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Bone marrow changes adjacent to the sacroiliac joints after pelvic radiotherapy mimicking metastases on MRI

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Abstract Radiation-induced changes in the sacroiliac joints mimicking metastases on MR images were evaluated. Twelve patients who received radiotherapy to the pelvic region due to pelvic malignancy were included in the study. All patients had undergone external beam radiation therapy to the pelvic region, and 2 patients received supplementary internal radiation. The changes in the sacroiliac joints were evaluated. Computed-tomography-guided core bone biopsy from the bone marrow was taken from their corresponding MR sections in 5 of the patients. T1 hypointense and T2 hyperintense areas with ill-defined margins in the bone marrow adjacent to the sacroiliac joints were observed in all patients. On bone scintigraphy all the lesions demonstrated increased activity. Other radiological modalities excluded fracture, soft tissue mass, and osseous destruction. Bone biopsies demonstrated peritrabecular fibrosis and inflammatory cell infiltration. Patients receiving radiotherapy to the pelvis may demonstrate T1 hypointense/T2 hyperintense, ill-defined postradiotherapeutic benign changes in the sacroiliac joints. In the absence of any other signs of disease progression and when the imaging pattern is typical, close radiological follow-up should be sufficient to rule out metastases.

Keywords Radiation · Injurious effects · Bones · MR imaging · Sacroiliac joints

Introduction

Radiation therapy has important applications in curative, adjuvant, and palliative therapy for a wide range of malignant conditions. Radiologic images obtained subsequent to therapy may demonstrate evidence of radiation therapy [1]. There are various reports regarding radiation-induced changes in bone [2, 3, 4]. There is an initial response to irradiation with vascular congestion, edema, and loss of cellularity. A fatty marrow later appears, which is hyperintense on magnetic resonance (MR) imaging on T1- and T2-weighted sequences. The early and late changes induced by radiation therapy are clearly depicted on MR imaging [5].

When radiotherapy is applied to pelvic region, sacroiliac joints and the adjacent bone marrow are inadvertently in the field of radiation port. There are many reports on the radiation-induced sacral insufficiency fractures, in which the changes are most commonly observed at the bone marrow adjacent to the sacroiliac joints [6]. The iliac and the sacral bones are also frequently the site of metastasis by most malignancies. Distinction of metastases vs benign changes secondary to radiotherapy becomes important especially in patients receiving radiotherapy to the pelvic region [6]. In this study, radiation-induced hypointensity on T1- and hyperintensity on T2-weighted images (WI) in the sacroiliac joints after radiotherapy due to pelvic malignancy of 12 patients is reported with biopsy performed in 5 of the cases.

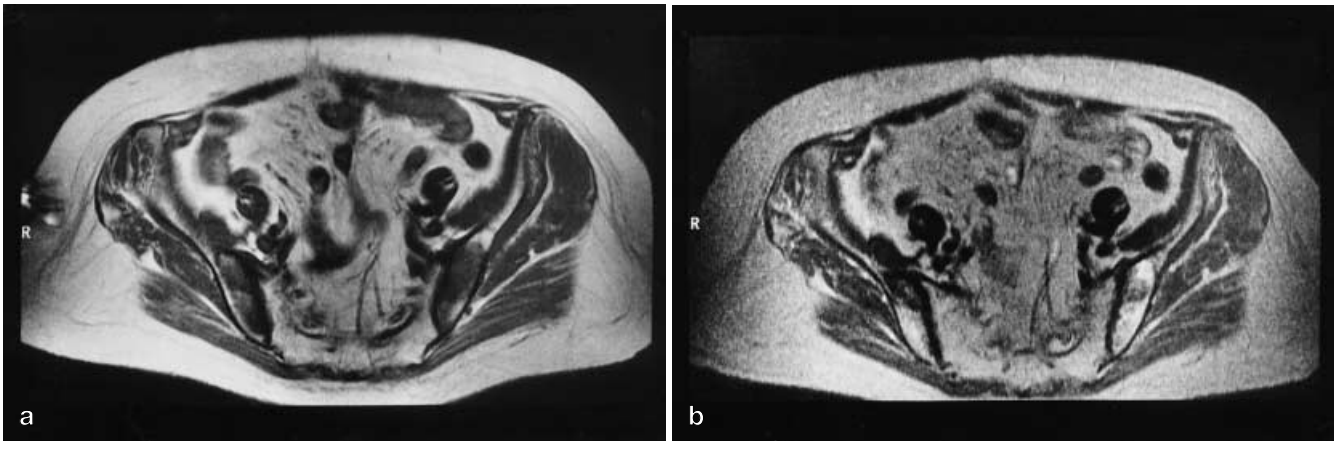

Fig. 1a, b A 75-year-old woman with cervix carcinoma. **a** Axial T1- and **b** axial T2-weighted MR images. On T1-weighted image, bilateral symmetric hypointense areas without a mass contour on iliac sides of the both sacroiliac joints are seen. On T2-weighted image these areas are hyperintense

Materials and methods

The study included 12 patients who received radiotherapy to the pelvic region, due to malignancy, from June 1990 to November 1998. There was 1 man (age 61 years) and 11 women (age range 27–75 years, mean age 61.3 years). The patients were being followed-up by serial control MR examinations. Eight of the patients had cervix carcinoma, 3 had rectum carcinoma, and 1 patient had endometrium carcinoma.

All patients had undergone external beam radiation therapy with 6- to 17-mV photons. The dosage was administered at 2 Gy per session (not exceeding 10 Gy per week). The irradiation field for each patient included the entire sacrum, pubic bones, lower lumbar vertebrae (including L4 and L5), and medial portions of the os ilium. Two patients received supplementary internal irradiation, but the adsorbed dose in the sacrum and iliac bones was negligible compared with that from the external-beam radiation therapy. The total treatment period ranged from 31 to 98 days.

Patients with sacroiliac joint involvement in whom T1 hypointense and T2 hyperintense abnormal signal characteristics were depicted on MR imaging on their routine follow-up were involved in this study. Four patients underwent MR imaging because of pain in the lower back and the sacroiliac regions, whereas the rest of the patients were on their routine follow-up due to their pelvic malignancy. The MR examinations were performed with a 1.0-T unit (Siemens, Erlangen, Germany). All examinations were performed with a body coil. All sections were 5 mm thick, with an intersection gap of 2.5 mm. A 256 × 192 matrix was used. Coronal and axial sequences (TR/TE: 704/15 ms; and TR/TE: 5500/90 ms) were performed. Contrast-enhanced images were not obtained.

The sacroiliac joints and the pelvic bones were evaluated in addition to the pelvic and visceral structures. The changes in the sacroiliac joints and adjacent bone marrow were noted. Other radiological modalities, such as CT, direct roentgenogram, and bone scintigraphy, were used in all patients. Biopsy from the bone marrow was performed in 5 patients, adjacent to the sacroiliac joints, which showed abnormal signal characteristics on MR suspicious for metastases. For the biopsy-site localization, under CT guidance either the iliac or the sacral site corresponding MR sections were used. Biopsy was done in 3 patients with unilateral involvement and in 2 patients with bilateral involvement.

All patients were followed up by MR imaging after the first depiction of the abnormal signal in the sacroiliac joints. Each patient gave written informed consent.

Results

In all patients the bone marrow adjacent to the sacroiliac joints demonstrated areas which were hypointense on T1WI and hyperintense on T2WI. The lesions were in the bone marrow just adjacent to the sacroiliac joints and did not have a typical mass contour. These ill-defined lesions were either on the iliac or the sacral side (Figs. 1, 2). Eight of the patients showed bilateral involvement, whereas four demonstrated unilateral signal abnormality. The cases of unilateral involvements were on the right side in 3 patients and on the left side in 1 patient. The abnormal signal intensity adjacent to the sacroiliac joints was seen on iliac side in 4 patients, sacral side in 7 patients, and on both the sacral and iliac sides in 1 patient. The other parts of the pelvic bones were normal. The delay between pelvic irradiation and the appearance of bone marrow changes detected by MR images showed a great variability (between 5 and 18 months, mean 9 months). Other findings related to the radiotherapy were fatty degeneration on gluteal muscles, iliopectineal bursitis in 1 patient, and radiation proctitis and increased wall thickness of the bladder in another patient. One patient also showed sacroiliac joint narrowing.

On bone scintigraphy all the patients demonstrated increased activity in the sacroiliac joints corresponding to the signals demonstrated on MR imaging. Also in 1 patient there was an increased activity at the L4 and L5 vertebrae. These could not be demonstrated on MR imaging and were referred to as degenerative changes. Suprapubic pelvis roentgenograms and CT demonstrat-

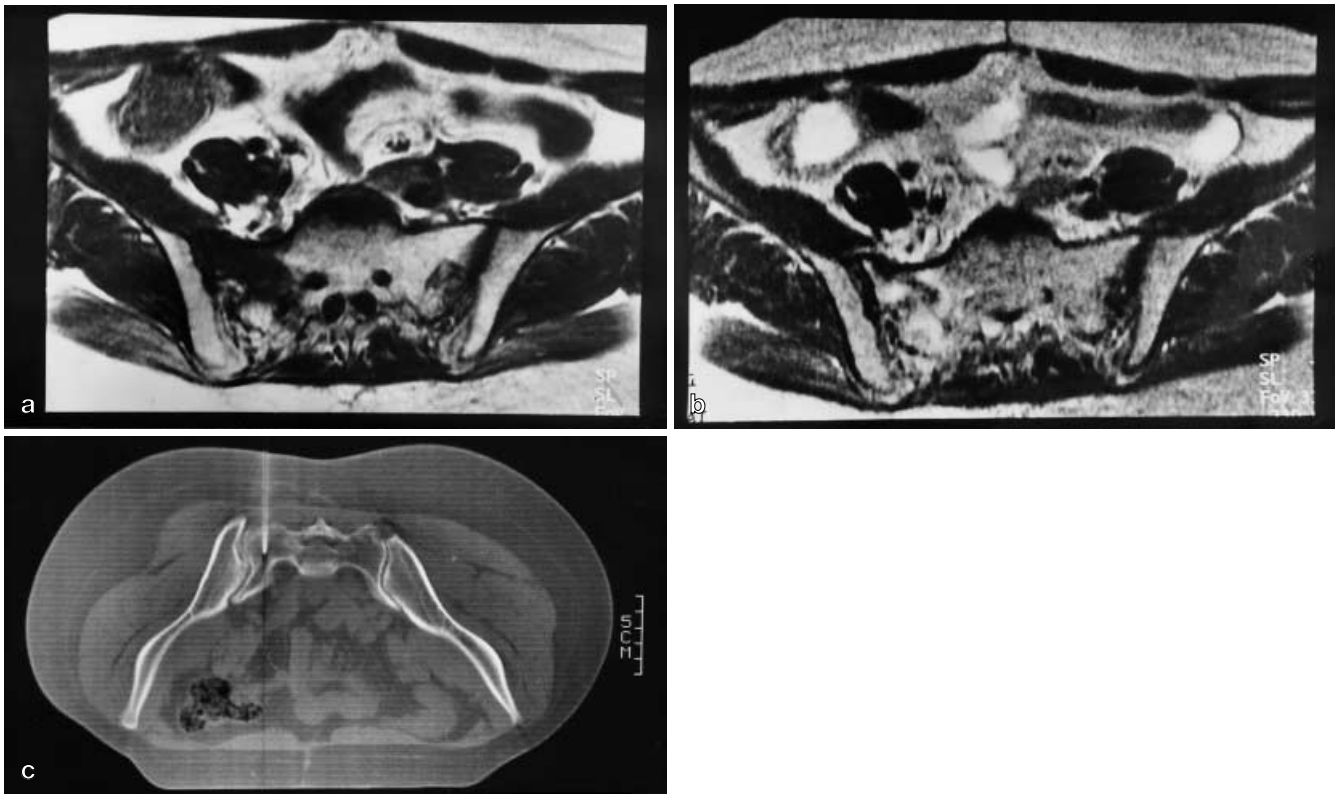

Fig. 2 a–c A 27-year-old woman with rectal carcinoma. **a** Axial T1; **b** axial T2-weighted MR images; **c** axial CT-guided biopsy image. On T1-weighted MR image, ill-defined hypointense lesion on the sacral side of the right sacroiliac joint, showing no mass contour, is seen. The lesion is hyperintense and partly nonhomogeneous in signal intensity on T2-weighted MR image. On CT image, the Tru-Cut needle is placed in the lesion corresponding to the MR images (patient is in prone position)

ed decreased joint space in 1 patient. There were neither a fracture, soft tissue mass, sclerosis, nor an osseous bone destruction detected on CT.

Bone biopsies showed periosteal connective tissue and new bone formation, osteoblastic activity, inflammatory infiltration of mononuclear cells, and peritrabecular fibrosis around the cortical and trabecular bone marrow. There were no complications related to the bone biopsies.

The mean follow-up of patients after first detection of the abnormal signal intensity was 23.3 months (range 6–60 months).

Discussion

As bone marrow contains fat protons and red marrow, MR is a valuable tool which offers the opportunity to map the distribution of red and yellow marrow. Variations in the composition of bone marrow contents and its distribution among normal subjects, mainly related to age and gender, contribute to create a wide spectrum in bone MR appearance, which must be known in order to avoid confusion from bone marrow abnormalities [7]. Different MR sequences are described in the evaluation of benign and malignant bone marrow lesions [8, 9]. The most commonly used sequences for bone marrow are T1- and T2-weighted spin-echo sequences, short tau inversion recovery (STIR) sequence, contrast-enhanced T1-weighted sequences, and fat suppression turbo spin-echo sequences. The bone marrow is susceptible to radiation at any dose. Bone marrow changes following radiotherapy are well known. There is a decrease in the granulocyte and erythrocyte precursors after the first 3 days of irradiation. Sinusoidal hemorrhage and young stem cell loss ensues in the following days. At day 16 the bone marrow cellularity decreases up to 20 %. Excessive hypoplasia and fat deposition occurs at day 35. Some cell regeneration occurs at the third month but usually irreversible bone marrow depression occurs at 5–12 months. This direct effect of radiation to the bone marrow stroma is called chronic radiation injury [10].

Stevens et al. [5] first described the MR findings of early and late effects of radiotherapy on bone marrow. After the radiotherapy in the first 3 weeks they could not find any change on T1-weighted sequences; however, on STIR images they found increase in the signal

probably related to the edema and hemorrhage. At 3–6 weeks the bone marrow became heterogeneous due to incomplete fatty replacement. After the sixth week, there were two patterns of changes. The first group demonstrated increase on T1WI due to diffuse fatty replacement. This pattern of changes is described in most of the studies in the literature [3, 5, 11, 12]. The second group showed central hyperintensity due to fatty degeneration and peripheral intermediate signal intensity due to hematopoietic regeneration. This second group consisted mostly of young patients and there is a good capability of the bone marrow to regenerate [13].

In most of the studies it was shown that the postradiotherapeutic changes can be anywhere at the radiation port. Blomlie et al. [6] studied 18 patients with sacral insufficiency fractures and found that the fractures and the resultant changes were most commonly at the sacral body. However, in our study the T1 hypointense and T2 hyperintense changes were at the bone marrow adjacent to the sacroiliac joints, without any demonstrable fracture line or any sclerosis indicating stress fracture on neither the direct roentgenograms nor the CT examinations. At our institution there are approximately 300 patients undergoing radiotherapy every year to the pelvic region. We included those patients who had radiation-induced T1 hypointense and T2 hyperintense changes in the sacroiliac joints detected in 4 patients who had low back pain and 8 patients at their routine follow-up due to their primary malignancy. In the international radiology literature radiation-induced changes in the sacroiliac joints were first described on direct roentgenograms as widening and irregularity of the sacroiliac joints and sclerosis of the ileal aspects simulating osteitis condensans ilii [14]. In our study only one of our cases was found to have narrowing of the joint space.

We are unaware of any previously published reports demonstrating areas of T1 hypointense/T2 hyperintense signal characteristic of the sacroiliac joint after radiotherapy without any demonstrable fracture secondary to radiotherapy. In our study on the basis of MR findings, CT and direct roentgenograms excluded sacral insufficiency fractures. It is well known that many lesions may present with low signal intensity on T1WI and high signal on T2WI. Although the lesions did not show a typical mass contour, metastases were of primary concern in a patient having malignant tumor; therefore, we performed biopsy for confirmation in 5 patients. These patients were the first 5 patients in whom we detected the changes at the MR examination. The biopsy findings were compatible with chronic inflammatory reaction and fibrosis and excluded metastases. As this is an ongoing study, we do not know the evolution of these changes in the sacroiliac joints yet. On follow-up (minimum 6 months to maximum 60 months) MR demonstrated no changes.

We expected the postradiotherapeutic changes occurring to be bilateral. Unilateral involvement may carry a higher suspicion for the presence of metastases. In our study, unilateral involvement was seen in 4 patients: Three of them had cervical carcinoma, whereas the remaining patient suffered from rectal carcinoma. The patients with cervical and rectal carcinomas showed intense one-sided parametrial and pararectal fatty plane invasion. Unilateral MR signal changes in the sacroiliac joints result probably from a higher radiation dose applied to the involved side. In 3 of these patients metastases were excluded by biopsy (Fig. 2). The other patient not undergoing biopsy was followed-up with no changes in a period of 10 months.

In our study group 8 of 12 patients were asymptomatic. Low back pain was present in 4 patients, but we are not sure if this can be attributed to the findings on MR images. The rest of the patients were asymptomatic for their present condition and the lesions were detected on their routine control MR imaging. Biopsies were performed with clinical history in 3 patients and in 2 without clinical history.

In conclusion, patients receiving radiotherapy due to pelvic malignancy may demonstrate T1 hypointense and T2 hyperintense areas in bone marrow adjacent to sacroiliac joints. If these lesions are bilateral and do not have a typical mass contour, they are most probably related to the radiotherapy; however, unilateral involvement may pose a diagnostic dilemma between sacral insufficiency fracture and metastases; therefore, in these patients with unilateral involvement biopsy may be performed. Nevertheless, if such lesions are unilateral or bilateral, typically located at the bone marrow adjacent to the sacroiliac joints, are diffuse in character, and do not show a typical mass contour, we suggest close follow-up which will be sufficient to rule out metastases in the absence of any other signs of disease progression. These lesions can be considered as postradiotherapeutic benign changes and should be followed-up instead of performing any invasive procedure such as biopsy.

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