Tibial Stress Fracture: A Diagnostic Pitfall

Jiraporn Sriprapaporn, M.D.
Department of Radiology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.

ABSTRACT

The author reports a young police cadet with a history of heavy running about 10 km per day for a few months, presenting with left shin pain especially during exercise. His first plain radiograph was not helpful and his MRI findings favored an infective or neoplastic process. However, three-phase bone scintigraphy suggested a stress fracture resulting in avoidance of an dispensable biopsy procedure.

Keywords: Stress fracture, bone scan, bone scintigraphy, pitfall

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INTRODUCTION

Stress fractures are divided into two types. A fatigue fracture occurs in a normal bone when the bone is overused, while an insufficiency fracture occurs when a normal stress is applied over an abnormal structural bone such as an osteoporotic bone.1

Fatigue fractures that are usually found in military and athletic populations are the most important stress fractures found in clinical practice. Diagnosis of such conditions is somewhat underestimated and sometimes may not be simple.

The author reports a young man with a history of heavy running about 10 km/day for a few months, presenting with left shin pain. MRI findings suggested an infective or neoplastic process, which required bone biopsy, but three-phase radionuclide bone imaging implied a stress fracture, which avoided an unnecessary biopsy procedure.

CASE REPORT

A 19-year-old police cadet with a history of heavy running about 10 km/day for a few months presented with left shin pain especially during exercise for a few weeks. He had no other history of traumatic injury before. On physical examination, he had no fever, no bruise over the left leg, but he had a point of tenderness at the posteromedial aspect of his left leg without signs of inflammation.

His first plain radiographs at a private clinic were clearly normal. He had obligatorily continued the same training program and the pain tended to be aggravated.

Further laboratory investigations found normal complete blood counts, normal erythrocyte sedimentation rate, suggesting no signs of infection. His magnetic resonance imaging (MRI) from another imaging center performed one month after onset of the symptom demonstrated a patchy lesion in the medulla of the mid left tibia with iso-to-low signal on T1-weighted images and high signal on T2-weighted and STIR (short tau inversion recovery) images with moderate gadolinium enhancement. There was also soft tissue edema at the posteromedial aspect of the lesion, which suggested an infective or neoplastic process. (Fig 1) He then was referred for bone scintigraphy for whole-body evaluation. A three-phase bone scintigraph of both legs was obtained using an intravenous injection of 20 mCi Tc-99m methylene diphosphonate (Tc-99m MDP). The technique included 120-second immediate vascular dynamic imaging, 5-minute static blood-pool images, and delayed 3-hour bone images. The study revealed mild hyperemia to the left leg, with focal increased uptake at the medial aspect of his left calf, and fusiform increased uptake in the cortico-medullary region at the posteromedial aspect at mid shaft of his left tibia (Fig 2). The skeleton elsewhere appeared unremarkable. These findings were compatible with grade III tibial stress fracture according to Zwas´ classification.2 The serial plain radiograph a few days following his bone scan demonstrated a solid periosteal reaction at his posterior cortex of the left tibia (Fig 3). Nevertheless, the patient was concerned about a bone tumor, thus a bone biopsy was then scheduled.

While waiting for a bone biopsy appointment, he had been advised to discontinue running activity. After that, his pain was gradually relieved. Serial plain radiographs of the left leg one month later demonstrated progressive periosteal thickening, which favored a healing process of the stress fracture. Thus, bone biopsy was canceled and a follow-up 3-phase bone scintigraphy (Fig 4) was obtained at the three-month interval. Although he had been back
for an intermediate training program recently prior to the second bone scanning, the study confirmed much improvement with corresponding sclerosis along the posteromedial aspect of his left tibia seen on SPECT/CT images (Fig 5).

**DISCUSSION**

Stress fractures are common overuse injuries among athletes and military recruits. The true incidence of stress fractures is hard to determine and they tend to be underestimated since many of them might be left unrecognized. However, it was estimated that stress fractures account for 0.7%-20% of all sports medicine injuries. Females are more susceptible than males to develop stress injuries of the bone especially in the military population.

Approximately 75% of stress fractures occur before the age of 40 years. In addition, the trend of such condition in young adults has been increasing due to increased participation in sporting activities. One study also found that 9% of fractures occurred in children aged less than 15 years and 32% in those between 16-19 years of age. The site of fractures depends on the type of activity involved. Running injuries play an important role for developing stress fractures in both athletes and military populations. Most stress fractures occur in the lower extremities, especially in long-distance runners. Running more than 20 miles a week is at increased risk to develop lower-extremity injuries. This injury typically occurs 6 to 8 weeks after a change in training duration or intensity, but can occur with repetitive stress alone. The most

![Fig 1](image1)

**Fig 1.** Coronal MRI images of left tibia showed patchy lesion in the medulla of mid left tibia with iso-to-low signal on T1-weighted images (A) and high signal on STIR images (B) with moderate gadolinium enhancement (C). Associated soft tissue edema at posteromedial aspect of the lesion was also noted.

![Fig 2](image2)

**Fig 2.** Three-phase bone scintigraphy revealed mild hyperemia to the left leg (A) with focal increased blood-pool activity at the medial aspect of left calf (B). The delayed 3-hour images in the anterior and lateral projections showed focal fusiform increased uptake in the cortico-medullary region at posteromedial aspect at mid shaft of left tibia. (C) These findings are compatible with grade III tibial stress fracture.

![Fig 3](image3)

**Fig 3.** Serial plain radiographs (AP-Lateral) of left tibia revealed periosteal reaction at posterior tibial cortex.
common site of stress fractures in most reports is in the tibia, which may be as high as 72%. \(^{2,13-14}\) Diagnosis of stress fractures primarily depends on a high index of suspicion since it may be problematic because several musculoskeletal disorders can cause exercise-induced leg pain such as soft tissue injuries, medial tibial stress syndrome (MTSS) or shin splints, artery or nerve entrapment, compartment syndrome, bone tumors, and bone infection. \(^{15-16}\) The classic clinical feature of a stress fracture is insidious onset of activity-related local pain with weight bearing. The pain is relieved by rest and becomes worse when the activity is continued. Local tenderness and swelling are often found at the fracture site. \(^{16}\) Nevertheless, stress fractures should be considered in any patient who presents with local pain after a recent increase in activity or repeated activity with limited rest. \(^{9,17}\) Early definite diagnosis is essential for preventing progression of lesions, avoiding complications and guiding proper management. Since clinical diagnosis may be inconclusive, various imaging tests should be performed to confirm stress fractures. These imaging modalities have their own advantages and disadvantages as listed in Table 1.

Plain radiography is usually the first imaging modality obtained because of its availability and low cost. \(^{19}\) Plain radiograph is usually negative initially, but is more likely to become positive over time. \(^{21}\) The initial plain radiograph has quite low sensitivity for stress fractures ranging between 10%-30%, as in this case. \(^{2,14,18}\) On follow-up examinations, the sensitivity of radiographs is higher with reported values ranging between 40% to 54%. \(^{2,19}\)

Radiographic manifestations of tibial stress injuries include decreased cortical density, so called “gray cortex” sign, periosteal reaction, endosteal thickening, and a cortical fracture line. \(^{16,20}\) If the initial radiograph is negative, more advanced imaging modalities such as three-phase bone scintigraphy and MRI may be helpful for further evaluation. Both modalities have similarly high sensitivity for detection of stress fractures, but MRI has greater specificity. \(^{16}\) Radio-nuclide bone imaging had traditionally been the standard tool to confirm stress fractures in most studies prior to the development of MRI, because of its high sensitivity. \(^{14,21-22}\)

**TABLE 1.** Advantages and disadvantages of imaging modalities for stress fractures (modified from Patel, et al.)\(^{16}\)

<table>
<thead>
<tr>
<th>Imaging</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td>Plain radiography</td>
<td>-Lowest cost</td>
<td>-Poor initial sensitivity</td>
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<tr>
<td></td>
<td>-Widely available</td>
<td>-Some radiation exposure</td>
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<td></td>
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<td>-Limited differential details</td>
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<tr>
<td>Bone scintigraphy</td>
<td>-Higher cost</td>
<td>-Limited availability</td>
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<tr>
<td></td>
<td>-High sensitivity</td>
<td>-Limited differential details</td>
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<td></td>
<td></td>
<td>-Some radiation exposure</td>
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<tr>
<td>Magnetic resonance imaging</td>
<td>-Best differential details</td>
<td>-Can be falsely positive in bony infection or tumor</td>
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<tr>
<td>(MRI)</td>
<td>-No radiation exposure</td>
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<td>-Highest differential details</td>
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<td>-Highest specificity</td>
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<td>-Equal or slightly better sensitivity</td>
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However, nowadays, MRI is currently considered the method of choice for this purpose due to its high image resolution of bone, bone marrow, and surrounding soft tissue, resulting in better anatomical evaluation and higher specificity as compared to bone scintigraphy. 3-25

Bone scintigraphy is really sensitive and may be positive as early as 48-72 hours after injuries. 22 In acute stress fractures, all three phases of the bone scan are positive. Zwas, et al., developed a scintigraphic classification of stress fractures, which was divided into four grades according to lesion dimension, bone extension, and tracer accumulation in the lesions.

Three-phase bone scintigraphy is also helpful in the differentiation between stress fractures and MTSS. In MTSS, only the delayed third phase is positive and tends to be longitudinally-oriented along the posterior cortex of the tibia. In contrast, the increased uptake in stress fractures tends to be more focal (with fusiform shape in advanced stages). 27

Apart from planar bone imaging, SPECT (single photon emission tomography) acquisition, which is a 3-dimensional imaging technique, which provides better delineation of bony lesions, can be used. Combined SPECT and computed tomography (CT) imaging together in the same instrument, so called SPECT/CT scanning, adds even more anatomical details over the SPECT images alone. To date, more and more SPECT and SPECT/CT imaging have been used in the field of Sports Medicine to evaluate several parts of the body, such as the spine, hips, knees, and feet. 3-29

Although MRI, is now the gold standard for the diagnosis of stress fractures, it might be of limited availability due to a long waiting list, especially in most busy tertiary centers. Furthermore, the MRI abnormalities such as periosteal reaction and bone marrow edema, if there is no demonstration of a fracture line, are nonspecific. 30 Thus, an unaware radiologist may be confused with other conditions such as osteomyelitis or infiltrative neoplasms. As in the reported case, MRI results were indicative for tumor pathology, so the attending clinician had scheduled bone biopsy for pathological evidence.

Prior to performing a biopsy, one should always keep in mind that this procedure should be strenuously avoided in a case with potential stress fracture since this procedure can disturb bone healing and the biopsy specimen may contain immature cells and osteoid, related to the healing process, which could be mistaken as malignancies. Follow-up imaging studies in the next few weeks may reveal characteristic findings of stress fractures and thus avoid an unnecessary invasive procedure. 30,31

CONCLUSION

Although MRI is currently accepted as the imaging of choice for evaluation of stress fractures, it still has some pitfalls. Three-phase bone scintigraphy on the other hand, is generally less specific, but careful interpretation along with precise clinical correlation can overcome this limitation resulting in accurate diagnosis for stress fractures. Therefore, three-phase bone scanning can be used solely or as an adjunct when the MRI findings are non-diagnostic in cases presenting with high clinical suspicion of stress fractures.

REFERENCES