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Demonstration of evolution of hemispherical spondysclerosis by contrast enhanced Gd-DTPA magnetic resonance imaging

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Background. *The purpose of the study was to estimate the value of Gd-DTPA magnetic resonance imaging (MRI) in demonstrating the evolution of hemispherical spondylosclerosis (HSS).*
Patients and methods. *In eighteen patients with chronic low back pain and typical radiographic findings of HSS seen on plain films, Gd-DTPA MRI of the lumbar spine was performed. MRI morphological and signal intensity appearances of HSS were analysed and compared with radiographic changes.*
Results. *On the basis of MRI features, three distinct groups of cases were identifiable. Within the first group the region of dome-shaped osteosclerosis demonstrated low signal intensity on T1-weighted precontrast spin-echo images, high signal intensity on T2-weighted images and diffuse contrast enhancement on T1-weighted postcontrast images, findings compatible with bone marrow oedema and hyperaemia. The second group showed high signal intensity vertebral body corners surrounded by low signal intensity area, which indicated the combination of fat accumulation and the sclerotic bone. In the third intermediate group anterior disco-vertebral junctions revealed a mixture of MRI appearances characteristic of the first and the second group.*
Conclusions. *Gd-DTPA MRI is capable of demonstrating a spectrum of features which reflect the evolution of HSS. These typical appearances showed by MRI could be of eventual clinical relevance in following the progression of HSS.*

Key words: spinal diseases; magnetic resonance imaging; gadolinium DTPA; osteosclerosis

Introduction

The term HSS was used by Dihlmann[1] to describe a peculiar form of localised erosive spondylopathy with well defined radiographic findings. The most typical features include dome-shaped osteosclerosis which usually affects the anteroinferior portion of the vertebral body with the base at the endplate. Commonly, similar appearances are seen in the neighbouring vertebra. Narrowing of the corresponding disc space indicating disc degeneration is present in the majority of cases. There is a predilection for L4, L5 and L3 vertebral bodies and the toracolumbar junction.

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HSS mainly affects middle-aged women and is clinically characterized by chronic low back pain. Since its first description in literature as nonneoplastic scleroses,[2] different terms like traumatic lesion of the disco-vertebral junction,[3] discogenic vertebral scleroses,[4] idiopathic segmental sclerosis[5] have been used to indicate the possible aetiology of the disease entity. However, the exact aetiology and pathogenesis of HSS still remains uncertain. Experience with MRI of this condition, especially with the use of paramagnetic contrast agents is limited.[6,7]

The purpose of this study was to investigate the morphological and signal intensity MRI appearances of HSS, to compare these features with the conventional radiography and to estimate the value of Gd-DTPA MRI in demonstrating the evolution of HSS.

Patients and methods

18 patients (12 women, 6 men, mean age 45 years) with radiographic findings typical of HSS seen on AP and lateral plain films of the lumbar spine were selected for the study. In 5 patients, lateral conventional tomograms were also available. In order to be included in the study, the radiographs were required to demonstrate dome-shaped osteosclerosis with the base at the intervertebral disc affecting the anterior part of the vertebral body. Other radiographic findings which were also noted included bone erosions of the endplate at the base of sclerosis, new bone production along the anterior vertebral body contour, the presence of an anterior ostephyte and the disc space narrowing.[1] Additional inclusion criteria were chronic low back pain and normal erythrocyte sedimentation rate. In six patients, the exacerbation of low back pain was registered during the last several weeks. MRI of the lumbar spine was performed on a 1.5 T superconducting scanner (Magnetom, Siemens) one to three weeks after plain films. A spin-echo sequence with T1W images (TR 500 ms, TE 15 ms, 2 averages) and T2W images (TR 1900 ms, TE 80 ms, 2 averages) was used, followed by the postcontrast examination immediately after Gd-DTPA (0.1 mmol / kg body weight) was injected intravenously as a bolus through a cannula. The field of view was 28 cm with a data acquisition matrix of 256 x 256. The region of the lumbar spine was presented in a sagittal plane with 5 mm thick consecutive slices. The axial images of the intervertebral discs and the neighbouring parts of the vertebral bodies were obtained at the levels of HSS seen on plain films.

Conventional radiographs and MR images were analysed in a qualitative fashion for morphological and signal intensity differences between normal and pathological disco-vertebral junctions. On the basis of MRI features, an attempt has been made to reconstruct the eventual evolution of HSS.

Results

Three distinct MRI patterns of disco-vertebral junction abnormalities were found at the levels of HSS seen on the plain film radiography. Within the first group of three patients the region of dome-shaped osteosclerosis demonstrated low signal intensity on T1-weighted precontrast images, high signal intensity on T2-weighted images and a diffuse intense contrast enhancement on T1-weighted postcontrast images. There was also focal Gd-DTPA accumulation within the endplate erosions at the base of sclerosis. In one of the patients, these typical MRI appearances were seen at the anterosuperior part of the vertebral body L5 while the neighbouring anteroinferior part of the vertebral body of L4 showed MRI findings characteristic of the second group (Figures 1a, 1b, 1c).

The second group comprised five patients with MRI features of high signal intensity an-

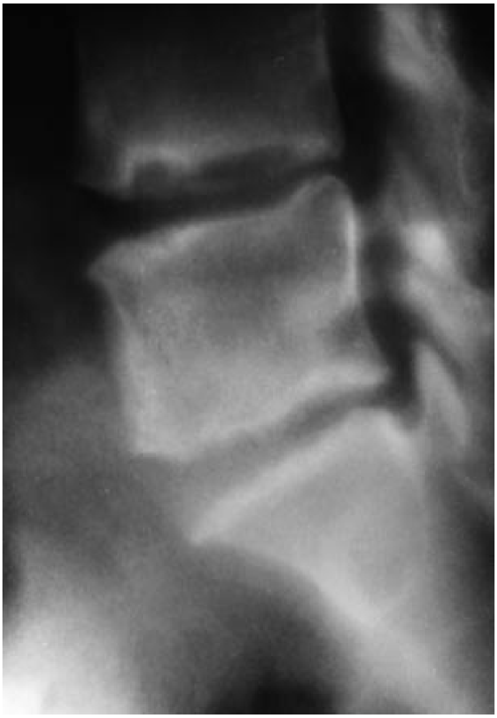

Figure 1a. Initial HSS of the vertebral bodies L4 and L5. Lateral conventional tomography shows discrete osteosclerosis of the vertebral body L4 and typical erosions affecting the anterior thirds of the endplates at the levels of L4 and L5 (big arrow heads).

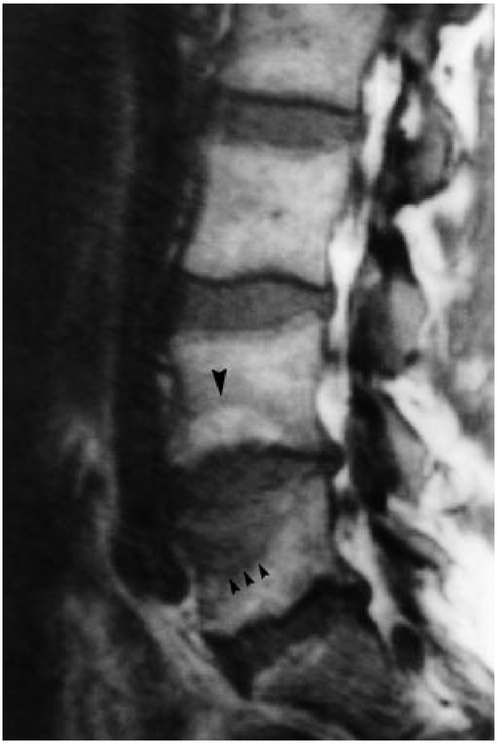

Figure 1b. T1 - weighted sagittal (TR 500 ms, TE 15 ms) precontrast image reveals high signal intensity anteroinferior part of the vertebral body L4, findings consistent with fat accumulation (big arrow head) and low signal intensity anterosuperior part of the vertebral body L5 indicating bone marrow oedema (small arrow heads). Note also that the erosion of the vertebral body L4 is sharply corticated while the erosion at the level of L5 shows indistinct contour.

terior portions of the vertebral bodies on T1-weighted precontrast and T2- weighted images surrounded by a band-like low signal intensity area. No contrast enhancement could be registered within the region HSS of (Figures 2a, 2b, 2c). The accumulation of paramagnetic contrast agent within the endplate erosions was seen in four of these patients. In one of the cases, typical MRI changes developed during the six months following a disc surgery.

In the remainder of the twelve patients, disco-vertebral junctions demonstrated heterogenous MRI appearances which represented a mixture of signal intensity changes and morphological findings from the first and the second group (Figure 3). A focal contrast enhancement was seen within the erosions of the vertebral body endplates. In two of the patients from this intermediate group, MRI showed the posterior disc herniation and in one the presence of ischemic spondylolysis localised at the same level as HSS.

The erosions of the vertebral body endplates typically localised at the anterior junctions of the peripheral bone rim and the cartilaginous endplate (Figures 3a, 3b, 3c, 3d, 3e) were identified by MRI in all of the patients. In three cases the erosions were not seen on the plain films. With the exception of six patients belonging to the first and the third group, in whom indistinct cortical bone was

Figure 1c. T1-weighted sagittal postcontrast image demonstrates contrast accumulation within the region of bone marrow oedema of the vertebral body L5 and within the endplate erosions (small arrow heads).

Figure 2a. HSS following disc surgery at the level of L4-L5. Lateral plain film with typical radiographic findings.

revealed (Figure 1); in the rest of the vertebral bodies the erosions were clearly corticated. Additional erosions localised more dorsally were demonstrated in two patients from the second and six from the third group (Figures 4a, 4b, 4c).

Varying amounts of new bone production along the anterior vertebral body contour contiguous with the anterior ostephytes (Figure 4) were revealed on the plain films in patients from all three groups. However, the signal intensity MRI appearances of the periosteal apposition differed between the groups. Within the first and the second group new bone production was of low signal intensity on T1-weighted precontrast images and of high signal intensity on T2-weighted and T1-weighted postcontrast images (Figures 3, 4). Similar findings were revealed in one case from the third group, while the rest demonstrated the linear high signal intensity area along the anterior surface of the vertebral bodies on all MRI sequences (Figure 2).

The anterior ostephytes were more pronounced in patients from the second and the third group. Their signal intensity characteristics were similar to MRI features of the neighbouring vertebral body bone marrow.

At the level of HSS an absence of normal high signal intensity on T2-weighted images affecting the anterior part or the whole disc space indicating disc degeneration was revealed in all of our patients with the exception of focally increased signal intensity within the bone erosions.

Figure 2b. T1-weighted sagittal (TR 500 ms, TE 15 ms) image reveals high signal intensity fat conversion within the bone marrow and the ostephytes (big arrow heads) surrounded by low signal intensity sclerotic bone (small arrow heads).

Figure 2c. T1-weighted postcontrast sagittal image shows minute contrast enhancement within the endplate erosion (small arrow head). There is no contrast accumulation within the vertebral bodies and the ostephytes.

Discussion

The exact aetiology and evolution of HSS is not completely clear. Therefore, different terms indicating possible aetiology or radiographic features have been applied to this entity.[1-5] In comparison to other radiological techniques, MRI proved to have a unique ability not only to present an excellent anatomical image but also to reflect closely pathophysiological and pathoanatomical changes in different osteoarticular diseases. The experience with MRI of HSS is limited[6,7] especially with the use of paramagnetic contrast agent GD-DTPA and no detailed description of the eventual evolution of MRI changes has been made.

MRI findings of low signal intensity on T1-weighted spin-echo images and of high signal intensity on T2-weighted images within the area of bone sclerosis seen in the patients from the first group (Figure 1) have already been reported.[6,7] In addition we were able to demonstrate a marked contrast enhancement affecting the same region. These MRI features were compatible with the presence of bone marrow oedema and hyperaemia. With the exception of different distribution, which has been focal in HSS and widespread in early degenerative disc disease, there was an obvious resemblance in MRI appearances between described changes in HSS and Modic I lesions[8] in which the existence of fibrovascular tissue below the vertebral body endplates was

Figure 3a. HSS at the level of L4-L5 disc. Lateral radiograph shows osteosclerosis affecting the anterior parts of the vertebral bodies (small arrow heads), erosions of the endplates (big arrow heads) and periosteal apposition at the anterior contour of the vertebral body L4 (arrow).

proved histologically. Furthermore, we showed similar focal MRI findings at the anterior disco-vertebral junctions in patients with ankylosing spondylitis, having early Romanus lesions.[9] Some histological studies proved that the bone erosions of the vertebral bodies at the attachment of the annulus fibrosus in spondylitis anterior were occupied by the vascularised granulation tissue.[10,11] Within the so-called Type a localised disco-vertebral destructive lesions, which radiographically resemble HSS, Cawley *et al*[12] revealed a peripheral focal infiltration by cartilaginous and fibrous tissue, new bone deposition with thickened trabeculae and oedematous bone marrow, histological evidence of trauma with persistent pressure. These similar histological and MRI appearances seen in various disco-vertebral lesions are evidently nonspecific phenomena and reflect the limited reactive abilities of the osteoarticular system to etiologically different joint diseases.

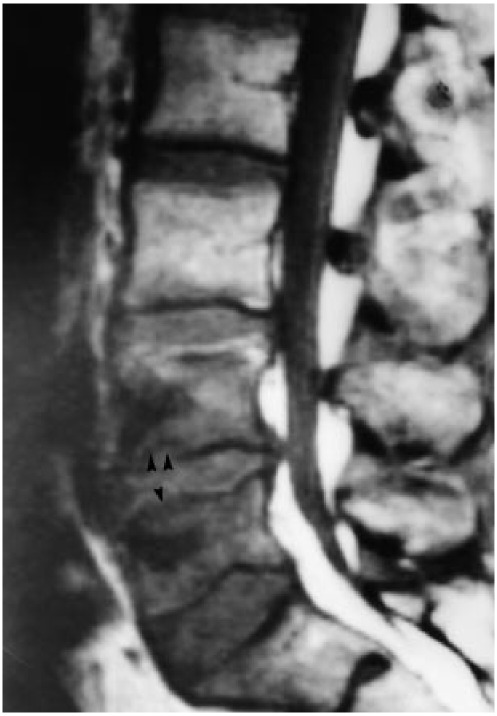

Figure 3b. T1-weighted sagittal (TR 500 ms, TE 15 ms) precontrast image reveals nonhomogenous low signal intensity anterior parts of the vertebral bodies L3, L4 and L5 and the erosions of the endplates (small arrow heads).

Within the second group of patients, high signal intensity anterior portions of the vertebral bodies on T1-weighted precontrast and T2-weighted images, surrounded by a band-like low signal intensity area without contrast enhancement on T1-weighted postcontrast images indicated a bone marrow fat conversion combined with a sclerotic bone (Figure 2) nonspecific reaction which has also been described in longstanding disc degeneration[8] or advanced nonactive sacroiliitis.[13]

The most numerous was the third intermediate group of cases in which a combination of signal intensity changes and varying degrees of contrast enhancement represented a mixture of MRI appearances characteristic of the first and the second group. MRI features within the anterior parts of the vertebral bodies were compatible with a combination of

Figure 3c. T2-weighted sagittal (TR 1900 ms, TE 80 ms) image demonstrates widespread high signal intensity bone marrow oedema (big arrow heads) surrounding low signal intensity osteosclerosis (small arrow heads).

Figure 3d. T1-weighted sagittal postcontrast image shows diffuse contrast enhancement within the vertebral bodies (big arrow heads) and linear enhancement within the endplate erosions and along the anterior surface of the vertebral body L4 (small arrow heads).

bone marrow oedema and hyperaemia, fat accumulation and sclerotic bone (Figure 3). The distribution of these changes within the individual vertebral bodies suggested the possibility that the initial bone marrow oedema at the vertebral body margins has been progressively replaced by fatty and sclerotic bone marrow, findings similar to those seen in progressive disc degeneration.[8]

The reported incidence of the endplate erosions in HSS varies.[1,4] In three of our patients the erosions were not identified on the plain films. However, with the use of MRI as a tomographic method, they were demonstrated in all the cases. This finding supports the opinion of some authors that the anterior defect of the vertebral body endplate represents the initial lesion[1,14] and that the common feature in HSS is the herniation of disc material into the vertebral body[4] which might be provoked by the subclinical endplate trauma.[3] The fact that the erosions were not clearly corticated in several of the patients from the first and the third group while the majority of cases from the third and all from the second group showed corticated erosions, suggests the possibility of advancing process of cortical healing. Gd-DTPA contrast accumulation within the erosion was consistent with the histological findings of the focal replacement of the disc and the disc-bone border by vascularised fibrous tissue in peripheral disco-vertebral destructive lesions reported by Cawley *et al.*[12]

The frequent location of HSS at the lumbosacral and the toracolumbar junctions has

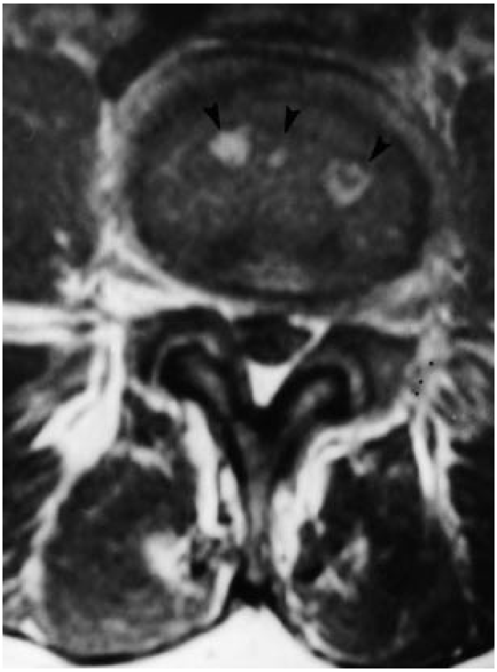

Figure 3e. T1-weighted axial postcontrast image at the level of the lower endplate of L4 demonstrates distribution of bone erosions (big arrow heads) at the border between the epiphyseal ring and the cartilage endplate.

Figure 4a. Disc degeneration at the level of L4-L5 with HSS affecting the anteroinferior part of the vertebral body L4. Lateral radiograph shows dome-shaped osteosclerosis (small arrow heads), an anterior erosion of the endplate (big arrow head) and periosteal apposition along the anterior surface of the vertebral body (arrow).

been attributed to the increased stress at these levels produced by the transition of a mobile to a fixed part of the axial skeleton. It has been postulated that the increase in the segmental mobility due to tears affecting the periphery of the intervertebral disc causes the overstretching of the anterior longitudinal ligament and provoke the osteoblastic production of the marginal osteophytes.[1] Indeed high signal intensity of the new bone production and of the contiguous ostephytes on T2-weighted and T1-weighted postcontrast images (Figures 3, 4) consistent with the presence of oedema and hyperaemia may indicate the instability of the corresponding vertebral dynamic segment. On the other hand, the organized periosteal apposition and marginal ostephytes of high signal intensity on all MRI sequences (Figure 2), due to a fat transformation, presumably represent the end stage of stabilization of abnormally mobile vertebral segments at the level of HSS.

The clinical relevance of different MRI features in HSS is not clear. Modic *et al*[8] suggested the possibility that early disc degenerative changes with the presence of subchondral bone marrow oedema might be symptomatic. Stäbler *et al*[15] showed that the Schmorl's nodes with adjacent bone marrow oedema were seen more frequently in symptomatic than in asymptomatic patients. It would seem therefore that the cases of HSS surrounded by widespread bone marrow oedema could eventually represent symptomatic or »active« lesions. It is of interest to note that all six patients with recent exacer-

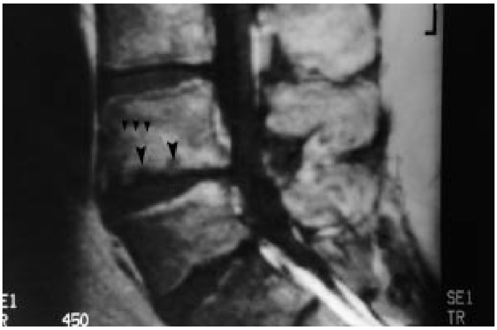

Figure 4b. T1-weighted sagittal (TR 450 ms, TE 15 ms) precontrast image demonstrates high signal intensity fat accumulation within the region of sclerosis seen on the plain film (small arrow heads). Note several erosions of the lower endplate of L4 (big arrow heads).

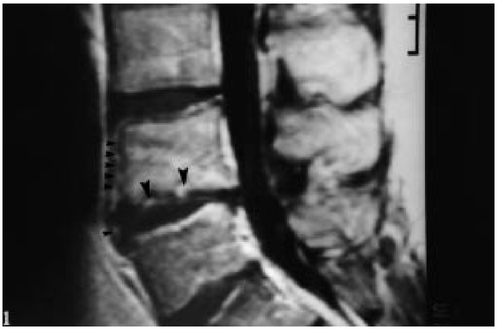

Figure 4c. T1-weighted Gd-DTPA postcontrast sagittal image reveals linear contrast enhancement at the anterior contour of vertebral body L4, the anterior part of the annulus fibrosus L4-L5 (small arrow heads) and within the endplate erosions (big arrow heads). There is no contrast accumulation in the region of osteosclerosis.

bation of low back pain belonged to the first and the second groups in which varying amounts of bone marrow oedema and hyperaemia were demonstrated by MRI. Analogously, it can be assumed that the cases of HSS similar to Modic II lesions[8] seen within the second group of our patients are presumably less symptomatic or »nonactive«.

Although the lack of histology in our study precludes definite conclusions on the basis of the histological results of others[3,4,7,8,10-12] and according to MRI appearances in our patients the eventual evolution of HSS could be postulated. The findings are in favour of the theory that the initial lesion could be anterior erosion at the junction between the epiphyseal ring and the cartilage endplate[1,3,4,14] followed by the instability of the corresponding vertebral dynamic segment. Due to a compromised vertebral body integrity and resulting instability, the bone underlying erosion is exposed to a persistent pressure, which similarly to the initial disc degeneration provokes bone marrow oedema and hyperemia.[8] The process of repair resembling healing of the fracture[12] ensues, characterized by the ingrowth of vascular fibrous tissue into the erosion and the vertebral body and consecutive new bone production within the bone and along its anterior surface. A favourable outcome may eventually result in which the cortication of the endplate erosion, the reinforcement of the vertebral body in the form of bone sclerosis and the anterior disco-vertebral junction shown as the organized periosteal apposition and marginal osteophytes lead ultimately to the spontaneous stabilization of the corresponding vertebral dynamic segment. In cases with an unfavourable outcome the instability persists and may eventually be followed by new bone erosions and the progressive disc degeneration. In our study, MRI proved to be a sensitive indicator of these complex dynamic changes.

It is concluded that GD-DTPA MRI is capable of demonstrating the evolution of HSS. It seems to enable the differentiation of a spectrum, including the initial phase characterized by a compromised integrity of the anterior endplate, followed by the intermediate phase of reactive changes, leading finally to the stabilization of the abnormally mobile vertebral dynamic segment. MRI appearances could be of eventual clinical relevance in following the progression of HSS.

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