Case 11321

Gray cortex sign in bilateral tibiofemoral stress fractures
Published on 06.11.2013

DOI: 10.1594/EURORAD/CASE.11321
ISSN: 1563-4086
Section: Musculoskeletal system
Area of Interest: Bones
Procedure: Comparative studies
Procedure: Diagnostic procedure
Imaging Technique: Conventional radiography
Imaging Technique: Nuclear medicine conventional
Imaging Technique: CT
Imaging Technique: SPECT
Special Focus: Athletic injuries Case Type: Clinical Cases
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Patient: 47 years, male

Clinical History:

A 47-year-old male patient complains of bilateral lower leg pain at his first presentation and subtle pretibial swelling after occasional running. He had a total thyroidectomy in 1996. His vitamin D3 level is in the lower normal range (60nmol/l). Six years later, he returns with similar pain in both femora.

Imaging Findings:

Conventional radiographs of both lower legs in 2007 show adjacent lucencies in the anterior cortex (Fig.1a+b) of both tibiae with minor pretibial soft tissue swelling on the right. Follow-up image of the right tibiae in 2013 shows a small residual horizontal radiolucent line in the anterior cortex (Fig.2). Bone scintigraphy from 2007 (Fig.3) presents symmetrical longitudinal linear signal intensities along the anterior tibial cortices with focal hotspots. Less pronounced longitudinal cortical tracer uptake is visible in both femora. Follow-up bone scintigraphy in 2013, obtained because of recurrent pain - now in the femora - demonstrates subtle residual longitudinal linear signal along both tibiae and now two symmetrical focal hotspots in the femoral midshafts and proximal femora. CT of the femoral midshafts (Fig.4a) obtained in 2013 demonstrates bilateral intracortical low density lesions. High-resolution CT shows an area of gray cortex (Fig.4b) with an adjacent irregular small horizontal fracture line (Fig.4b-d) without signs of periosteal reaction.

Discussion:

Although stress fractures may arise in many different bones of the body, the lower extremities are more prone to insufficiency due to higher tensile forces during upright movement. Stress fractures can be subdivided into fatigue (mechanical overload of normal bone) or insufficiency (normal loading of weakened bone) fractures [1]. In our patient the low vitamin D level may have contributed to osseous insufficiency due to hypomineralisation of bone. Stress fractures of the tibiae are typically seen in runners, ballet dancers and military recruits, more frequently in untrained individuals [1-6].

The term ‘shin splints’ used in this context derives from the clinical presentation of patients with pain around the shin and summarizes a variety of tibial pain syndromes including the ‘medial tibial stress syndrome’ (MTSS) that is generally associated with periosteal soft tissue changes in the antero- or postero-medial circumference of the tibiae.
Many authors [5, 6] believe that MTSS is a precursor stage of stress fractures and the underlying pathophysiology affecting the muscle-bone unit is a continuous process rather than a single event although the location of pain in shin splints and MTSS and radiologically documented stress fractures vary in the literature [1-6]. This discrepancy may also be due to the imaging modality employed in each case and insufficient resolution in order to depict fine fracture lines in many cases only visible with high resolution CT. Prevalent sites for radiologically proven stress fractures are anterior midshaft and distal tibia and medial or lateral femoral midshaft. Transverse fractures are more common than vertical ones. Positive bone scintigraphy (linear pattern in MTTS precede focal hotspots in stress fractures) has a sensitivity of almost 100% in the depiction of stress fractures thus presenting the method of choice [3, 4]. Scintigraphy and MR signal changes precede radiographic changes by weeks. Mulligan and others [2, 5, 7] describe the “gray cortex sign” around stress fracture sites (Fig.4) which most likely represent areas of increased intracortical remodelling as demonstrated by SPECT images of transverse femoral fractures sites (Fig.5a+b). Especially when this gray cortex sign presents without obvious transverse fracture lines, the radiologist may be faced with a diagnostic challenge. Therapeutic options include either limitation of external forces, e.g. training rest or modify internal material properties by strengthening the muscle-bone unit by physical therapy or correction of calcium-phosphate-metabolism (Vit.D substitution in our case). Radiographic proof of true fracture lines will result in adaption of treatment duration.

**Differential Diagnosis List:** Tibio-femoral stress fractures (syn. shin splints), Polyostotic osteofibrous dysplasia Campanacci, Intracortical metastases

**Final Diagnosis:** Tibio-femoral stress fractures (syn. shin splints)

**References:**

**Figure 1**

**Description:** a) Lateral conventional radiograph (CR) of the left tibia (2007) shows consecutive lucencies in the anterior cortex of the midshaft. **Origin:** Dept. of Radiology, Leiden University Medical Center, Netherlands
Description: Lateral CR (2007) of the right tibia shows consecutive lucencies in the anterior cortex of the midshaft and a pretibial soft tissue swelling. Origin: Dept. of Radiology, Leiden University Medical Center, Netherlands
Description: Lateral radiograph (2013) of the left tibia shows a small residual linear lucency in the anterior cortex of the midshaft. Origin: Dept. of Radiology, Leiden University Medical Center, Netherlands.
**Description:** Bone scintigraphies 2007 (left) and 2013 (right) show transformation of a longitudinal linear signal pattern along the antero-lateral tibial and bilateral femoral cortices to new focal hotspots.

**Origin:** Dept. of Radiology, Leiden University Medical Center, Netherlands
Description: CT of the femoral midshafts show bilateral intracortical areas with reduced density and an adjacent endocortical resorption site on the left. Origin: Dept. of Radiology, Leiden University Medical Center, Netherlands
Description: ‘Gray cortex sign’ representing focally decreased cortical density surrounding a fracture site. Origin: Dept. of Radiology, Leiden University Medical Center, Netherlands
Description: An irregular small fracture line is visible adjacent to the gray cortex. Origin: Dept. of Radiology, Leiden University Medical Center, Netherlands
Description: An irregular small fracture line is visible adjacent to the gray cortex. Origin: Dept. of Radiology, Leiden University Medical Center, Netherlands
Figure 5

Description: Upper row: CT images of the parallel lesions in the left femur. Lower row: SPECT of the parallel lesions in the left femur showing significant tracer uptake. Image right: Scintigraphy of the lesions. Origin: Dept. of Radiology, Leiden University Medical Center, Netherlands

Description: Overlayed SPECT on sagittal CT of the left femur shows the parallel pattern of the gray cortex lesions with increased tracer uptake representing significant intracortical remodelling. Origin: Dept. of Radiology, Leiden University Medical Center, Netherlands