, but also peripheral joints and entheses. The SIJ and spinal involvement cause chronic inflammatory back pain and progressive stiffness due to joint destruction which may result in ankylosis. The disease onset is often in early adulthood and it can over time cause severe disability. Males predominate and there is a genetic disposition with a frequent association with the human leukocyte antigen (HLA) B27 (1).

Conventional radiography of the SIJ and the spine has previously been the hallmark for the diagnosis of AS although it is insensitive to early bone and joint damage. However, until recently the absence of effective treatment limited the need for more sensitive imaging techniques. This changed after the introduction of the anti-tumor necrosis factor alpha (anti-TNF$\alpha$) agents that have proven promising for alleviating inflammatory symptoms of AS and possibly preventing structural damage (2).

Magnetic resonance imaging (MRI) has proven effective in depicting disease activity in the SIJ and the spine in AS. MRI has also been shown to be valid for assessing change of disease activity over time in patients treated with anti-TNF$\alpha$ agents (3;4). However, according to the international accepted modified New York criteria a definite AS diagnosis still demands the presence of manifest sacroiliitis by radiography in addition to typical clinical findings (low back pain lasting for three months, limitation of lumbar spine motion, decreased chest expansion) (5). The weakness of the modified New York criteria is the limited ability to diagnose the early stages of AS due to the obligatory demand for manifest sacroiliitis by radiography. This may delay the AS diagnosis with 8-11 years (6). MRI is the most sensitive method for diagnosing sacroiliitis and can detect signs of activity early in the disease, even before the occurrence of erosion (7). However, the occurrence of active inflammation at the SIJ does not always imply AS because other forms of seronegative arthritides involving the axial skeleton can cause joint inflammation. The concept spondyloarthritis (SpA) was introduced in 1976 (8) and in 1991 the European Spondylarthropathy Study Group (ESSG) classified the disorders into five entities: idiopathic AS, psoriatic arthritis, reactive arthritis, arthritis associated with inflammatory bowel disease (Crohn’s disease or ulcerative colitis) and unclassified SpA (9). The ESSG classification is mainly based on clinical findings, but also includes radiographic evidence of sacroiliitis. It has therefore not solved the problem with a delayed diagnosis due to a low sensitivity of radiography early in the disease. Extensive international collaborative work has recently resulted in new ASAS (Assessment of SpondyloArthritis international Society) classification criteria for SpA encompassing MR signs as the imaging confirmation of sacroiliitis (10). A positive MRI for sacroiliitis was defined mainly based on signs of active inflammation (11). The ASAS criteria will facilitate the early diagnosis of SpA, but it is most important to predict changes as part of AS and thereby valuable with regard to therapy, prognosis and working capacity. However, a certain early diagnosis of AS sacroiliitis by MRI cannot be based on signs of disease activity only because the other forms of arthritides involving the SIJ also cause joint inflammation. Some of the SpA disorders diagnosed with the ASAS criteria (e.g. reactive arthritis) may have a time limited course and do not imply a progressive course as seen in AS. It is therefore important that the early AS diagnosis established by MRI is not only based on active inflammatory SIJ changes. There should also be some degree of detectable chronic structural changes corresponding to the radiographic changes included in the New York criteria for AS. The recent finding of a significant correlation between radiographic erosions and erosions detectable by MRI using both T1 and T1FS sequences (12) is important in this aspect. With the inclusion of erosions by MRI it is possible to establish a correct diagnosis of AS sacroiliitis by MRI in relative
early stages. MRI of the SIJ is therefore important for the early AS diagnosis, but spinal and peripheral changes may also be present in the early stages as well as later on and contribute to the diagnosis.

Characteristics of sacroiliitis in AS
To achieve a certain diagnosis of AS sacroiliitis it is important to know the characteristic imaging features and be able to differentiate them from the various differentials. It is in this aspect important to be aware of the joint anatomy as active inflammatory changes in the ligamentous part of the SIJ has been shown significantly related to the development of AS according to the modified New York criteria after 2-7 years of follow-up (13).

The SIJ is composed of a C-shaped cartilaginous portion between the iliac and sacral bone and a dorsal syndesmosis in which the adjacent bony surfaces are united by inter-osseous ligaments (Fig. 1). At histology, the cartilaginous portion has characteristics of a symphysis with surrounding ligaments attached to the hyaline cartilage in a zone of fibro-cartilage, and some characteristics of a synovial joint occur only in the distal joint portion (14).

Fig. 1. Lateral view of the C-shaped sacral joint facet by 3D reconstruction of CT data and a trans-axial drawing showing the anterior cartilaginous (Car.) and the posterior ligamentous (Lig.) portion of the joint.

Because the detection of inflammation in the ligamentous joint portion is important for the AS diagnosis, the optimal MR sequences consist of a semi-axial STIR or T2 fat saturated (FS) sequence visualizing active inflammation in both joint portions; semi-coronal T1 and T1 FS sequences, which visualize chronic changes in the form of fat deposition in the subchondral bone marrow, erosion and joint space alteration. Additional post-contrast T1 FS sequences often improve the delineation of activity signs, but it is not mandatory for the diagnosis (15).

Using these sequences it is possible to visualize the rather specific MR signs of AS sacroiliitis in the form of bilateral subchondral inflammation which often occur both at the sacral and iliac side of the joints and usually is accompanied by erosion and/or some degree of subchondral fatty marrow deposition early in the disease (Fig. 2). Differentiation from the other forms of SpA can usually be done based on the location, extent and features of MRI abnormalities. Psoriatic and reactive sacroiliitis is often unilateral and with no or less pronounced signs of chronic changes, but SIJ changes associated with inflammatory bowel disease may be somewhat similar to AS changes.
Fig. 2. Typical MR signs of early ankylosing spondylitis. There are signs of activity with bilateral subchondral edema (white arrows) and chronic changes in the form of erosion and fat deposition in the subchondral bone marrow (black arrows).

Characteristics of spinal changes in AS
Spinal changes in AS mainly include disco-vertebral abnormalities and posterior joint and ligamentous abnormalities in addition to complications such as fracture.

MRI is a sensitive method for visualizing active spinal inflammation in AS. Routine sagittal STIR and T1-weighted sequences of the entire spine have been widely used to diagnose and monitor the changes. Signs of activity mainly consist of edema and/or enhancement at vertebral plates, costo-vertebral and apophyseal joints and at the spinous processes and interspinous ligaments (Fig. 3). Inflammation at vertebral plates is the most frequent finding, often located to vertebral corners (16). The edema in vertebral corners corresponds to areas later showing radiodense shiny corners representing enthesitis at the insertion of the peripheral annulus fibrosus. Signs of activity at costo-vertebral joints are also relatively frequent whereas signs of activity corresponding to apophyseal joints are less frequently detected when using sagittal slice orientation. It is possible that detection of active inflammation in posterior structures will increase if the routine sagittal sequences are supplemented by axial or coronal slices with a small field of view (FOV) (17;18) (Fig. 3). Due to the extent of the spine this is, however, time consuming and therefore less feasible. Supplementary coronal slices of the entire spine are also a possibility for improving the visualization of both apophyseal, costo-vertebral and costo-transverse joints. It can, however, be difficult to detect minor abnormalities when using a large FOV, and coronal slices of the entire spine have therefore not gained widespread acceptance.
Fig. 3a. Lateral view of the spine showing enhancement at vertebral corners both anterior and posterior with an enhancing syndesmophyte anterior (white arrows). Furthermore, costo-vertebral arthritis (grey arrows) best visualized on the axial slice.

Fig. 3b. To the left, axial and sagittal STIR images showing soft tissue and subchondral edema at the right apophyseal joint between L2 and L3 (black arrows). To the right, sagittal and coronal post-contrast T1 FS images showing enhancement of the inter-spinous ligaments, best visualized on the coronal image (white arrows).

Investigations of spinal MR changes in AS has mainly been driven by rheumatologists and focused on activity, in particular the ability of anti-TNFα agents to reduce MR signs of disease activity (3;4;19). This will change the patients from active to more chronic stages of the disease. Despite
this, chronic structural damage detectable by MRI has gained less attention. Chronic changes mainly consisting of features detectable by radiography (erosion, sclerosis, squaring, syndesmophytes, osseous bridging, fusion) have been analyzed by MRI (20). However, the inter-reader reliability was poor and the MR evaluation method has not gained widespread acceptance, partly because it was later shown that the MR assessment offered no advantages compared with radiography (20). Radiography is therefore still widely used in rheumatologic studies to monitor chronic spinal changes (21). Radiography is, however, insensitive for detecting permanent damage and anti-TNFα agents have been reported not to prevent development of chronic radiographic changes significantly (22;23).

Fatty marrow deposition at vertebral corners has been shown to be an important sign of chronic disease being significantly related to radiographic AS changes, especially vertebral squaring (16). If fatty marrow deposition is included among MR features of chronic structural damage it seems possible to use MRI to detect and monitor chronic AS changes in the thoraco-lumbar spine. MRI has proven superior to radiography for detecting erosion of vertebral plates (Fig. 4) except in the cervical regions. MRI in addition visualizes osseous bridging/fusion. MRI is, however, inferior to conventional radiography in depicting syndesmophytes (16;24) unless there are active inflammation (Fig. 3) or fatty deposition, but the validity of fatty marrow deposition may outweigh this. Taking this into account it has been shown possible to substitute radiography of the thoraco-lumbar spine with MRI and thereby omit repeated exposure to radiation (16).

![Fig. 3b. Disco-vertebral erosion. Sagittal T1 and STIR image showing erosion of the upper vertebral plate of L4 with edema in the erosion as sign of active inflammation, but also surrounding fatty marrow deposition as sign of sequels of previous inflammation.](image)

**Characteristics of peripheral joint involvement in AS**
AS may involve peripheral joints and entheses (areas where tendons, ligaments and joint capsules attach bone). The shoulder, hip and knee are well known affected sites, but AS may also involve minor joints. MRI can visualize active synovitis and enthesitis in addition to chronic changes in the form of joint space alteration, erosion and paro-articular new bone formation. Inflammatory involvement of entheses is a characteristic feature, which may occur outside joints areas such as the attachment of the plantar fascia to the calcaneus (Fig. 5). The detection of manifest hip or
shoulder arthritis or inflammatory enthesopathy in young patient should always point to the possibility of AS and be an indication for MRI of the SIJ (Fig. 5).

Fig. 5. The images illustrate a young man presenting with active synovial inflammation in both hip joints and active enthesopathy in the left heel (arrows). Supplementary MRI of the SIJ (bottom right image) shows bilateral active sacroiliitis in early AS.

Conclusion
MRI is the most sensitive method for diagnosing sacroiliitis and spinal involvement in AS. It has therefore been widely accepted as an important diagnostic procedure to confirm the early AS diagnosis. This implies that therapy reducing inflammation can be instituted earlier and thereby probably prevent progressive structural damage causing disability.

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