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MUSCULOSKELETAL IMAGING

PICTORIAL ESSAY

Spectrum of skeletal disorders during the peripartum period: MRI patterns

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ABSTRACT

Pregnancy is a normal condition in which a combination of biomechanical and hormonal changes may result in a wide spectrum of skeletal disorders. Skeletal overloading due to postural and weight changes, combined with increased ligamentous laxity stemming from the action of relaxing and the risk of pregnancy-related osteoporosis during childbearing, childbirth, and postpartum, have been associated with various pathologies. Owing to the heterogeneity of proposed contributing factors, skeletal lesions in the peripartum period may be related to different pathogenesis depending on the metabolic status of the patient and the degree of biomechanical stress; thus, a fatigue or insufficiency discrimination is not always easy to make. When combined with clinical data, magnetic resonance imaging (MRI) is a powerful tool in clarifying the cause of skeletal pain in the majority of patients or alerting clinicians to proceed to further investigations. Early detection and tailored treatment are important in order to avoid disease progression and long-term restriction of daily activities which may have an adverse impact on the relationship between the mother and the newborn. This pictorial essay provides an overview of the MRI characteristics and pattern of involvement of skeletal lesions presenting during the peripartum period, combined with demographic data and dual-energy X-ray absorptiometry (DEXA) measurements.

During pregnancy and postpartum period, the female skeletal system is prone to certain lesions. Weight gaining, posture and gait alterations, and the procedure of delivery itself induce increased biomechanical stress and skeletal overloads, thus representing potential contributors (1). In addition, pregnancy-related osteoporosis represents a rare condition of undetermined etiology, affecting women during the third trimester of pregnancy or early postpartum period (2). Pregnancy-related osteoporosis has been linked to a combination of genetic, environmental, and biochemical factors leading to an increased bone turnover state and skeletal insufficiency (2).

Osseous lesions occurring during the peripartum period tend to target certain anatomical areas. In this context, the axial skeleton and pelvic brim are most commonly involved, with thoracolumbar spinal and sacral fractures representing the most commonly encountered pathologies. Fractures of the proximal femur and knee may also be encountered (3). Apart from fractures, degenerative, infectious or inflammatory lesions and stress injuries affecting other sites, especially the sacroiliac joints, symphysis pubis, wrist, and elbow, may occur (4).

Pain associated to the above mentioned disorders, may have an adverse impact on the relationship between the mother and the newborn due to restriction of daily activities; thus, early diagnosis is important. Magnetic resonance imaging (MRI) can aid in diagnosis and provide additional information concerning the extent of disease owing to its superb ability for depiction of bone marrow changes (5). However, in many atypical cases further workup may be needed.

In this pictorial essay, we provide a description of the pattern of involvement and MRI appearance of skeletal lesions presenting during the peripartum period. Demographic properties related to the underlying pathophysiology and dual-energy X-ray absorptiometry (DEXA) measurements are also discussed.

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Patterns of skeletal involvement and MRI appearance

Spine

Vertebral fractures represent the most commonly encountered osseous lesions of the axial skeleton in the peripartum period usually occurring during late pregnancy and early postpartum period while there are isolated reports of fractures related to the delivery process (Figs. 1, 2) (3). Vertebral fractures in the peripartum period usually involve multiple vertebral bodies, appear with various degrees of vertebral deformity with potential depiction of a low signal intensity band on T1-weighted images and are uncommonly associated with spinal canal stenosis or neural compression. The presence of bone marrow edema is indicative of acute (<6 months) origin.

Sacrum, coccyx, and sacroiliac joints

Considering its rather unspecific symptoms, the diagnosis of sacroiliac joint pathology during pregnancy and early postpartum period is challenging. Differential diagnostic considerations include infectious arthritis, axial spondyloarthropathy, stress reactions, and stress fractures (6).

The pathogenesis of infectious sacroiliitis is linked to either direct contamination from a local infection or hematogenous spread of bacterial infections including urinary tract infections or endometritis, with *Staphylococcus aureus* being the most prevalent organism (6). The onset is usually acute and patients present with fever and low back pain while blood tests show raised C-reactive protein level and leukocytosis in most cases. MRI is regarded the method of choice and should be performed as soon as the diagnosis is clinically suspected. Beyond its ability to excellently show the extend of disease and involvement of surrounding tissues, it can demonstrate imaging findings highly suggestive of an underlying infectious process, including unilateral involvement, subperiosteal or transcapsular infiltrates of the surrounding muscles combined with extensive bone marrow edema (7). In these patients, further clinical and laboratory workup and follow-up is usually necessary to confirm the diagnosis and isolate the responsible pathogen.

Axial spondyloarthropathy may flare up or present for the first time during the peripartum period; however, disease evolution is not predictable (8). According to various studies, it has been reported that during pregnancy, ankylosing spondylitis shows stability in 40%, improvement in 30%, and deterioration in 30% of patients (5). Deterioration is more likely expected in patients with spinal involvement due to the additional impact of increased biomechanical stress (5). An inflammatory spondyloarthritis that is usually seronegative to rheumatoid factor and associated with human leucocyte antigen (HLA) B27 should be considered. The diagnosis of inflammatory sacroiliitis can be established according to ASAS criteria. The presence of either one subarticular bone marrow edema lesion on two consecutive slices or two lesions on a single slice, typically located at the inferior half of the joints and at the iliac surface, is indicative of inflammatory arthritis (9). The presence of synovitis, capsulitis, and enthesitis or structural changes, in the context of erosions, subchondral sclerosis, periarticular fat deposition and ankylosis are suggestive of and are not sufficient alone to make the diagnosis of axial spondyloarthropathy (9). MRI findings, combined with clinical and laboratory data may be necessary to exclude other diseases and confirm an inflammatory background. Beyond axial spondyloarthopathies, the course of rheumatoid arthritis may be affected by pregnancy. It is acknowledged that more than 70% of patients show symptoms improvement during the early stages of pregnancy following by relapse of symptoms in 90%

Main points

- A wide spectrum of skeletal disorders occurs in the peripartum period, affecting the axial and peripheral skeleton.
- MRI is a powerful tool in clarifying the cause of skeletal pain in the peripartum.
- DEXA measurements should be obtained in patients with stress-related skeletal disorders in the peripartum period.

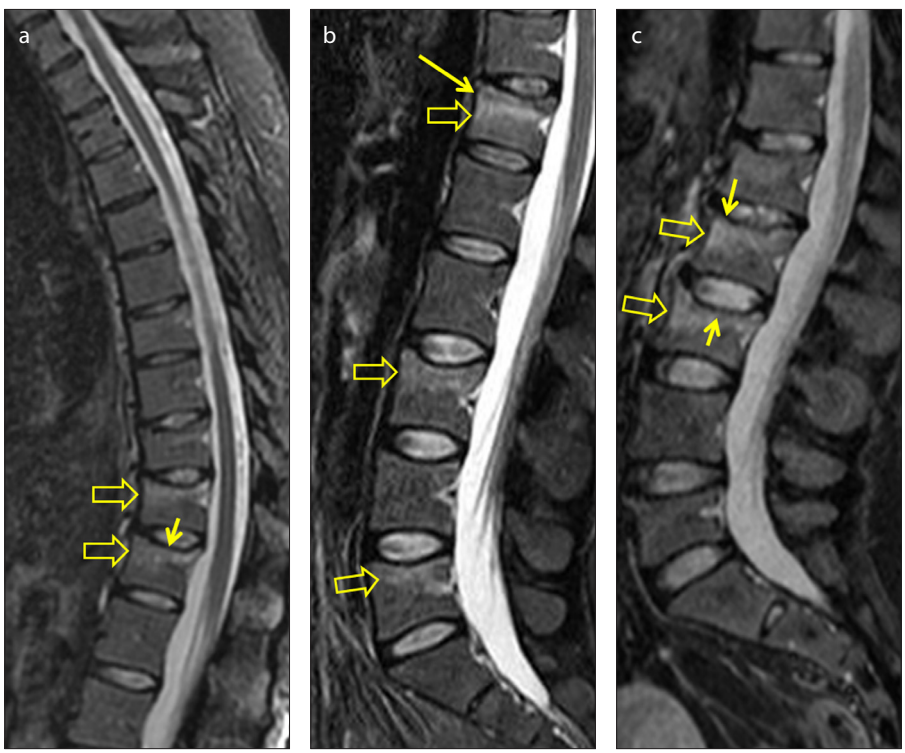

Figure 1. a–c. Sagittal short tau inversion recovery (STIR) image **(a)** in a 35-year-old patient, shows bone marrow edema *(open arrows)* of T11 and T12 vertebral bodies consistent with microtrabecular insufficiency fractures with epiphyseal plate collapse *(short thin arrow)*, which occurred during labor (boy, 3.3 kg), 3 weeks before imaging when symptoms initiated. Spinal dual-energy X-ray absorptiometry (DEXA) measurement revealed osteopenia. Sagittal STIR image **(b)** in a 32-year-old lactating mother, who remained bedridden for 4 months during pregnancy, shows microtrabecular insufficiency fractures of T12, L3 and L5 vertebral bodies *(open arrows)* and subepiphyseal fracture line *(long thin arrow)* of T12 vertebral body, which occurred during the delivery process, 2 weeks before imaging. Spinal DEXA showed osteoporosis. Sagittal STIR image **(c)** in a 34-year-old patient with onset of low back pain 10 days after caesarian section shows microtrabecular insufficiency fractures of L2 and L3 vertebral bodies *(open arrows)* with epiphyseal plate collapse *(short thin arrows)*. Imaging was performed 8 weeks after onset of symptoms.

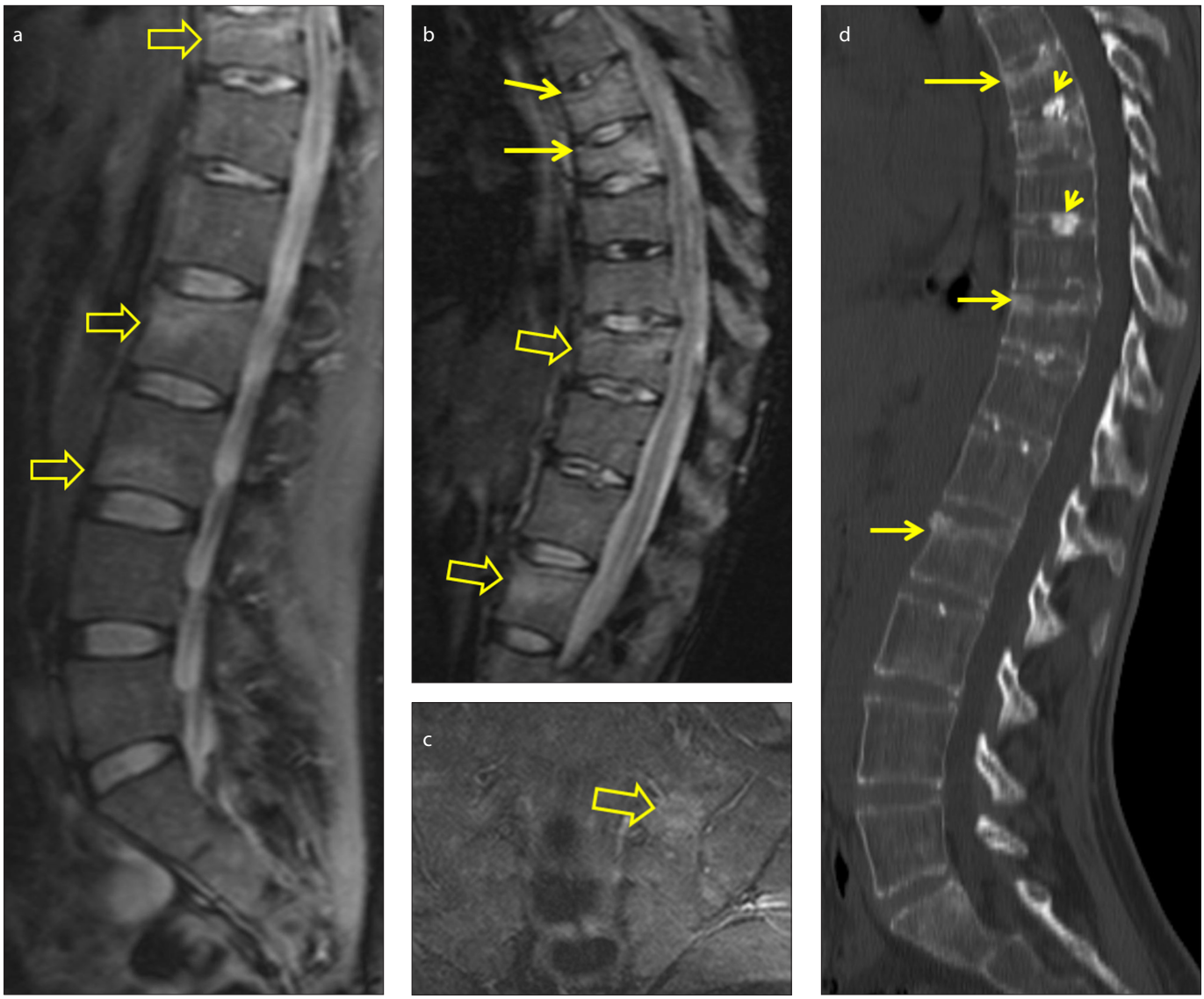

Figure 2. a–d. Sagittal STIR images of the lumbar **(a)** and thoracic **(b)** spine and oblique coronal STIR image of the sacroiliac joints **(c)** in a 35-year-old female patient with a low energy fall following recent delivery show bone marrow edema *(open arrows)* and epiphyseal collapse *(thin arrows)*, in keeping with insufficiency fractures. Sagittal computed tomography multiplanar reconstruction (MPR) image **(d)** performed at the emergency room, shows the multiple fractures with superior endplate collapse *(long arrows)* as well as nucleus pulposus calcification in multiple discs *(short arrows)*. Spinal DEXA showed osteopenia.

of cases in the postpartum period (5, 10). In patients with rheumatoid arthritis, apart from MRI, ultrasonography may be utilized for monitoring involvement of peripheral joints or guide steroid injections.

Along with vertebral fractures, sacral stress fractures are the most commonly encountered lesions of the axial skeleton in the peripartum period. They appear as linear low signal intensity lesions on T1-weighted sequences which typically parallel the sacroiliac joints and are surrounded by extensive bone marrow edema on fluid sensitive sequences (Fig. 3) (11). Bilateral involvement is common. In the absence of sacroiliac joints' structural changes, inflammatory lesions, or sacral fracture lines, the presence of subarticular marrow changes that do not suffice to meet the ASAS criteria for axial spondyloarthropathy are usually indicative of stress-related lesions (Fig. 4).

Finally, coccygodynia may also be related to pregnancy. Patients typically refer to the onset of symptoms in the first postpartum day, exacerbated in the sitting position. Static and dynamic lateral radiographs have been accepted as first-line imaging for abnormalities in the area of the sacrococcygeal joint, while MRI has been recently proposed as a second-line method. Based on its relation to sacrum, coccyx's mobility has been categorized into four types: (*i*) rigid, when fused with the sacrum; (*ii*) normal, once there is flexion or extension within 5°–25° on dynamic radiography; (*iii*) hypermobile, when the range of movement exceeds 25°; and (*iv*) dislocated, when it is located posterior to the sacrum. Dislocation and severe hypermobility have been associated with pain. On MRI, hyperintensity of the sacrococcygeal or intercoccygeal disc and/or the adjacent vertebral endplates, or abnormal signal intensity of the soft tissue surrounding the caudal part of the coccyx have been related to the presence of pain

(12). The first two features have been reported mainly in patients with mobile coccyx (12).

Symphysis pubis

Osteitis pubis is the most common condition affecting the symphysis pubis in the peripartum period. The presence of subchondral marrow edema, intraarticular fluid and periarticular soft tissue edema are the most reliable MRI findings to suggest the diagnosis (4). Irregularity and sclerosis of subchondral articular margins are expected in chronic (>6 months) disease.

In patients with groin pain, the pubic bones should be carefully evaluated for the presence of insufficiency fractures which are determined by the presence of a fracture line parallel to the joint, surrounded by bone marrow and soft tissue edema (Fig. 5).

In addition, symphysis pubis diastasis represents a condition which has been associated with pregnancy and childbirth. It is defined as separation of the joint, in the absence of fracture of the superior pubic rami. The interpubic cartilaginous disc and the anterior pubic ligament offer significant stability to this non-synovial joint. The width of the joint space is age-dependent, ranging from 6 mm at 20 years of age to 3 mm at 50 years of age. However, under hormonal stimulation during pregnancy, the joint gap may normally increase by 2–3 mm. Widening of more than 10 mm is regarded as abnormal. Diagnosis classically relies on plain radiographs, while MRI is superb for depicting potentially associated soft-tissue injury and bone marrow changes (13).

Hip

Transient hip osteoporosis and regional migratory osteoporosis are the two conditions described under the term acute bone marrow edema syndromes. It has been proposed that these entities are related to the presence of reduced bone mineral density on spinal DEXA examinations and associated insufficiency fracture (14). They share the triad of history of acute onset pain, resolution of symptoms only with conservative treatment, and the presence of bone marrow edema on MRI.

Transient hip osteoporosis usually affects women during the postpartum period and the third trimester of pregnancy (14). The proximal femur represents the most common site of involvement while the condition may affect or migrate to alternative predicted areas, including the contralateral hip, knee and ankle, unilaterally or bilaterally. MRI is the gold standard for diagnosis, showing marrow edema of the femoral head, starting subarticularly and potentially extending to the intertrochanteric area and femoral neck (Fig. 6). Based on the time of imaging, bone marrow edema has a specific distribution pattern; from the onset of symptoms and for 4–6 weeks, edema spares the inferomedial part of the femoral head and the greater trochanter, forming the "sparing" sign, which may be evident in up to 96% of patients with transient hip osteoporosis (14). The depiction of subchondral linear lesion of low signal intensity is consistent with microtrabecular insufficiency

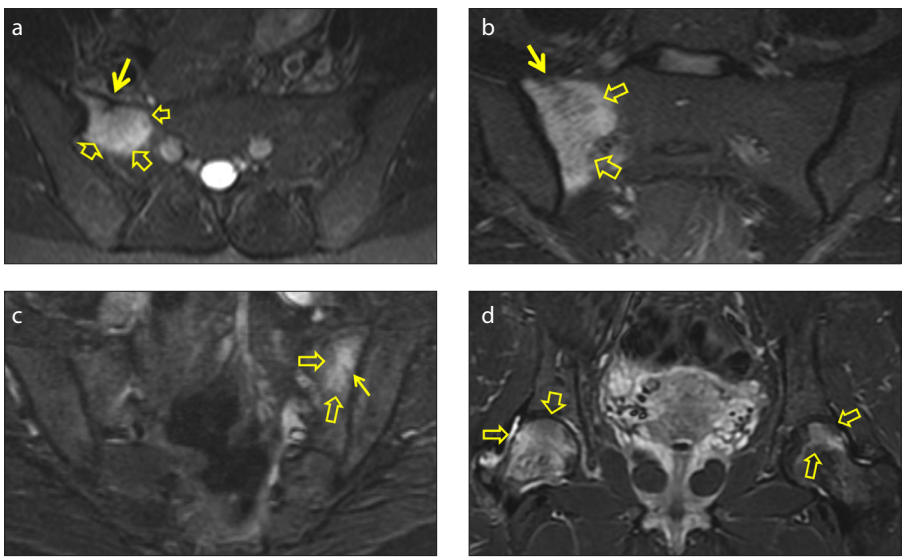

Figure 3. a–d. Oblique axial **(a)** and coronal **(b)** STIR images of the sacroiliac joints show an insufficiency fracture of the right sacral wing *(arrows)* with surrounding bone marrow edema *(open arrows)*, in a 39-year-old patient presenting in the postpartum period with low back pain, 4 months after onset of symptoms. DEXA of the spine showed osteopenia. Oblique coronal STIR image of the sacroiliac joints **(c)** and coronal STIR image of the hips **(d)** show a thin stress fracture *(thin arrow)* surrounded by bone marrow edema in the left sacral wing and marrow edema of both femoral heads *(open arrows)* in keeping with transient osteoporosis, in a 23-year-old patient presenting with postpartum low back pain and bilateral hip pain, at 6 weeks after delivery.

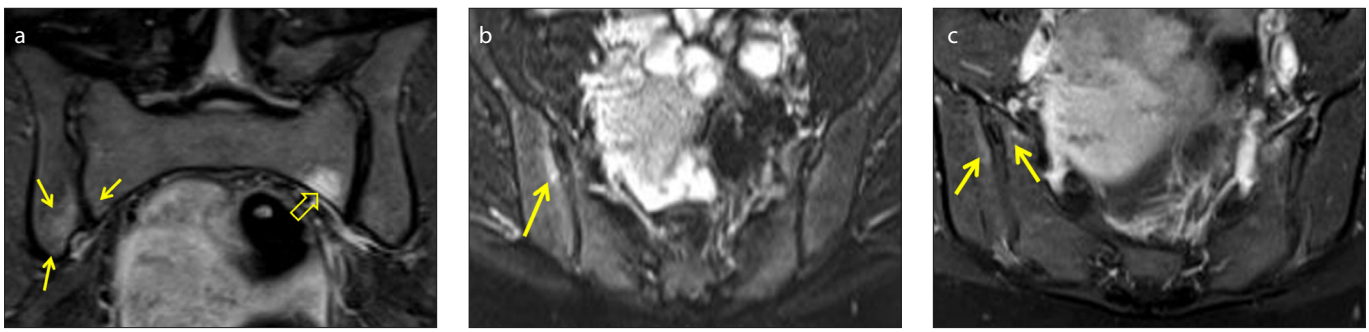

Figure 4. a–c. Oblique coronal **(a)**, oblique axial **(b)** STIR and T1-weighted fat-suppressed post intravenous gadolinium administration **(c)** images, show stress-related subarticular, enhancing bone marrow edema at the inferior part of the right sacroiliac joint *(thin arrows)*, in a 33-year-old patient presenting in the postpartum period with sacroiliac joint pain since 2 weeks. Note the presence of bone marrow edema at the inferior part of the left sacral wing *(open arrow)* without depiction of definite fracture line and without subarticular extension, in keeping with sacral stress reaction. Clinical and laboratory data did not confirm inflammatory or infectious background.

fracture (Fig. 6) (14). DEXA measurements in these patients should be assessed as they usually reveal reduced bone mineral density (14).

Avascular necrosis of the femoral head represents another condition, although infrequently, potentially related to pregnancy. Transient osteoporosis is characterized by a totally reversible benign course. Contrary to this, long standing avascular necrosis, depending on size and location of the lesion, may proceed to femoral head collapse and subsequent osteoarthritis. In pregnant patients, femoral head involvement is typically unilateral. The hallmark of avascular necrosis on MRI is the "band-like" lesion which is demonstrated as a subchondral band of low signal intensity on T1-weighted sequences, circumscribing an area of normal fatty bone marrow. The presence of the "crescent" sign which corresponds to a subchondral fracture of the femoral head is the mainstay of disease progression (15). Bone marrow edema is found during the advanced stages of disease, denoting the presence of subchondral fracture or extensive degenerative changes. It is of note that there is a longstanding scientific debate on the differential diagnosis between avascular necrosis and transient hip osteoporosis and it had been suggested that transient hip osteoporosis may progress to avascular necrosis. Currently, it is well accepted that the two conditions are not related. A probable reason causing confusion is the potential presence of subchondral fractures in both entities; however, discriminating features have been described. Contrary to the irregular, linear, and deeply located fractures seen in transient hip osteoporosis, the "crescent" sign of avascular necrosis courses in an immediate subchondral location, parallel to the articular surface (14).

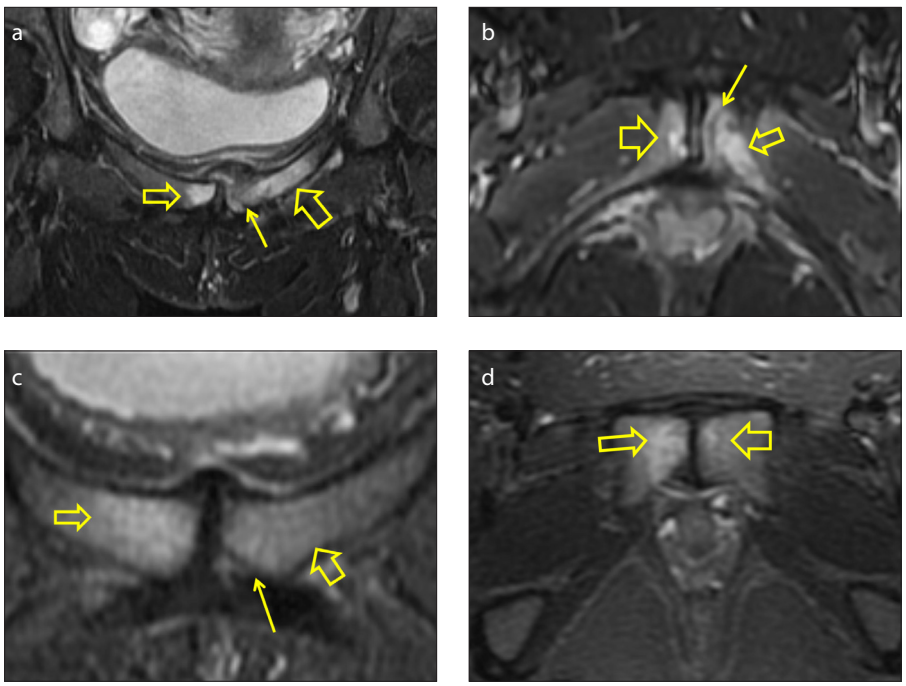

Figure 5. a–d. Coronal **(a)** and axial **(b)** STIR images show bone marrow edema *(open arrows)* in the pubic bones bilaterally, and subarticular insufficiency fracture *(thin arrows)* of the left pubic bone, in a 30-year-old patient presenting with postpartum groin pain. MRI was performed at 12 weeks from the onset of symptoms. Coronal **(c)** and axial **(d)** STIR images show subarticular bone marrow edema *(open arrows)* in the pubic bones bilaterally, and a tiny subarticular insufficiency fracture *(thin arrow)* of the left pubic bone, in a 35-year-old patient with groin pain during the postpartum period. MRI was performed 14 weeks following the onset of symptoms.

Knee, ankle and foot

During the peripartum period, stress fractures and reactions account for the majority of osseous lesions in the knee and ankle/foot region. Stress injuries in the peripartum period may be related to underlying pregnancy-related osteoporosis and the degree of physical activity or to a combination of metabolic and biomechanical factors. Thus, a fatigue or insufficiency discrimination is not always easy. Stress fractures in the knee are typically located in weight bearing medial compartment and appear as band-like low signal intensity lesions on T1-weighted images with associated marrow edema. Stress reaction is defined as the presence of marrow edema in weight-bearing areas, without depiction of a fracture line (Fig. 7). Intraarticular effusion represents a typical associated finding. In the ankle and foot area, stress injuries tend to involve the posterosuperior part of calcaneus and the metatarsals (Fig. 8).

Conclusion

The metabolic status of the patients and the degree of biomechanical stress are important pathogenetic contributors resulting in a wide spectrum of skeletal disorders in the peripartum period. The pattern of skele-

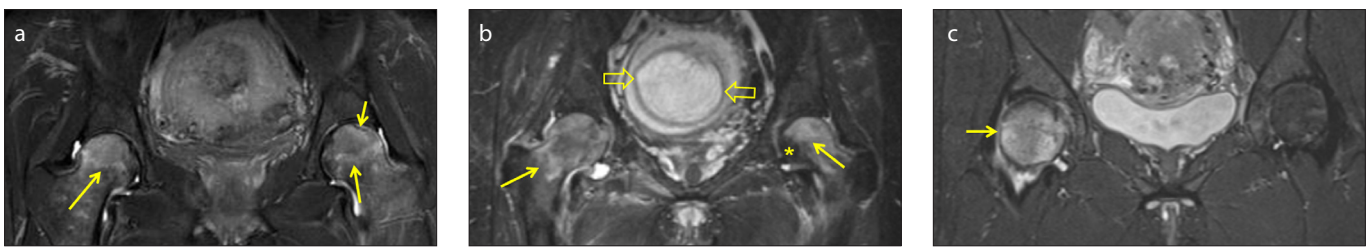

Figure 6. a–c. Coronal STIR image **(a)** shows bone marrow edema of both proximal femurs *(long arrows)* in keeping with transient osteoporosis and a subchondral insufficiency fracture of the left femoral head *(short arrow)*, in a 31-year-old patient 5 days after first delivery. Coronal STIR image **(b)** in a 40-year-old female in the third trimester of her second pregnancy, shows bone marrow edema of both proximal femurs extending to the femoral neck *(long arrows)*, consistent with transient osteoporosis. Note that edema spares the inferomedial part of the left femoral head, forming the "sparing sign" *(asterisk)*. The fetal head is shown *(open arrows)*. Coronal STIR image **(c)** shows bone marrow edema of the femoral head *(arrow)* in keeping with transient hip osteoporosis, in a 35-year-old in the early postpartum period, 6 weeks following the onset of symptoms.

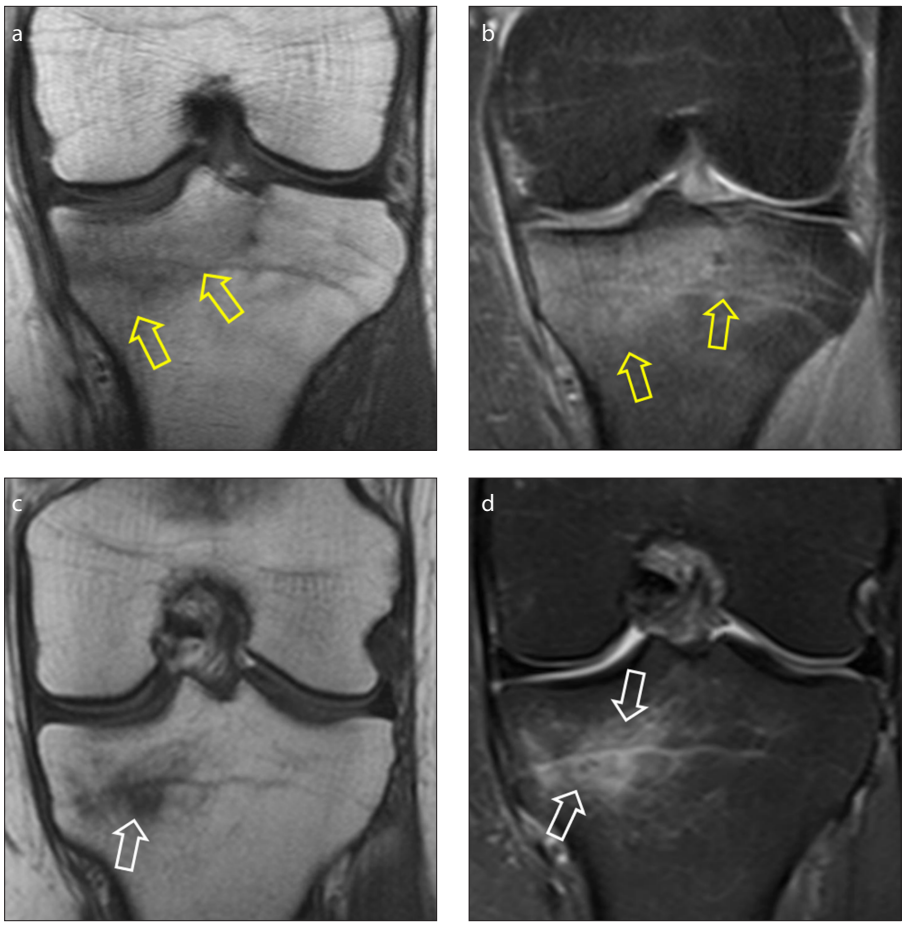

Figure 7. a–d. Coronal T1-weighted **(a)** and fat-suppressed proton density **(b)** images show bone marrow edema in the medial tibial meta-epiphysis *(arrows)* in keeping with microtrabecular fracture representing a combined fatigue and insufficiency injury, in a 33-year-old avid athlete, presenting with acute pain during the fifth kilometer of jogging, 8 weeks following delivery of her third child and 2 weeks following initiation of symptoms. Coronal T1-weighted **(c)** and fat-suppressed proton density **(d)** images show bone marrow edema in the medial tibial meta-epiphysis *(arrows)* consistent with microtrabecular fracture in a 39-year-old athletic patient, presenting in the postpartum period with pain during jogging at 3 weeks after initiation of symptoms. Pain improved after two weeks of rest from sports. In both patients, spinal DEXA measurements showed osteopenia.

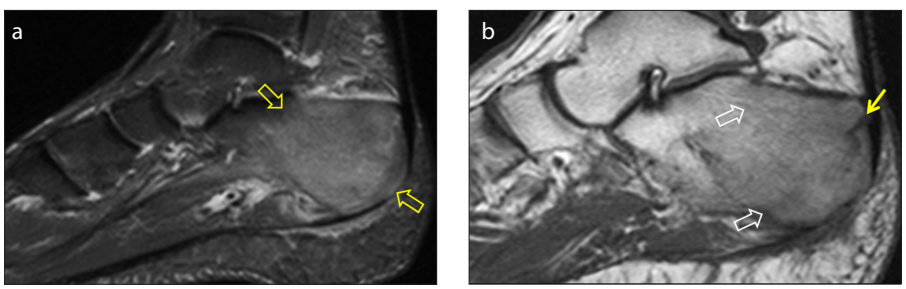

Figure 8. a, b. Sagittal STIR **(a)** and T1-weighted **(b)** images show bone marrow edema in the os calcis *(open arrows)* and a small fracture line at the level of Achilles tendon insertion *(thin arrow)*, in a 34-year-old female, trained in gym-aerobics who presented in the early postpartum period (third delivery), 3 weeks after the initiation of symptoms. Spinal DEXA showed osteopenia.

tal involvement includes the spine, symphysis pubis, sacrum, hip, knee, ankle, and foot. Transient hip osteoporosis, stress fractures and reactions, osteitis pubis, inflammatory and infectious arthritis represent the most prevalent pathologies. When combined with clinical data, MRI is a powerful tool in clarifying the cause of skeletal pain.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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