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 a dispensable biopsy procedure.

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

Siriraj Med J 2012;64:163-166

E-journal: http://www.sirirajmedj.com

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 so 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

Correspondence to: Jiraporn Sriprapaporn
E-mail: sijmh@mahidol.ac.th
Received 7 December 2011
Revised 12 March 2012
Accepted 13 March 2012

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.[3] Females are more susceptible than males to develop stress injuries of the bone especially in the military population.[4-5]

Approximately 75% of stress fractures occurr before the age of 40 years.[6] In addition, the trend of such condition in young adults has been increasing due to increased participation in sporting activities.[7] 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.[8] The site of fractures depends on the type of activity involved.[9-10] 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.[11] This injury typically occurs 6 to 8 weeks after a change in training duration or intensity, but can occur with repetitive stress alone.[12] The most

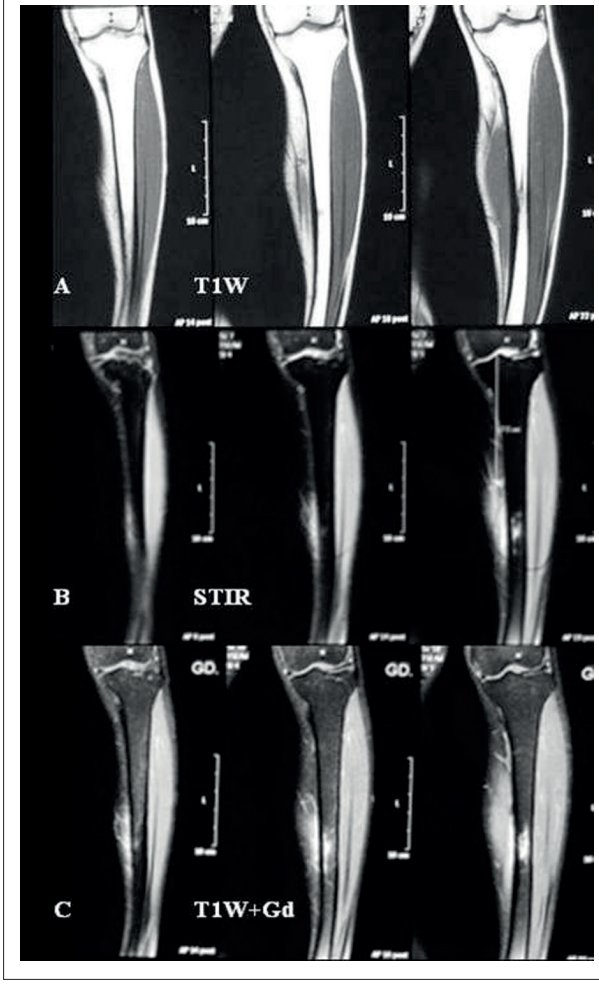


Fig 1. Coronal MRI images of left tibia showed patchy lesion in the medulla of mid left tibia with iso-to-low signal on T1-weighted images (A) and high signal on STIR images (B) with moderate gadolinium enhancement (C). Associated soft tissue edema at posteromedial aspect of the lesion was also noted.

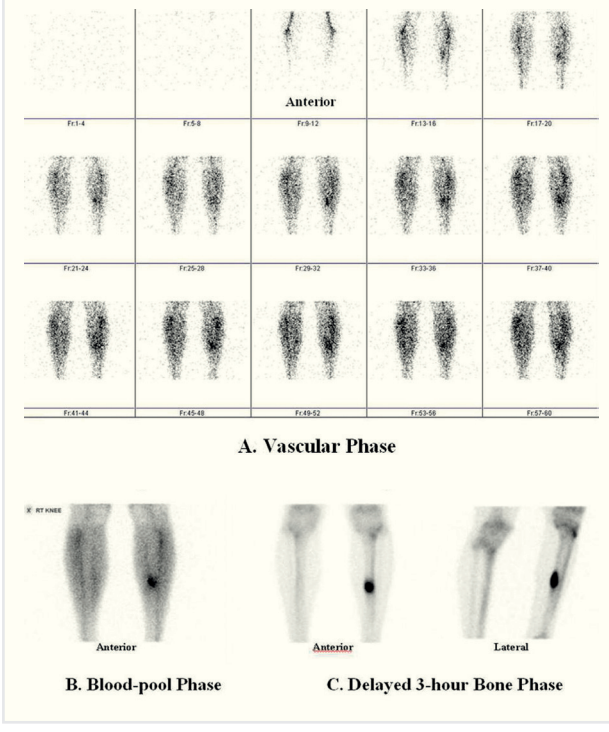


Fig 2. Three-phase bone scintigraphy revealed mild hyperremia to the left leg (A) with focal increased blood-pool activity at the medial aspect of left calf (B). The delayed 3-hour images in the anterior and lateral projections showed focal fusiform increased uptake in the cortico-medullary region at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

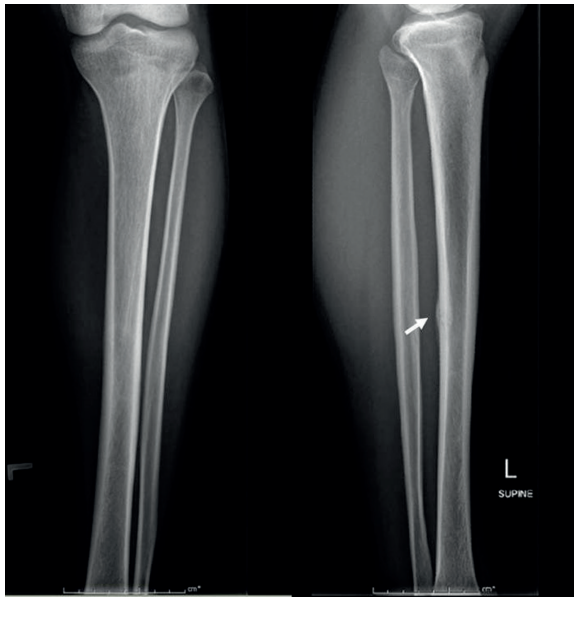


Fig 3. Serial plain radiographs (AP-Lateral) of left tibia revealed periosteal reaction at posterior tibial cortex.

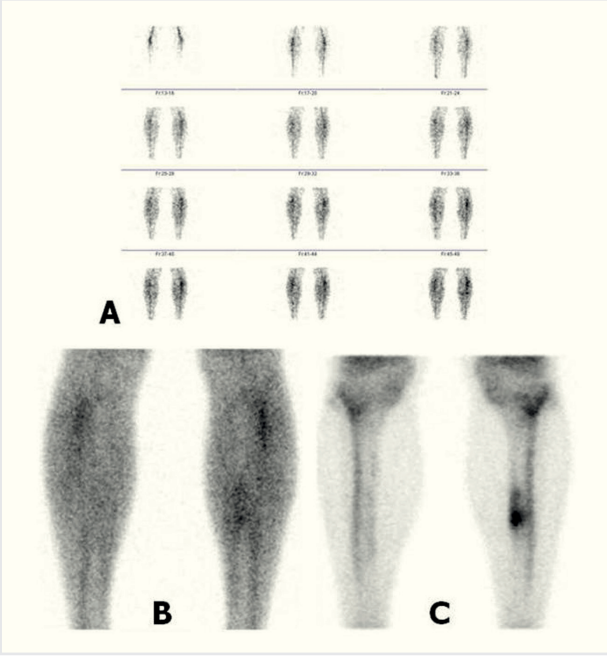


Fig 4. The follow-up 3-phase bone scan of the leg in the anterior view showed symmetrical blood flow to both legs (A), almost normal blood-pool image (B), and less intense uptake at left tibial shaft, suggesting improvement of stress fracture.

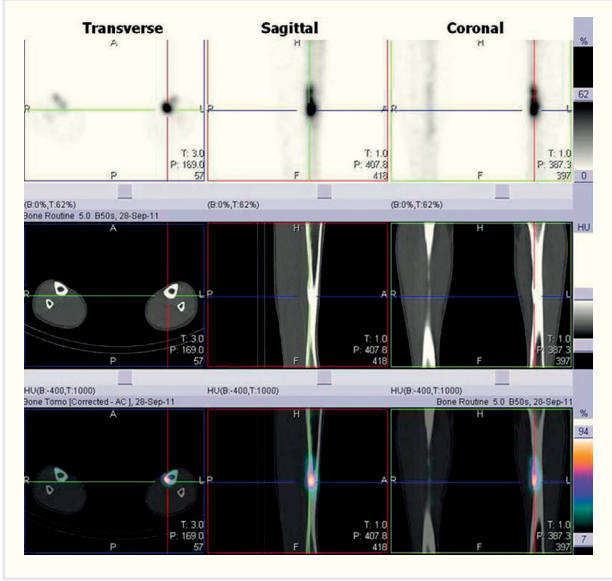


Fig 5. SPECT/CT images of the leg (acquired with 15 second/step x 60 steps, 360 degree of rotation for SPECT and 130 kV, 50 mAs for CT) demonstrated increased uptake along the posteromedial aspect of left tibial shaft with associated sclerosis observed on the corresponding CT scan.

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] Radionuclide 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]

Imaging	Advantages	Disadvantages
Plain radiography	-Lowest cost -Widely available	-Poor initial sensitivity -Some radiation exposure -Limited differential details -Limited availability -Limited differential details
Bone scinitigraphy	-Higher cost -High sensitivity	-Some radiation exposure -Can be falsely positive in bony infection or tumor
Magnetic resonance imaging (MRI)	-Best differential details -No radiation exposure -Highest differential details -Highest specificity -Equal or slightly better sensitivity than scintigraphy	-Highest cost -Limited availability -Sometimes may be falsely positive in bony infection or tumor

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.[23-25]

Bone scintigraphy is really sensitive and may be positive as early as 48-72 hours after injuries.[26] 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.[2]

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-dimentional 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.[28-29]

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.[9,31]

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 could 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

1. Flinn SD. Changes in stress fracture distribution and current treatment. Curr Sports Med. Rep. 2002 Oct;1(5):272-7.
2. Zwas ST, Elkanovitch R, Frank G. Interpretation and classification of bone scintigraphic findings in stress fractures. J Nucl Med. 1987 Apr;28(4):452-7.
3. Bergman AG, Fredericson M. MR imaging of stress reactions, muscle injuries, and other overuse injuries in runners. Magn Reson Imaging Clin N Am. 1999 Feb;7(1):151-74.
4. Protzman RR. Physiologic performance of women compared to men. Observations of cadets at the United States Military Academy. Am J Sports Med. 1979 May-Jun;7(3):191-4.
5. Bijur PE, Horodyski M, Egerton W, Kurzon M, Lifrak S, Friedman S. Comparison of injury during cadet basic training by gender. Arch Pediatr Adolesc Med. 1997 May;151(5):456-61.
6. Courtenay BG, Bowers DM. Stress fractures: clinical features and investigation. Med J Aust. 1990 Aug;153(3):155-6.
7. Dixon S, Newton J, Teh J. Stress fractures in the young athlete: a pictorial review. Curr Probl Diagn Radiol. 2011 Jan-Feb;40(1):29-44.
8. Orava S, Jormakka E, Hulkko A. Stress fractures in young athletes. Arch Orthop Trauma Surg. 1981;98(4):271-4.
9. Daffner RH, Pavlov H. Stress fractures: current concepts. Am J Roentgenol. 1992 Aug;159(2):245-52.
10. Bennell KL, Brukner PD. Epidemiology and site specificity of stress fractures. Clin Sports Med. 1997 Apr;16(2):179-96.
11. Hootman JM, Macera CA, Ainsworth BE, Martin M, Addy CL, Blair SN. Predictors of lower extremity injury among recreationally active adults. Clin J Sport Med. 2002 Mar;12(2):99-106.
12. Harmon KG. Lower extremity stress fractures. Clin J Sport Med. 2003 Nov;13(6):358-64.
13. Orava S, Puranen J, Ala-Ketola L. Stress fractures caused by physical exercise. Acta Orthop Scand. 1978 Feb;49(1):19-27.
14. Matheson GO, Clement DB, McKenzie DC, Taunton JE, Lloyd-Smith DR, MacIntyre JG. Stress fractures in athletes. A study of 320 cases. Am J Sports Med. 1987 Jan-Feb;15(1):46-58.
15. Key VH. Leg pain in runners. Current Opinion in Orthopaedics. 2007 Mar;18(2):161-5
16. Patel DS, Roth M, Kapil N. Stress fractures: diagnosis, treatment, and prevention. Am Fam Physician. 2011 Jan;83(1):39-46.
17. Wall J, Feller JF. Imaging of stress fractures in runners. Clin Sports Med. 2006 Oct;25(4):781-802.
18. Prather JL, Nusynowitz ML, Snowdy HA, Hughes AD, McCartney WH, Bagg RJ. Scintigraphic findings in stress fractures. J Bone Joint Surg Am. 1977 Oct;59(7):869-74.
19. Greaney RB, Gerber FH, Laughlin RL, Kmet JP, Metz CD, Kilcheski TS, et al. Distribution and natural history of stress fractures in U.S. Marine recruits. Radiology. 1983 Feb;146(2): 339-46.
20. Mulligan ME. The "gray cortex ": an early sign of stress fracture. Skeletal Radiol. 1995 Apr;24(3):201-3.
21. Rupani HD, Holder LE, Espinola DA, Engin SI. Three-phase radionuclide bone imaging in sports medicine. Radiology. 1985 Jul;156(1):187-96.
22. Brukner P, Bradshaw C, Khan KM, White S, Crossley K. Stress fractures: a review of 180 cases. Clin J Sport Med. 1996 Apr;6(2):85-9.
23. Fredericson M, Bergman AG, Hoffman KL, Dillingham MS. Tibial stress reaction in runners. Correlation of clinical symptoms and scintigraphy with a new magnetic resonance imaging grading system. Am J Sports Med. 1995 Jun-Aug;23(4):472-81.
24. Arendt EA, Griffiths HJ. The use of MR imaging in the assessment and clinical management of stress reactions of bone in high performance athletes. Clin Sports Med. 1997 Apr;16(2):291-306.
25. Gaeta M, Minutoli F, Scribano E, Ascenti G, Vinci S, Bruschetta D, et al. CT and MR imaging findings in athletes with early tibial stress injuries: comparison with bone scintigraphy findings and emphasis on cortical abnormalities. Radiology. 2005 May;235(2):553-61.
26. Markey KL. Stress fractures. Clin Sports Med. 1987 Apr;6(2):405-25.
27. Holder LE, Michael RH. The specific scintigraphic pattern of "shin splints in the lower leg": concise communication. J Nucl Med. 1984 Aug;25(8): 865-9.
28. Van der Wall H, Lee A, Magee M, Frater C, Wijesinghe H, Kannangara S. Radionuclide bone scintigraphy in sports injuries. Semin Nucl Med. 2010 Jan;40(1):16-30.
29. Hirschmann MT, Davda K, Rasch H, Arnold MP, Friederich NF. Clinical value of combined single photon emission computerized tomography and conventional computer tomography (SPECT/CT) in sports medicine. Sports Med Arthrosc. 2011 Jun;19(2):174-81.
30. Moran DS, Evans RK, Hadad E. Imaging of lower extremity stress fracture injuries. Sports Med. 2008 Apr;38(4):345-56.
31. Anderson MW, Greenspan A. Radiology. Stress fractures.1996 Apr;199(1): 1-12.