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Histological findings of bone marrow edema pattern on MRI in osteonecrosis of the femoral head

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Abstract Sequential magnetic resonance imaging (MRI) was performed on a 38-year-old woman with systemic lupus erythematosus who had received corticosteroid and had developed non-traumatic osteonecrosis of the femoral head. The initial MR finding was a band lesion on the T1-weighted image, which had been present before the onset of symptoms. At the onset of symptoms, a diffuse bone marrow edema pattern, with a low signal intensity on T1 and high signal intensity on T2-weighted images, was noted around the band lesion, extending to the femoral neck. Histopathologically, this region was found to consist of serous exudate, focal interstitial hemorrhage, and mild fibrosis, without any evidence of extension of osteonecrosis. It should be noted that extension of a low signal intensity area on MRI after the onset of hip pain may not be the result of the extension of osteonecrosis, but may represent concomitant edema due to collapse.

Key words Osteonecrosis · Femoral head · Bone marrow edema · MRI · Histology

Introduction

One of the characteristic magnetic resonance imaging (MRI) findings in the early stage of osteonecrosis of the femoral head has been reported as a low-intensity band pattern on T1-weighted images.[5,9,11] During the disease course, a diffuse low signal intensity area on T1-weighted image is often seen with a high signal intensity on T2-weighted image in the corresponding area. This is interpreted as a bone marrow edema pattern. This extension of a low signal intensity area on T1-weighted image has occasionally been considered as an extension of the necrotic area.

In this report, sequential MRI was performed in a patient with systemic lupus erythematosus, and a histological examination was conducted when a diffuse low signal intensity area was observed on T1-weighted image.

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Case report

A 38-year-old woman was diagnosed as having systemic lupus erythematosus in 1981, and started to receive prednisolone. The maximum daily dose was 60 mg, and total dosage until the onset of hip pain was 46 000 mg.

In January 1994, she experienced pain in the left hip joint. Plain radiograph revealed collapse of the left femoral head (Fig. 1a). Bone scintigram presented a diffuse high uptake. The patient was considered to have Association Research Circulation Osseous (ARCO) Stage IV osteonecrosis of the left femoral head.[6,9] At that time, the right femoral head was asymptomatic, and no abnormality was found on plain radiograph (Fig. 1a), but a band pattern was depicted on T1-weighted image (Fig. 1b). On bone scintigram, a cold-in-hot pattern was noted in the right hip. The right femoral head was considered as ARCO Stage I (i.e., asymptomatic phase).

The patient had used canes and was followed-up, but she experienced pain in the right hip in November 1994. Plain radiograph showed mild flattening of the articular surface at the superior portion of the femoral head (Fig. 2a). A bone marrow edema pattern was noted around the previously detected band pattern on T1 and T2-weighted images (Fig. 2b,c). A core decompression biopsy was performed on the right hip.

The surgical sections obtained from the right hip were compared with the MR images. Grossly, the necrotic lesion was opaque yellow, and the area corresponding to the band lesion on MR image was mixed whitish-yellow. The periphery of the band lesion, where a diffuse low signal intensity area was seen on T1-weighted image, was mixed red and white (Fig. 3a). Histologically, the area of necrosis showed empty lacunae and bone marrow tissue necrosis. The band

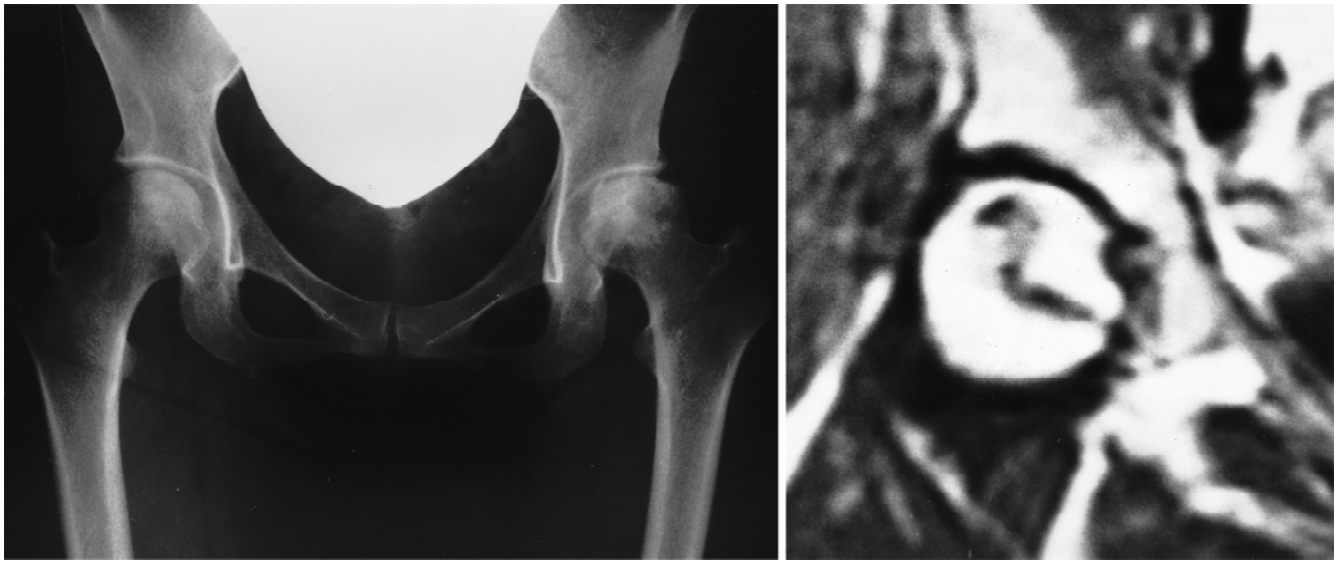

Fig. 1a,b. Imaging studies in January 1994. **a** On plain radiograph, collapse of the left femoral head is seen, but the right femoral head is normal. **b** On T1-weighted (TR/TE: 500/20) magnetic resonance (MR) image, a band pattern is noted in the right femoral head

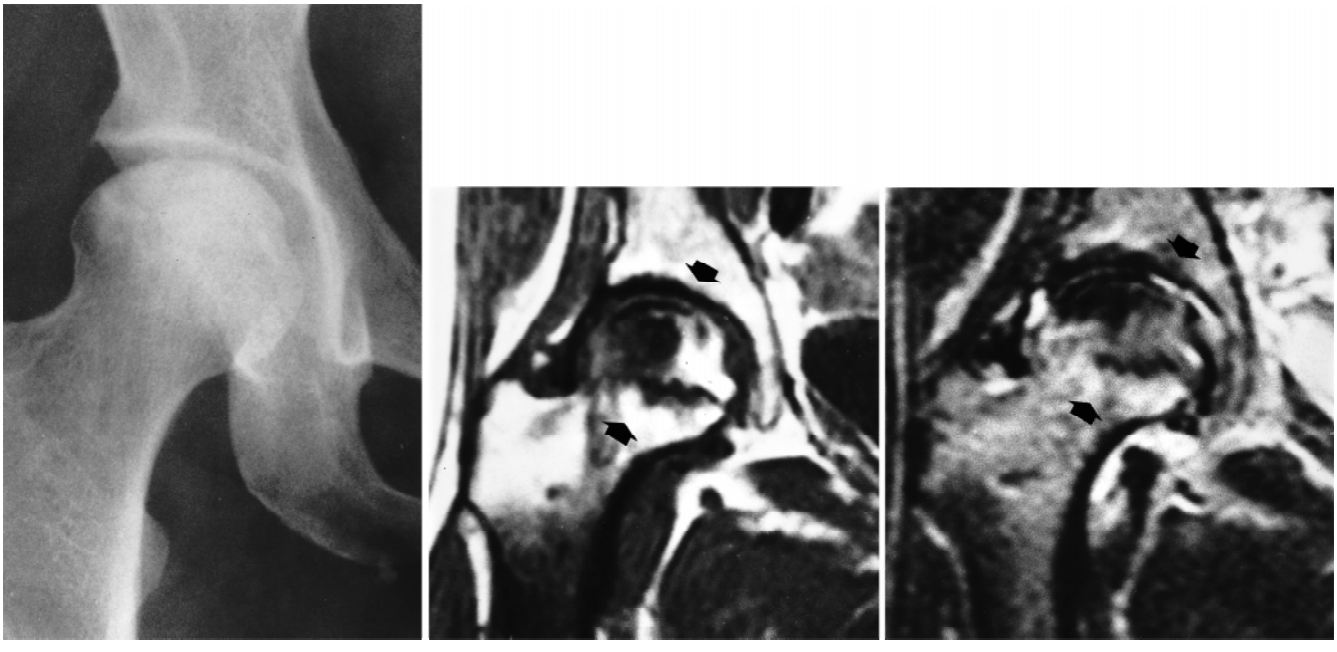

Fig. 2a–c. Imaging studies in November 1994. **a** Plain radiograph reveals mild flattening of the articular surface of the right femoral head. **b** T1-weighted (TR/TE: 500/20) MR image shows a diffuse low signal intensity area around the band lesion extending to the femoral neck. A core biopsy section was obtained from the area pointed out by *arrows*. **c** T2-weighted (TR/TE: 3000/22) MR image shows a diffuse high signal intensity in the corresponding area. The core biopsy section was obtained from the area pointed out by *arrows*

lesion consisted of repair tissue, including appositional bone and fibrous granulation tissue. Microfracture due to a collapse was found around the boundary between the necrotic area and the band lesion. In the area of extended diffuse low signal intensity on T1-weighted image, no evidence of osteonecrosis was noted in either the bone trabeculae or bone marrow tissue. This area was viable and consisted of serous exudate, focal interstitial hemorrhage, and mild fibrosis, with associated chronic inflammatory cells (Fig. 3b).

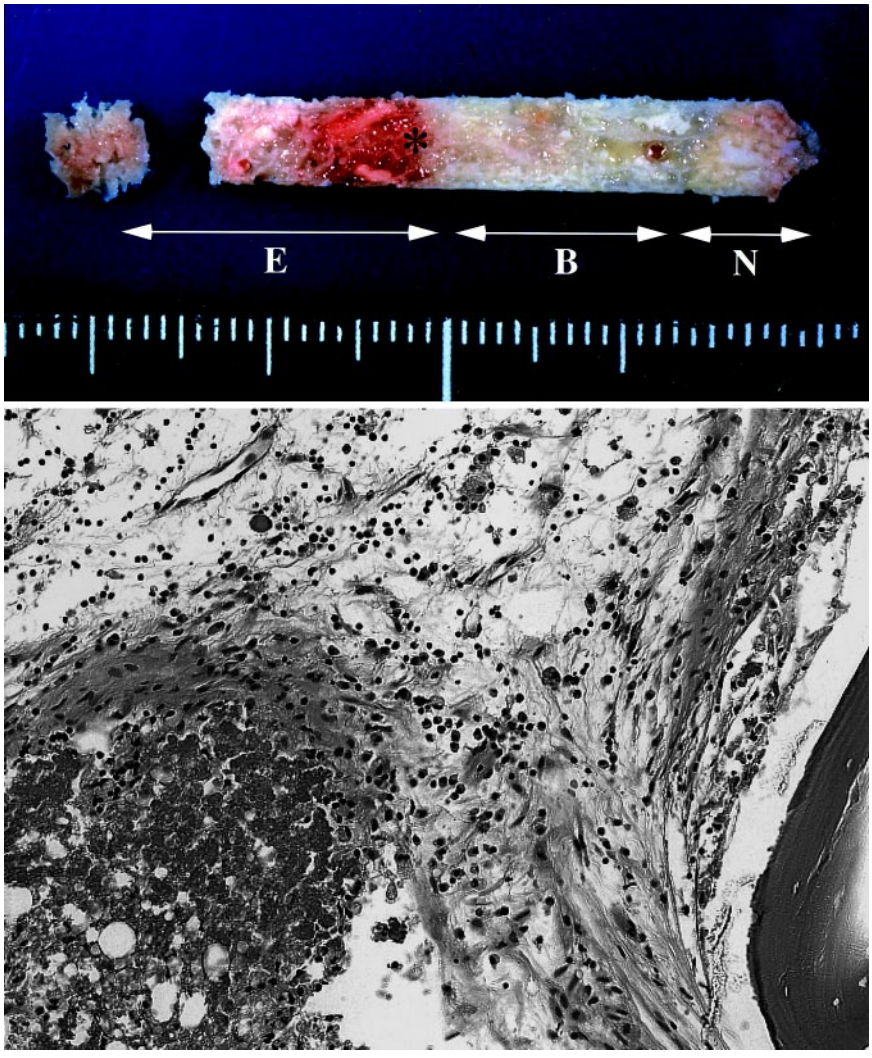

Fig. 3a,b. Histopathological findings of surgical section obtained from the area pointed out by *arrows* in *Fig. 2b,c*. **a** Grossly, the necrotic area (*N*) is opaque yellow, the area corresponding to the band lesion on MR (*B*) is mixed whitish-yellow, and the area of an extended diffuse low signal intensity area on MR T1-weighted image (*E*) is mixed red and white. **b** Microscopic findings in the area shown by the *asterisk* in **a**. Focal hemorrhage and mild fibrosis, with associated chronic inflammatory cells and vascular channels are observed. No osteonecrosis is seen. H&E, ×150

Discussion

A band pattern depicted on MRI is one of the important early findings in osteonecrosis of the femoral head, and histopathologically corresponds to the repair tissue formed to the necrosis.[1,5,6,9,11] In our patient, the band lesion consisted of appositional bone and fibrous granulation tissue, which are the result of repair phenomenon, and this agrees with the previously reported findings.[1,6,11,13] The peripheral area from the band, where a diffuse low signal intensity was noted on T1-weighted image, histologically consisted of focal hemorrhage and edematous bone marrow tissue, and there was no evidence of osteonecrosis. It should be noted that such a diffuse low signal intensity area on T1-weighted image reflects concomitant edema due to a collapse,[5] and does not necessarily mean enlargement of the necrotic area or recurrent osteonecrosis.[13]

MR images of osteonecrosis of femoral head vary widely during the disease course, and sometimes show an inhomogeneous or homogeneous pattern even before a collapse occurs. These patterns are thought to correspond to the repair tissue infiltrated from the surrounding viable tissue.[5,11,12]

A band pattern on MR image is also useful for determination of the necrotic area, i.e., the area inside the band is thought to represent necrosis.[10,11,13] During the course of the disease, a bone marrow edema pattern could mask the band pattern, making determination of the necrotic area difficult. In such a case, it is recommended to capture the focal band lesion by using high-resolution T2 weighted image.[2,3,12]

A bone marrow edema pattern with a diffuse low signal intensity on T1-weighted image and high signal intensity on T2-weighted image is also observed in transient osteoporosis of the hip.[8] It is thus proposed that transient osteoporosis of the hip could be the early reversible phase of osteonecrosis of the femoral head, mainly based on the bone marrow edema pattern, as well as the histopathological similarity between these

two conditions.[4,7] However, a recent clinicopathologic study has reported that transient osteoporosis of the hip is a different entity from osteonecrosis and that a bone marrow edema pattern is not a specific finding for the necrotic region.[14]

In conclusion, in our patient, a diffuse low signal intensity area on T1-weighted image after the appearance of a band pattern represented concomitant edema, not the extension of the necrotic region.

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