RADIOLOGY CORNER

Case 24: Stress Fracture of the Tibia

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Note: This is the full text version of the radiology corner question published in the May 2008 issue, with the abbreviated answer in the June 2008 issue.

Stress fractures, also known as 'fatigue fractures', are common overuse injuries. They have been described in almost every bone of the human body though they most commonly occur through the diaphysis of lower extremity weight bearing bones. Most often this micro trauma is found in military recruits and athletes taking part in running activities. A diagnosis can often be made by patient history and radiographic findings. However computed tomography, magnetic resonance imaging, and scintigraphy can help with the workup. Although the cause most often is contributed to repetitive skeletal overloading, underlying metabolic disorders must be evaluated.

Introduction

Stress Fractures have been reported to have a 5-30% incidence in runners and military recruits. The repetitive application of force most commonly related to running and jumping results in micro trauma to the cortical bone. The weight bearing bones of the lower extremity to include the vertebral body, femoral neck, tibial diaphysis, metatarsal shaft and calcaneous are most commonly affected. If the offending activity does not cease and a period of rest not allowed cortical changes combined with clinical symptoms manifest.

Stress fractures can be categorized into two subtypes: insufficiency fracture and fatigue fracture. Insufficiency fractures result when abnormal bone, such as bone with a low bone mineral density, gives way under normal stress. Fatigue fractures on the other hand present when normal bone is exposed to repetitive abnormal increase in stress resulting in fracture.

Imaging studies play a key role in diagnosis and management. Plain radiographic imaging is ordered early in the evaluation yet often is inconclusive. Magnetic resonance imaging has better soft tissue contrast resolution, multi-planar capability and can better identify bone marrow edema. High resolution computed tomography has excellent bony detail and periodically can better visualize the fracture lucency, where as bone scintigraphy can often pick up subtle changes early in the healing/breakdown process.

History

This patient is a 28 year old active duty U.S Army combat soldier deployed to Iraq. He had had progressive pain over his lower right leg that radiated to his knee joint for approximately 3 months. His pain was described as sharp and focal to his superior, medial, lower leg and intensified with prolonged walking or running short distances. Although symptoms improved while non-weight bearing, a steady ache was always present. There had been no history of direct trauma and symptoms where thought to have started shortly after arriving in the AOR. Non-steroidal anti-inflammatory medications provided temporary relief but did not improve his ambulatory pain. His pain slowly subsided over a four week period with relief from his combat duties. A tender mass formed on his lower leg during this period of rest. Physical exam revealed a 2 cm firm, non-mobile mass to the medial-posterior aspect of the proximal 1/3 tibial diaphysis. The mass was mildly tender to direct palpation. Overlying skin was not erythematous, ecchymotic, or warm. There was no evidence of fluctuance or right lower extremity lymphadenopathy. The patient had full range of motion without pain to his right knee.

Summary of Imaging Findings

The Anteroposterior (AP) and lateral radiographs were obtained and demonstrated the classic appearance of a stress fracture of the tibia (Figure 1A, 1B). Note the absence of any defined fracture lucency. A CT was performed to further define the extent of the fracture. On CT periosteal reaction is confirmed on the axial image (figure 2). Coronal, sagittal and 3D volume rendering were performed to more fully analyze the extent. In addition, CT helped characterize the periosteal reaction, look for potential underlying lesions or radiographically occult fracture lucencies, and helped with characterization of matrix calcifications, if any were present. An irregular lucency is noted to run the AP diameter of the tibia (figure 3). Also note the periosteal extent demonstrated nicely on the volume rendered 3D reformation (figure 4).

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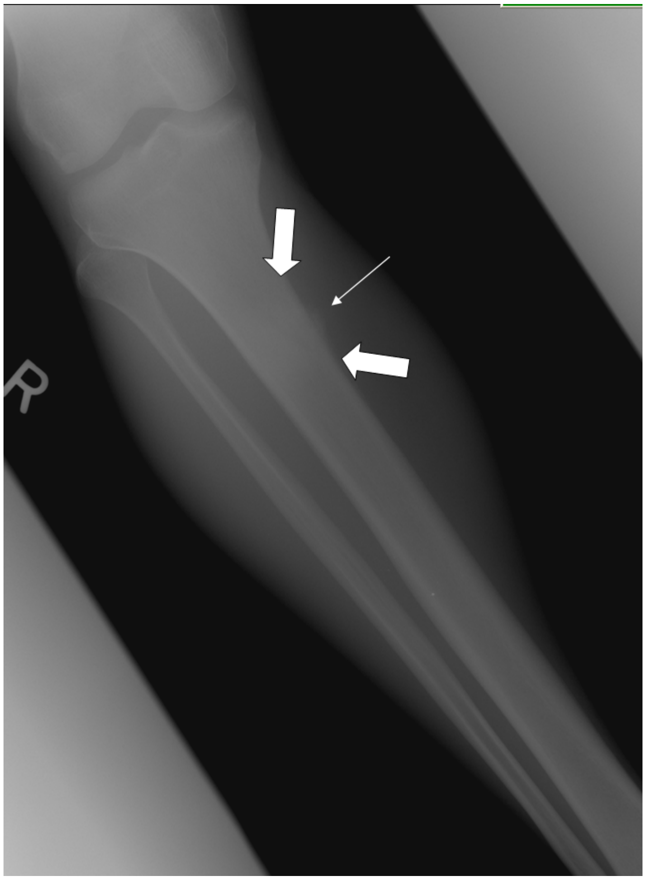

Fig. 1A (AP) demonstrates the periosteal reaction (thin arrow) along with the typical wide zone of transition band of increased density (wide arrows) commonly seen in tibial stress fractures.

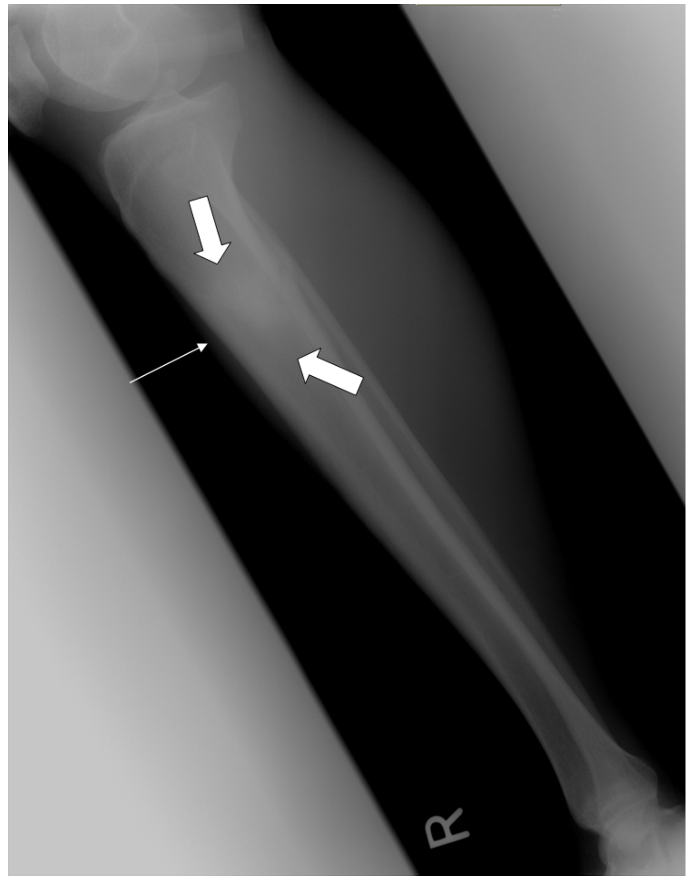

Fig. 1 B (lat) demonstrates the periosteal reaction (thin arrow) along with the typical wide zone of transition band of increased density (wide arrows) commonly seen in tibial stress fractures.

Diagnosis:

Near-complete stress fracture of the tibia.

Patient Discussion

Initial treatment on of this patient was conservative and had included Non-steroidal anti-inflammatory medication, rest and a working diagnosis of shin splints provided (no prior plain films were obtained). At the time of the patient's diagnosis of fatigue fracture ambulatory pain had ceased. The healing process had already started as evident by the abundant hard callus formation at the fracture site. All contact and high impact activities were restricted. Non-steroidal anti-inflammatory medications were stopped. A physical therapy protocol of generalized right lower extremity strengthening was started. At six-week follow up, periosteal involvement was subsiding and a healing sclerotic band was seen across the tibial shaft on radiograph. The patient was able bear all weight and hop on effected leg without pain. A weight-bearing strengthening program was advanced; however, the patient was lost to follow-up due to frequent re-deployment within the operational theatre.

Discussion

Tibial stress fractures were first cited in the literature from case studies of soldiers in the 19th and 20th century.[1] These fractures became linked to marching activities within the military troops during World War II.[2] Although the reported incidence of stress fracture in the general population is less than 1 %, runners and military recruits have a 5-30% chance of obtaining one. Being the most common site, the tibia accounts for 41-55 percent of all stress fractures.[3] The condition occurs when the bone is subject to repetitive stress. Repetitive mechanical loading causes micro fractures in the trabeculae. This can occur in a variety of locations, though more commonly occurs within the tibia, femoral neck, sacrum, pubic ramus, calcaneous, navicular, or metatarsal bones. They usually results from a change in exercise status (ie: increased running distance or workout intensity, new foot wear, a change in walking terrain) or an anatomical variance such as a Q-angle greater than 15 deg resulting in genu varum[4]. Over foot pronation once thought of being a risk factor for tibial stress fractures may actually have a protective effect in obtain stress fractures of the tibia and femur[5].

Stress Fractures that occur on the posterior medial side of the tibia (compression side) usually have the best prognosis for healing. Stress fractures occurring in the distal tibia or on the anterior lateral aspect (tension side of the fracture) have a poorer prognosis.[6,7] This could lead to a non-union, despite prolonged conservative treatment, possibly requiring intra-medullary fixation.

According to Wolff's Law, bone responds to physical stress. New bone is formed in areas experiencing stress and is reabsorbed in areas absent of stress. With the repetitive application of a loading or deformation force, the bone goes through an osteoclastic followed by an osteoblastic process at the site of resulting stress. When this reparative and adaptive capacity is overwhelmed by chronic overloading, damage can accumulate. When insufficient time is allowed for osteoblastic mediated bone deposition, the osteoclastic micro damage may coalesce into a stress fracture.

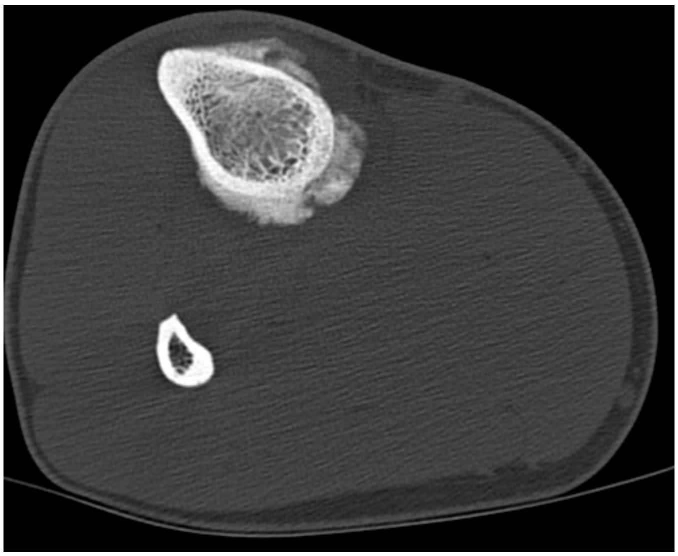

Fig. 2: Axial CT showing the periosteal reaction.

Female athletes have the greater tendency of acquiring tibial stress fractures. This may be due to a multi-factorial etiology. Possible causes include eating disorders, skeletal alignment, amenorrhea, decreased bone density.

Fatigue fracture is only one type of stress fracture. An insufficiency fracture is a subtype that has a similar pathophysiology however differing etiology. Insufficiency fractures most commonly occur in individuals greater than 60 years old. They develop when normal physiological stress is applied to weakened bone. Disease processes that decrease bone mineralization are the most common etiology, i.e.: Osteoporosis, Pagets Disease, Osteomalacia, Osteogenesis Imperfecta, pelvic irradiation, corticosteroid therapy, Rhematoid Arthritis.

Patients present with a history of progressive lower leg pain that may or may not radiate to the knee or ankle joint. There usually is a recent history of starting or advancing to a new exercise program. Often, patients complain of nocturnal pain that makes sleeping difficult. On physical exam the overlying skin is often normal in appearance. Focal pain is reproducible with any stressful loading activity such as having the patient hop on the affected leg, varus or valgus stress of the tibia, or elicited bone vibrations using a tuning fork placed proximal or distal to the fracture site. Only late in the healing process can the region of healing callus be palpated. The clinical differential diagnosis includes the following: Shin splint (tibial stress syndrome), osteoid osteoma, chronic sclerosing osteomyelitis, osteochondroma, osteomalacia, metastasis, osteogenic sarcoma, and Ewings Sarcoma. In this case with the findings presented, osteoid osteoma would be included as one of the differential diagnosis for periosteal reaction.

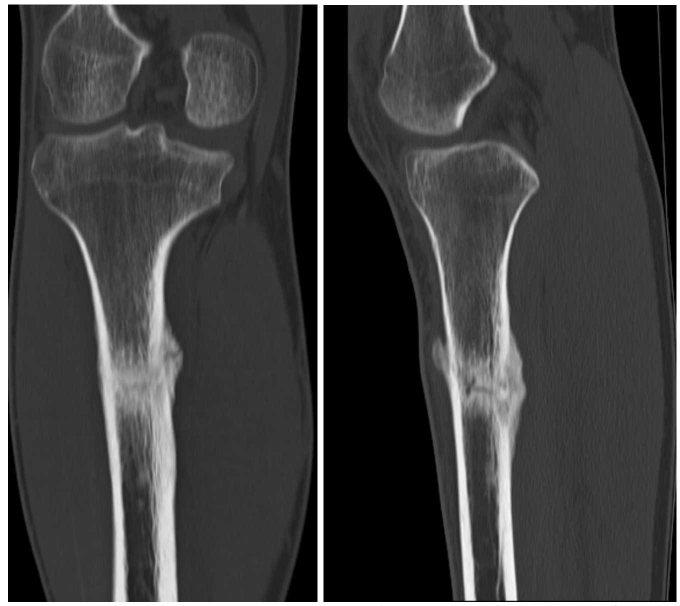

Fig. 3 A, B: Coronal and sagital reformations of the stress fracture demonstrating a lucency running from anterior to posterior in the center of the stress fracture.

Often with most pathology, stress fracture being no exception, symptoms precede any changes that can be detected with radiographic or even computed tomgraphy imaging. This makes early diagnosis difficult. Magnetic resonance imaging and skeletal scintigraphy are more sensitive than any other means of evaluation and better in detecting bone edema.[8,9,10]

Radiographs are used initially because they are readily available, and are useful if obvious findings are present to explain the patient's symptoms. In the early pathogenesis of stress fractures radiographic imaging is relatively insensitive and more advanced modalities such as computed tomography (CT), skeletal scintigraphy or magnetic resonance imaging (MRI) are needed. CT can demonstrate ossified periosteal reactions better than radiographs, and may demonstrate radiographically occult fractures or other pathologic lucencies. A CT also better demonstrates calcified matrices in cases of primary bone tumors, if the patient's underlying cause of pain is a neoplasm. Bone Scintigraphy has a high sensitivity with it's ability to detect stress fractures within a few days after initial of injury. However it has been known to have a low specificity with up to 50 percent of positive findings in asymptomatic sites. The MRI is becoming the study of choice for the diagnosis of stress fractures. Numerous studies show that there is at least an equal sensitivity and superior specificity when compared to bone scinitigraphy. MRI can also better provide a differential diagnosis as well as grade the severity of injury predicting injury morbidity. [11]

Fig. 4 demonstrates the extent of the

Most tibial fatigue stress fractures are treated symptomatically. After onset of injury a patient is restricted from weight-bearing. This is continued for 3-6 weeks or until weight bearing is tolerated without pain. Activity level should slowly be advanced over a three-month period as long as progressive radiographic healing is evident and symptoms are diminishing. Low serum calcium has been shown as a possible risk factor in developing stress fractures however increased calcium intake has not been shown to improve fracture healing.[12,13] Periodically delayed unions and non-unions develop. Although electrical stimulation has shown to be beneficial with the healing of tibial fractures, tibial stress fractures have been shown to be less responsive to this treatment[14,15]. Patients should continue to be followed 3-6 months until complete resolution of their symptoms and able to perform a prolonged run without pain. Complete healing with return to all activities is expected. However, if despite conservative treatment, the tibial stress fracture fails to achieve complete union, intramedullary nail fixation is warranted.

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