Fractures of the ankylosed spine: MRI features

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Abstract
The diagnosis of transverse spinal fractures in patients with ankylosing spondylitis and Forestier’s disease (DISH) may be difficult. The MRI features of 9 such fractures at the disk, vertebral body, spinal canal and posterior elements are presented. Fractures of the posterior elements (posterior arch fractures and/or rupture of interspinous or supraspinous ligaments and contiguous soft tissue structures) were present in all cases, underscoring the importance of MR signal abnormalities of posterior structures for diagnosis of these fractures. MR is advantageous due to its ability to demonstrate signal abnormalities of the posterior elements, which combined with disk and vertebral body abnormalities, play a major role for accurate diagnosis of this type of fracture.

Mots-clés : Ankylosing spondylitis. DISH. Fracture. Spine. MRI.

Materials and Methods
Retrospective review of 9 cases of spinal fractures in 7 patients with ankylosed spine over a 10-year period. Six fractures occurred in 5 patients with known AS (with a mean duration of 20 years) and 3 fractures occurred in 2 patients with DISH. All fractures occurred after a recent (few weeks to months) minor trauma (fall) or without identifiable trauma. The patient population included 6 males and 1 female aged 45, 51, 62, 62, 65, 75 and 80 years (mean age: 63 years). Six fractures were thoracic in location whereas 2 were lumbar and 1 was cervical in location. Two patients had 2 fractures (cervical and thoracic in locations in a patient with AS, and both thoracic in location in a patient with DISH). The cervical fracture was associated with anterolisthesis of the superior component. Two patients presented with neurological deficits, with paraplegia progressing to death in one case. In both cases, neurological complications were secondary to thoracic epidural hematoma. Imaging included conventional radiographs, CT and MRI (1.5T). MRI included sagittal and axial T1W and T2W sequences, and in 4 cases, fat-suppressed postcontrast T1W images. MRI findings were correlated with radiographic and CT findings (when available) with evaluation of discal, vertebral body, spinal canal, ligamentous, posterior element and surrounding soft tissue lesions. All imaging studies were reviewed by 2 radiologists, including an experienced musculoskeletal radiologist.

Results (fig. 1 à 5)
The anterior column was involved in all cases with either a transvertebral (2 cases) or transdiscal (7 cases) fracture associated.
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with a fracture of the posterior column: pedicles, posterior articular masses, spinous process and/or rupture of interspinous or supraspinous ligaments, and lesions of adjacent soft tissues.

One transvertebral fracture was characterized by a T1W and T2W hypointense fracture line surrounded by edema. The other transvertebral fracture was characterized by a T1W hypointense and T2W hyperintense fluid filled cleft suggesting avascular necrosis. Fractures of the posterior elements were present in both cases.

The seven transdiscal fractures presented either with a fracture through the disc space (3 cases) or pseudoarthrosis (4 cases) with endplate erosions and signal changes of the disc spaces: T1W hypointense, T2W hypointense or hyperintense, endplate enhancement after gadolinium injection. A fracture of the posterior elements or rupture of the interspinous and supraspinous ligaments was present in all cases. Fractures of the posterior elements were easily detected by the presence of large areas of hypointense signal. In one case, the fracture was limited to both pedicles and was less conspicuous.

Gadolinium injection demonstrated enhancement of the edema around fractures, or enhancement at the periphery of osteonecrosis or pseudoarthrosis.

The MR diagnosis of these transverse fractures was based on the combination of signal alterations involving the anterior (vertebral body, disc) and posterior (posterior elements, supraspinous and interspinous ligaments, soft tissues) columns. Signal abnormalities included fracture lines, edema, avascular necrosis and pseudoarthrosis.

Discussion
AS and DISH both predispose to transverse fractures of the spine secondary to ankylosis and osteoporosis. Severe neuro-
logical complications (paraplegia, quadriplegia) may sometimes occur. The fractures may be the result of minor trauma, or occur without traumatic context (1-6), similar to fatigue fractures. They are the result of hyperextension or flexion mechanism, reminiscent of seat belt or Chance fractures (7). The mean age of patients with this type of fracture is usually between 50 and 60 years for AS (mean disease evolution of 20 years) and a little older for DISH. Classically, these fractures have been considered frequent at the cervical level. In our patients, a single fracture involved the cervical spine whereas the remaining 8 involved the thoraco-lumbar spine. Recent published series (8, 9) also confirm the increased prevalence at the thoraco-lumbar segments in AS. A publication (6) reviewing the MR imaging features of fractures in 6 patients with DISH described 4 fractures at the thoraco-lumbar junction, one at T9 and one at C5. Clinical and imaging diagnosis of these fractures may be difficult. Indeed, such fractures occur in patients with a long history of spinal ankylosis, chronic back pain, in whom a minor traumatic event may be unknown and fracture related pain go unrecognized. The fractures may be difficult to detect on radiographs because of spinal ossification and ankylosis, osteoporosis, poor visualization of disc spaces, and suboptimal demonstration of some spinal segments, especially the cervico-thoracic junction. In a series of 12 AS patients with spinal fracture (9), the authors reported that 2 fractures were only detectable on MR and not visible on radiographs. In another series (10), the diagnosis of spinal fracture in AS patients was initially correctly made in only 41.67% of 8 patients, with progression to neurological complications in 16.67% of cases. Undiagnosed fractures may progress to pseudoarthrosis and simulate infectious discitis or other erosive discopathies.

The diagnosis of transverse fractures of the spine is greatly improved by the use of CT with multiplanar and 3D reconstructions and MR depicting fracture-related signal changes and associated complications.

Based on reports from the literature (6, 8, 9) and findings in our patients, these fractures may have the following presentations:

- Transdiscal and/or transvertebral fracture line, horizontal or oblique, regular or irregular, sometimes with anterior disk widening, and syndesmophyte fracture. An associated vertebral compression fracture may be present. These fractures may be undetectable on conventional radiographs but are conspicuous on CT and MR. Edema around the fracture may be noted on MR depending on the age of the fracture, and may obscure the fracture line, especially on T1W images.
- Pseudoarthrosis (most frequent presentation type in our series), corresponding to the evolution of a missed fracture due to lack of immobilization, characterized by endplate irregularities, erosions, and endplate sclerosis. On radiographs, this appearance may simulate inflammatory or infectious discitis.
- Avascular necrosis (6, 9) (one case in our series), that may present as a gas filled cleft on radiographs or fluid filled cleft on MR allowing diagnosis, especially in cases where a lytic bone lesion may not be excluded on radiographs or CT.

However, the finding allowing a confident diagnosis of transverse fractures of the spine is the frequent presence of posterior column involvement (articular masses, spinous process, pedicles, interspinous ligamentous structures) in addition to the anterior column involvement. In a series of 12 AS patients with spinal fracture (9), 11 had posterior column involvement on MR (articular mass, spinous process, lamina fractures, and/or ligamentous rupture with interspinous soft tissue injuries). Another series of 16 AS patients (8) reported the presence of posterior column fracture in all patients with anterior column fracture. In our patients, a fracture of the posterior column (posterior elements, interspinous ligaments, adjacent soft tissues) was present in every case of anterior column fracture. Involvement of the posterior column is an important diagnostic feature, well depicted on MR. These areas of signal abnormality on MRI are T1W hypointense and T2W hyperintense.
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hypointense or hyperintense depending on lesion age and use of fat suppression techniques. Gadolinium injection demonstrates enhancement of edema around a fracture line, and at the periphery of pseudoarthrosis or avascular necrosis. A diagnosis of transverse fracture of the spine should be considered on MR in AS and DISH patients with anterior column signal abnormalities suggesting a transdiscal or transvertebral fracture, pseudoarthrosis or avascular necrosis when associated with a posterior column fracture. It is important to note that most of these MR examinations are performed on patients who are not known to have spinal ankylosis, especially those patients with DISH. It is thus important to recognize the presence of intervertebral disc hyperintensity, especially on T1W images, suggesting the presence of spinal ankylosis which in turn would raise concern for related complications such as transverse fractures of the spine.

An additional advantage of MR is its ability to assess the contents of the spinal canal in patients with such unstable fractures that may secondarily cause severe neurological complications (1, 2, 5, 8-11). Two patients in our series developed neurological complications, including one patient with paraplegia rapidly progressing to quadriplegia and death. Neurological complications may include spinal misalignments with anterior vertebral translation (due to rupture of the anterior longitudinal ligament, well depicted on MR), contusion, cord compression (by epidural hematoma, bone, dural or soft tissue thickening) and spinal stenosis. These fractures are indeed very unstable and diagnosis should not be overlooked.

References