Tibial stress injury: MRI findings

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Purpose

Osseus abnormalities are very common in response to an abnormal chronic repetitive stress when applied in healthy bone. That is known as bone stress injury and represents a wide spectrum of diseases, among which is tibial stress injury, also known as "shin splints". This type of lesions are common in athletes (about 10 % of injuries seen in sports medicine) affecting the tibia, tarsal bones, metatarsals, femur and fibula, in order of decreasing frequency, but also occurs in non-athlete people. The repetitive stress causes accelerated bone remodeling and may lead to stress fracture.

A lot of imaging techniques have been described in the literature including plain radiograph, radionuclide bone scanning, CT and MRI.

Nowadays, MRI has become the choice imaging modality for evaluating patients when this pathology is suspected, because can also identify injuries affecting muscles and tendons of the lower extremities.

The pathogenesis of stress lesions is poorly understood. Daily activity produces a basic bone remodeling: osteoclastic bone resorption, which is the first body’s stress response. When this response is not balanced and the bone replacement is not sufficient, the bone becomes a weak structure, on which muscular forces act constantly, increasing the risk of little cracks and then fractures. CT and MRI imaging findings of stress fractures have been described by some authors, but the early image changes in bone stress injuries are much less known. So we want to describe the MRI features in patients with anterior tibial pain, known as "shin splints".

Methods and Materials

We have reviewed retrospectively 4 patients, with a total of eight tibias.

All MRI examinations were performed on 1.5 Tesla MR (Intera and Achieva, Philips Medical Systems) using a phased array coil. Gadolinium was not necessary. The patients were positioned in a supine neutral position. Both tibias were imaged regardless of symptoms.

Axial T1W (TR/TE 500/18; NEX 2; matrix 468 x 252; slice thickness 5 mm; FOV 400 x 200 x 293 mm) and T2W FSE (TR/TE 4024/30; NEX 2; matrix 432 x 139; slice thickness 6 mm; FOV 400 x 180 x 250 mm) sequences were obtained. Also T2W-PD with fat suppression
sequence. In the coronal plane T1W (TR/TE 536/10; NEX 2; matrix 360 x 335; slice thickness 5 mm; FOV 360 x 420 x 150 mm) and STIR (TR/TE 3599/30; inversion time 140 ms; NEX 4; matrix 244 x 200; slice thickness 5 mm; FOV 360 x 407 x 149 mm) sequences were obtained.

Our four patients presented with selective pain and tenderness showing some alteration at MRI. They had not a clinical suspicion of "shin splints syndrome".

Faced with this type of selected pain on the anterior region of the tibia, it becomes necessary to evaluate the tissue signal of that area. The radiologist should be aware looking for slight soft tissue and bone anomalies. The anteromedial region of the leg, by reference to the tibia, is covered only by subcutaneous tissue fat and skin. Against, the anterolateral region presents some muscles between the tibia and fibula, from medial to lateral the anterior tibial muscle, the extensor digitorum longus, the extensor hallucis longus deep to previous, fibularis brevis and fibularis longus. The posterior leg (less commonly affected) has a lot of muscles compared to the anterior: superficially, soleus and gastrocnemius muscles and plantaris tendon, and deeply from medial to lateral, the flexor digitorum longus, the tibialis posterior and the flexor hallucis longus.

Then, knowing that stress injury is a pathology that can affect the entire perimeter of the bone, the tibia can be divided, according to the axial plane and using two orthogonal crossing lines, into four regions: anterior, posterior, medial and lateral. These are important in describing the periosteal edema location. According its length, the tibia is divided into proximal (epiphysis and metaphysis), diaphysis and distal tibia (distal metaphysis and epiphysis).

In this review we have focused on the key findings of "shin splints" such as periosteal and bone marrow edema. The edema is better evaluated on STIR and T2 with fat suppression images. The axial plane is sufficient to quantify the degree of edema and longitudinal plane (coronal or sagittal), to assess its extension.

So the radiologist may review the regional anatomy from the surface (subcutaneous tissue fat), intermediate layer (muscles) to the periosteum and bone, including bone marrow.

**Results**

Our four patients presented with selective pain and tenderness with MRI alterations. One of them complaint of bilateral pain with bilateral afectation by MRI.
We have considered the patients that presented a signal alteration on the pretibial region. T2W-FSE with fat suppression and STIR images showed a hyperintensity on the anteromedial surface of the tibia, affecting the soft tissue adjacent to periosteum, which means periosteal edema (fig 1). All of them affected at middle region of the tibia. In general, T1W imaging was able to demonstrate the presence of periosteal edema (fig 2 and 3). One of the patients presented another affected tibial region (posterior), which is less common (fig 4 and 5).

Only one patient presented with bone marrow edema (mid-diaphysis of the tibia) as an area of high signal intensity on T2W, and low signal intensity on T1W (fig 6 and 7), but on STIR images the bone marrow edema was demonstrated with more confidence (fig 8). Another one presented with unilateral pain but bilateral findings suggesting tibial stress injury.

Some classifications, as the Fredericson’s, has been developed based on the presence of periosteal edema, bone marrow edema and intracortical signal alteration. The reason for the classification may lead to assess the severity of stress injuries.

No one of our four patients presented cortical abnormalities, which are common findings in bone stress injuries. Sometimes the stress-related cortical abnormalities are appreciable on both T2W and STIR images. The presentation may be like a round cavitation of high signal intensity or striation showing a hyperintense line extending only through a part of the cortical thickness. Also it is common to see several parallel hyperintense lines affecting the bone cortical. Irregularity of subperiosteal bone is a less frequent finding. T1W FSE images have lesser values in detecting these type of lesions affecting the bone cortical.

Also the radiologist should know that sometimes, the periosteal edema may be seen as a non-specific soft-tissue mass, not shown in our patients.

The MRI can sometimes reveal a signal alteration on a non-symptomatic patient, this is less common but can occur. It has not been well stablished whether stress reactions detected on MRI are always related to clinical symptoms. This could be because imaging findings could precede symptoms. Also the cortical abnormalities may not cause always a source of pain and have been described in asymptomatic runners, and in symptomatics.

The radiologist always have to exclude different causes of lower leg pain like muscular strain, myositis, tendinopathy, chronic compartment syndrome or neural entrapment.
syndrome, which may occur alone or associated (very unlikely) to bone stress. The specialist will carefully evaluate the different structures of the lower leg afore mentioned.

Images for this section:

Fig. 1: A 24 year old female complaining of bilateral tibial pain. A. Fat-suppressed T2-weighted fast spin-echo images show mild periosteal edema (arrows) on medial cortex of mid tibial diaphysis. The signal alterations were affecting bilaterally. B. STIR sequence showing the same findings. Normal signal of the bone marrow (asterisk).
Fig. 2: Sagittal T1-weighted spin-echo images show periosteal edema (arrow) on medial cortex of mid tibial diaphysis.
**Fig. 3:** Axial T1-weighted fast spin-echo image. A band of low signal can be seen on medial cortex of the right tibia, because of the periosteal edema. The left one shows the normal high signal of the fat.
Fig. 4: Axial fat-suppressed T2-weighted fast spin-echo image shows moderate periosteal edema (arrow) on medial and posterior cortex of the right tibia.
Fig. 5: The corresponding axial T2-weighted fast spin-echo image. Compare with the left tibia the high signal (arrow) on right posterior cortex, showing moderate periosteal edema, less evident than in fat suppression sequences.

Fig. 6: Axial T2-weighted fast spin-echo image shows mild bone marrow edema (arrow) within intramedullary canal of the left mid tibial diaphysis.
Fig. 7: A. Axial fat-suppressed T2-weighted fast spin-echo image shows mild periosteal edema (red arrow) on medial cortex of the left tibia. B. Axial fat-suppressed T2-weighted fast spin-echo image shows mild bone marrow edema (yellow arrow) within intramedullary canal of mid tibial diaphysis. We can compare with the right normal tibia.
Fig. 8: A. Coronal STIR sequence shows medular hyperintensity as bone marrow edema (circle) within intramedullary canal of the left tibia. B. Corresponding T1-weighted spin-echo images show the marrow edema (hypointensity) of mid tibial diaphysis.
Conclusion

1. Tibial stress injury is a spectrum of osseous abnormalities caused by chronic stress on healthy bone.

2. MR imaging allows depiction of edema. The most frequent imaging finding is the periosteal edema, which is a useful marker for stress injury. Also usually bone marrow edema may be seen. The presence of cortical injury is easily revealed on T2W and STIR sequences.

3. So nowadays, MRI is the gold standard technique, being a very sensitive tool for detecting edema.

4. But MRI’s low specificity requires clinical support: the diagnoses of tibial stress injury, also known as "shin splints", depends on both imaging findings and clinical features.

5. When anterior lower leg pain is reported, the signal alterations around the mentioned structures (muscles, soft-tissue, periosteal region, cortical and bone marrow) may lead the radiologist to this diagnosis.

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