Diffusion-weighted MR imaging of vertebral bone marrow: Differentiation of degenerative spines and spondylitis involving to bone marrow adjacent to end plates

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Introduction

Common causes of signal intensity changes of vertebral bone marrow are degenerative change, metastasis, and osteomyelitis et al. Modic et al (1) reported that two main forms of degenerative changes of vertebral body marrow adjacent to the end plates are classified on MR imagings. Type I changes that related to the vascularized fibrous tissue within adjacent bone marrow demonstrated decreased signal intensity on T1-weighted images and increased signal on T2-weighted images. They mentioned that MR findings of pyogenic spondylitis are similar compared to that of Type I degenerative changes The purpose of this study is to investigate imaging findings for differential diagnosis between degenerative spine with fibrovascular change and spondylitis using diffusion-weighted MR imaging

Methods

The MR images of 10 patients with pyogenic spondylitis and 50 patients with degenerative spine diagnosed from clinical symptoms or CT-guided biopsy were prospectively evaluated. CT guided biopsy was performed five paients in pyogenic spondylitis and one patient in fibrovascularized degenerative spine. Type of degenerative spines was categorized as three patterns: type 1 (10 cases), type 2 (15 cases), and type 3 (25 cases). MR imaging was performed with a 1.5-T scanner (Magnetom Vision, Siemens, Erlangen, Germany) with a spine array coil. On spine-echo sequences, axial and sagittal T1-(583/12¡²repetition time msec/echo time msec)) and turbo-T2¨Cweighted images(3800/128) were obtained. Diffusion-weighted MR imaging sequence was based on reversed fast imaging with steady-state precession (PSIF), in which the echo part of PSIF signal was used with TR of 21.6 msec and a diffusion pulse length of 2 msec. The diffusion gradient strength was 24 mT/m, with a relatively low b value (165 sec/mm2). Signal intensity changes of the vertebral body marrow adjacent to the end plates of the degenerative spine on conventional spin-echo sequence MR and diffusion-weighted MR were compared with those of pyogenic spondylitis. Bone marrow contrast ratios and signal-to-noise ratios on diffusion-weighted MR were analyzed in all patients. Statistical analysis of marrow contrast ratios and signal-to-noise ratios was performed by means of the Student t test. A P values of less than .01 was considered to indicate a statistically significance difference.

Results

Bone marrow adjacent to the vertebral end plate in both degenerative spine with fibrovascular change (type 1) and pyogenic spondylitis showed hypointense on T1-weighted images and hyperintense on T2-weighted images.

On diffusion-weighted MR imaging, all vertebral body marrow with the type1 degenerative change showed hypointense to normal vertebral bodies, but pyogenic spondylitis was hyperintense to normal vertebral bodies. Type 1 degenerative bone marrow had negative bone marrow contrast ratios at diffusion-weighted MR imaging, whereas pyogenic spondylitis had positive values (P<.001). Diffusion-weighted MR imaging revealed hyperintense in fatty change (type 2) and hypointense in sclerotic change of bone marrow (type 3) adjacent vertebral end plate in the degenerative spine.

Discussion

Various pathological processes can involve vertebral body marrow adjacent to the end plates, including degeneration, infection and tumors, and these may present with a variety of signal intensity as depicted by MRI. Of the bone marrow change adjacent to the vertebral end plates, degenerative spine is common. Modic et al (1) mentioned that body marrow adjacent to the vertebral end plates with Type I changes demonstrated decreased signal intensity on T1-weighted images and increased signal on T2-weighted images. In our study, early degenerative bone marrow (type 1 change) showed nonspecific signal intensities such as, hypointense on T1-weighted images and hyperintense on T2-weighted images.

Several articles mentioned that various pathological processes can involve vertebral body marrow adjacent to the end plates, but it is sometimes difficult to distinguish each other when based on MR signal intensity values of vertebral bone marrow alone (2-3). Toyoda et al (3) described that signal changes of bone marrow in degenerative disc disease are not specific, but are sometimes difficult to distinguish from the signal changes in other conditions such as spinal tumor or bone marrow disorder on spin-echo sequence MR.

Typical MR findings of pyogenic spondylitis are a decreased signal intensity on T1-weighted images and increased signal intensity on T2-weighted images in the adjacent vertebral bodies and the involved intervertebral disc. Kapeller et al (4) described that evidence of inflammation in pyogenic spondylitis consisted of an elevated sedimentation rate in 76%, leukocytosis in 61% and fever in 61% of individuals. Laboratory findings may be supportive but not confirmatory evidences in pyogenic spondylitis. Diffusion-weighted MR imaging is a new method that was introduced as intravoxel incoherent motion by Le Bihan et al (5). Baur et al (6) applicated diffusion-weighted MR imaging for vertebral bone marrow pathology. In our study, diffusion-weighted MR imaging of the vertebral bone marrow adjacent to the endplate showed low signal intensity reflecting to increased apparent diffusion coefficient in all degenerative type 1 marrow changes, and hyperintense bone marrow reflecting to decreased apparent diffusion coefficient in all pyogenic spondylitis. In general, histopathologic findings of the type 1 bone marrow are fibrovascular tissue totally replacing normal marrow elements (1). Our pathologic study in one patient showed that fibrovascular tissue has entirely replaced normal marrow with depletion of marrow elements. A possible explanation for our result on diffusion-weighted MR imaging is that in fibrovascular degenerative change, the increased free water of bone marrow caused by depletion of normal marrow elements leads to an increase in the extracellular volume fraction. Therefore, the apparent diffusion coefficient is high, which produces low signal intensity in diffusion-weighted MR imaging. Conversely, in vertebral osteomyelitis the reduction of the extracellular volume duet to densely infiltrated inflammatory cells might lead to a decrease in the apparent diffusion coefficient and, therefore, an increase in signal intensity on diffusion-weighted MR imaging. In clinical practice, most radiologic and clinical findings are sufficiently supportive for differential diagnosis of pathological processes involving vertebral body marrow adjacent to the end plates. But apparent signal intensity differences between degenerative fibrovascular change of the spine and pyogenic spondylitis on diffusion-weighted MR imaging may provide excellent differential diagnosis when results of clinical and conventional MR findings are often equivocal. Further study for correlation between histopathlogic and diffusion-MR findings is needed.

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