# Roentgenologic Diagnosis of Stress Fractures and Stress Reactions

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**ABSTRACT: We examined 26 athletes with continued pain after strenuous exercise. We found stress fractures in 15 patients, all of whom had positive roentgenographic studies. Seven of these 15 also had bone scans, all of which were positive. Five patients had stress reactions, all of which showed positive results on bone scan and negative roentgenographic results. Five had occult stress reactions manifested by pain, with normal roentgenographic and scintigraphic results, and one had minor pain not requiring radiologic studies. Stress reaction is contrasted with stress fracture by demonstrating the role of bone imaging in the diagnostic continuum of stress reaction to stress fracture.**

AN APPRECIATION of bone imaging in the continuum of stress reaction to stress fracture is necessary to a proper diagnostic evaluation of patients who have lingering pain after strenuous exercise. Bone has a graded response to increasing levels of stress. Bone scintigraphy and roentgenography are the windows through which one can view the spectrum of bone stress manifested by abnormal remodeling and stress fracture.

Since the introduction of technetium Tc 99m polyphosphate in 1971 as a bone imaging agent, several articles have shown the usefulness of bone imaging in the diagnosis of stress fractures.[1-3] Fortunately, the radionuclide bone scan is very sensitive in revealing increased remodeling of bone,[4] though it is not very specific.[5] Therefore, findings must be evaluated by correlating clinical history with roentgenologic findings. The purpose of this article is to discuss the diagnostic continuum of stress to bone to contrast the differences between stress reaction and stress fracture.

We examined 26 athletes complaining of pain. Most of the patients were examined roentgenographically and scintigraphically. We report the results of these studies to demonstrate the usefulness of bone imaging in the diagnosis of injuries spanning the continuum of stress reaction to stress fracture (Table 1).

**TABLE 1.** Roentgenologic Findings in the Continuum of Stress Reaction to Stress Fracture

| *Continuum of Stress* | *Pain* | *Bone Scan* | *Early Roentgenogram* | *Delayed Roentgenogram (2 to 3 wk Later)* |
|---|---|---|---|---|
| Occult stress reaction | Yes | Normal | Normal | Normal |
| Stress reaction | Yes | "Hot spot" | Normal or stress reaction | Normal or stress reaction |
| Occult stress fracture | Yes | "Hot spot" | Normal | Fracture or evidence of a healing fracture |
| Stress fracture | Yes | "Hot spot" | Fracture | — |

## MATERIALS AND METHODS

During the three years from Feb 4, 1981, to Feb 22, 1984, we saw 26 athletes with a final diagnosis of either stress reaction or stress fracture in an outpatient clinic. The diagnosis of stress reaction was made when there was pain and a focal area of increased perfusion on bone scan, with or without evidence of stress reaction (Fig 1) on early or delayed roentgenograms of the painful extremity. On the other hand, stress fracture was diagnosed when there was pain and a focal area of increased perfusion on bone scan, plus evidence of a stress fracture (Fig 2) on roentgenograms of the painful extremity.

The patients, who were members of athletic teams at a local university, were followed up by the team physician for six months to three years after the initial injury. Treatment was conservative; no discontinuity of bone occurred during the follow-up period.

Evaluation often included bone scanning and x-ray studies. Patients receiving a bone scan were given 10 to 20 mCi of technetium Tc 99m methylene diphosphonate intravenously. An anterior dynamic flow study over the painful area was usually done to exclude osteomyelitis, and delayed static images in two projections were made

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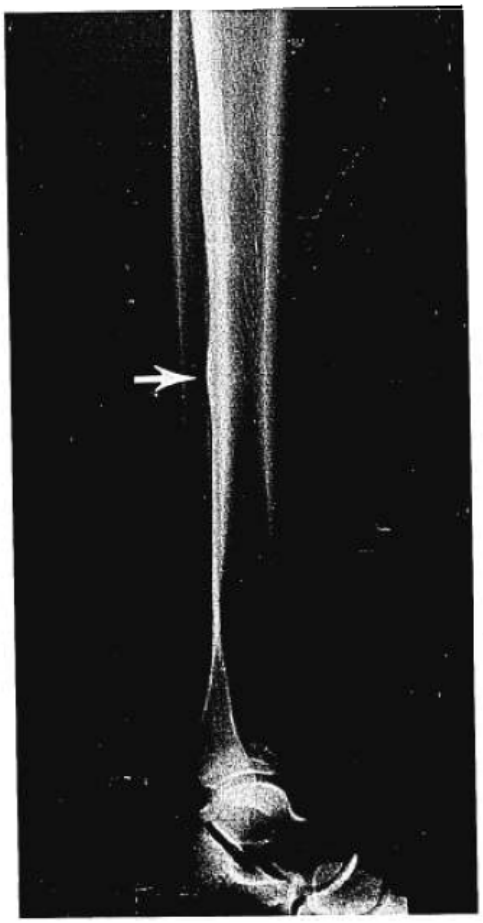

FIGURE 1. (Patient 23) Lateral roentgenogram of right tibia shows linear periosteal new bone formation (stress reaction) in middle third of diaphysis, as well as stress fracture (arrow) in posterior midshaft.

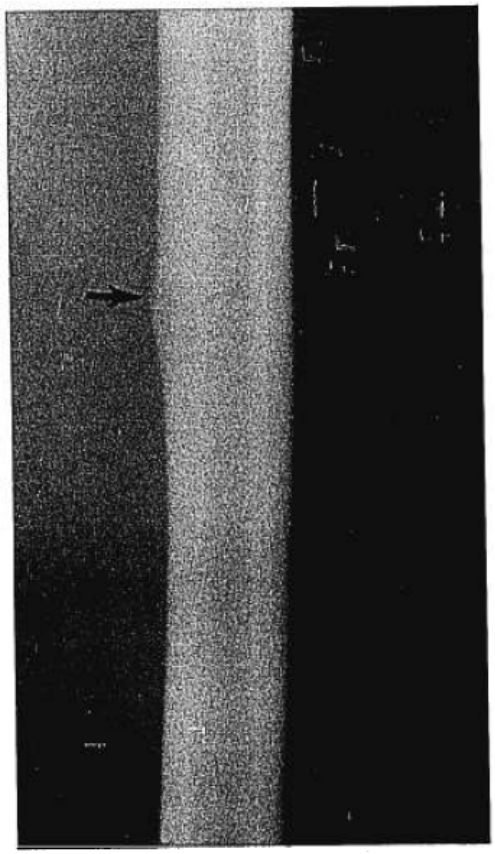

FIGURE 2. (Patient 21) Anteroposterior roentgenogram of midshaft of left femur shows localized area of periosteal new bone formation (stress fracture) on medial side (arrow).

two to three hours later with a gamma camera (Siemans Co). Appropriate roentgenograms were made when indicated, and delayed roentgenograms were obtained in some of the patients.

The bone imaging continuum of stress reaction to stress fracture is shown in Table 1. Bone has a graded response to increasing levels of stress. The least severe stress to bone may be manifested by pain only. This injury is called *occult stress reaction* because all diagnostic studies yield normal findings and there is no imaging evidence of stress reaction. The second degree of stress, *stress reaction,* causes increased remodeling of bone. The bone scan shows increased uptake at the stress site, yet roentgenograms do not indicate a stress fracture. The third level, *occult stress fracture,* is manifested by pain and positive findings on bone scan. Early roentgenograms are normal, but delayed x-ray films show evidence of a healing stress fracture. One may suspect an occult fracture initially, but this hypothesis cannot be proven until the delayed roentgenogram is made. The most severe stress causes a *stress fracture*; the patient has pain, bone scan shows a focal region of increased activity, and a fracture can be seen on x-ray films.

## RESULTS

All patients were treated conservatively. In general, patients with a stress fracture or stress reaction were told to stop exercising for various periods ranging from six weeks to six months. Two athletes had to stop participating in the sport. Analysis of the patients by category shows that 15 patients had stress fracture, with pain and positive roentgenogram (seven of these 15 also had bone scans, all of which were positive); five had stress reaction, with pain, positive bone scan, and roent-

**TABLE 2. Patient Data**

| Patient No. | Age, Sex | Sport | Location of Lesion | Date of Injury or Duration of Pain | Roentgenogram | | Bone Scan |
|---|---|---|---|---|---|---|---|
| | | | | | Initial | Delayed | |
| 1 | 19, F | Volleyball | Both medial tibias | 2 mo | – | 0 | + |
| 2 | 22, F | Volleyball | Right leg | 8-18-81 | – | – | – |
| 3 | 23, F | Volleyball | Both proximal femurs | 2-18-82 | + | 0 | + |
| 4 | 22, F | Tennis | Both femurs | 1981 | – | + | 0 |
| 5 | 22, M | Tennis | Right femur | ? | 0 | 0 | 0 |
| 6 | 19, M | Baseball | Left proximal ulna | 7 mo | – | + | + |
| 7 | 21, M | Baseball | Base of 5th metatarsal | 6 mo | + | + | 0 |
| 8 | 24, F | Basketball | Right distal fibula | 2 mo | – | + | 0 |
| 9 | 23, M | Track | 2nd & 3rd metatarsals | 9-2-82 | + | 0 | 0 |
| 10 | ?, F | Track | Hip | ? | + | + | + |
| 11 | 23, F | Track | Left navicular; 3rd & 4th metatarsals | 4-20-80 | + | 0 | + |
| 12 | 27, M | Track | Right proximal femur | 5-2-80 | + | + | + |
| 13 | 23, F | Track | Right calcaneus | 2-18-81 | – | 0 | + |
| 14 | 23, F | Track | Left medial tibia, midshaft | 6 mo | – | – | + |
| 15 | 20, M | Track | Right 2nd metatarsal | 11-28-83 | – | 0 | – |
| 16 | 20, F | Track | Right femur (subtrochanteric) | 2½ mo | – | + | + |
| 17 | ?, M | Track | Femur | ? | + | 0 | 0 |
| 18 | 23, M | Track | Upper third of left fibula; right lateral malleolus | 8 mo | – | – | – |
| 19 | 24, M | Track | Calcaneus | 9-5-80 | – | 0 | – |
| 20 | 22, M | Track | Both proximal femurs | 3-18-81 | – | + | 0 |
| 21 | 25, M | Track | Left proximal femur | 2-4-81 | + | + | 0 |
| 22 | 21, F | Track | Both tibias | 1-16-82 | – | – | – |
| 23 | 24, F | Track | Right posterior tibia | 2-20-81 | – | + | 0 |
| 24 | 21, M | Track | Left distal tibia | 2-11-84 | – | – | + |
| 25 | 19, F | Track | Calcaneus | 2-84 | – | – | + |
| 26 | 20, M | Track | Right tibia | 4-18-84 | – | + | + |

– = Negative; + = positive; 0 = not done.

genogram negative for fracture; five had occult stress reaction, manifested by pain only, with negative roentgenogram and bone scan; and one patient's pain was so minor that no radiologic studies were done (Tables 2 and 3).

Pain that intensified with exercise and decreased with rest was by far the most common reason our patients consulted a physician. The pain nearly always involved the leg, common sites being the lower back, hip, thigh, leg, and foot. Sometimes there was point tenderness over the affected bone.

Stress injuries to the calcaneus were common. Patient 25, a 19-year-old woman, complained of pain in the right heel. Bone scan showed a focal area of increased activity, but roentgenograms showed no abnormality, so stress reaction was diagnosed (Fig 3).

Runners frequently complained of "shin splints." Patient 23, a runner, had a long history of unilateral "shin splints." Lateral roentgenogram showed linear new bone formation (Fig 1) parallel to the periosteum of the middle third of the tibial diaphysis, representing periosteal stress reaction. There was also a localized area of cortical thickening in the posterior midshaft of the tibia, typical of stress fracture.

Injury to the medial aspect of the thigh not infrequently caused a stress reaction at the insertion of the adductor muscles on the femur. In Patient 21, a male athlete, pain that increased with exercise developed in the medial portion of the upper thigh. Increased bone formation and localized periosteal thickening was seen 13 cm below the lesser trochanter (Fig 2), where the adductor longus inserted. In Patient 12, another athlete complaining of pain just below the lesser trochanter, roentgenogram showed punctate cortical thickening at the insertion site of the adductor brevis (Fig 4). Bone scan done on the same day showed a focal area of increased perfusion at the same site. Figures 2 and 4 show stress fractures at the insertion sites of the adductor longus and adductor brevis, respectively.

Patient 10 had pain in the medial portion of the upper thigh. Initial x-ray film was normal (Fig 5), but bone scan showed a focal area of increased perfusion, indicative of stress reaction. Occult stress fracture at the insertion site of the adductor brevis was diagnosed when later roentgenograms showed a localized area of periosteal new bone formation at the insertion site of the muscle.

Runners frequently complained of diffuse tibial pain typical of shin splints, but they rarely complained of focal pain in the shin suggestive of a stress

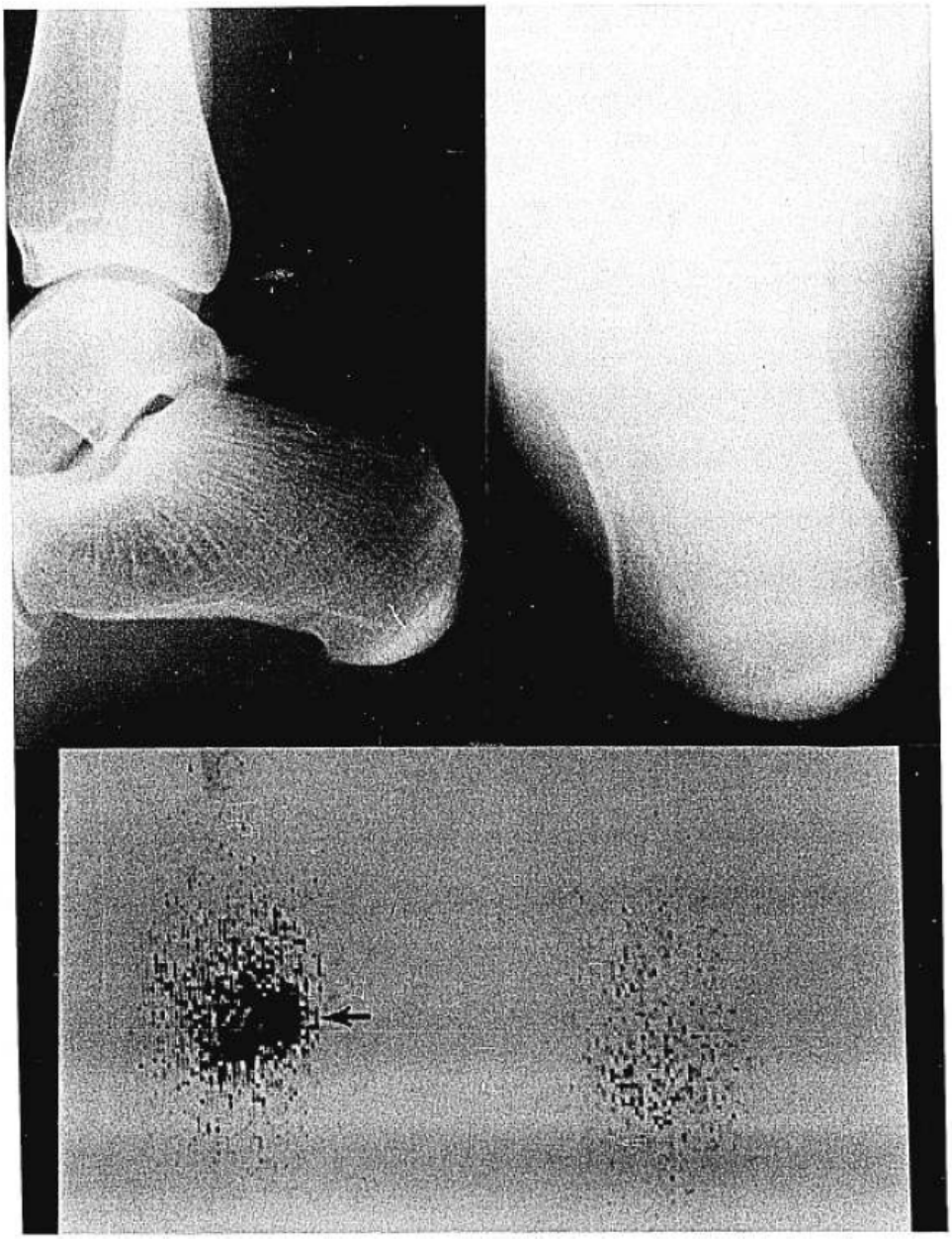

**FIGURE 3.** (Patient 25) Lateral *(top left)* and plantar *(top right)* roentgenograms of calcaneus show no fracture. *(Bottom)* Plantar scintiscan of both heels shows focal area of increased activity in right calcaneus (arrow).

fracture. Patient 26 complained of pain along the popliteal-soleal line of the posterior midshaft of the tibia. The initial x-ray film was normal, and the patient continued to run, against medical advice. The pain became more intense and localized, and two months later, roentgenogram showed a stress fracture (Fig 6) of the midportion of the posterior tibia, confirmed by bone scan done on the same day.

## DISCUSSION

Distinguishing stress reaction from stress fracture allows the physician to choose appropriate treat-

**TABLE 3.** Frequency of Results of Diagnostic Studies

| Roentgenogram | | | |
|---|---|---|---|
| *Initial* | *Delayed* | *Bone Scan* | *No. of Patients* |
| − | + | 0 | 4 |
| − | + | + | 3 |
| − | − | + | 3 |
| + | + | + | 2 |
| + | 0 | 0 | 2 |
| + | 0 | + | 2 |
| + | + | 0 | 2 |
| − | 0 | + | 2 |
| − | 0 | − | 2 |
| 0 | 0 | 0 | 1 |
| − | − | − | 3 |

− = Negative for stress fracture; + = positive for stress fracture; 0 = not done.

ment. Treating a stress reaction nearly always prevents serious fractures from causing significant morbidity. Appropriate therapy for stress reaction commonly obviates the need for a delayed roentgenogram.

Wilcox et al[6] studied 34 patients with symptoms of stress fracture, and found that 13 had normal and 21 had abnormal findings on bone scan. None of the patients with normal bone scans had roentgenographic evidence of stress fracture, but 18 of the 21 with abnormal bone scans had roentgenographic evidence of stress fracture. Many of these patients had normal initial roentgenograms. The three with abnormal bone scans and normal findings on both initial and delayed roentgenograms may have had stress reaction, ligamentous injury, bone abrasion, or soft tissue trauma with hemorrhage. Since the abnormal scans all involved the tibia, a classic site for stress reaction, the authors concluded that the three had tibial stress reaction.

Marty et al[7] reported a study of 21 athletes at the University of Washington. Three had symptoms of stress fracture with normal bone scans, and 18 had symptoms of stress fracture with abnormal bone scans. Four of the 18 had normal roentgenograms initially, and abnormal roentgenographic findings two to three weeks later. Unfortunately, the authors did not mention the number of patients with abnormal bone scans and normal roentgenograms.

Spencer et al[8] studied four young patients who had pain over the anterior compartment of the legs after strenuous exercise. Roentgenograms were normal in each case, but bone scans were abnormal; delayed roentgenograms were not obtained. Repeated stress causes bone remodeling, which may result in stress fracture. Initial roentgenograms may be normal, but roentgenograms made two to three weeks later may show a fracture or evidence of healing.

The pathophysiology of stress reaction may in-

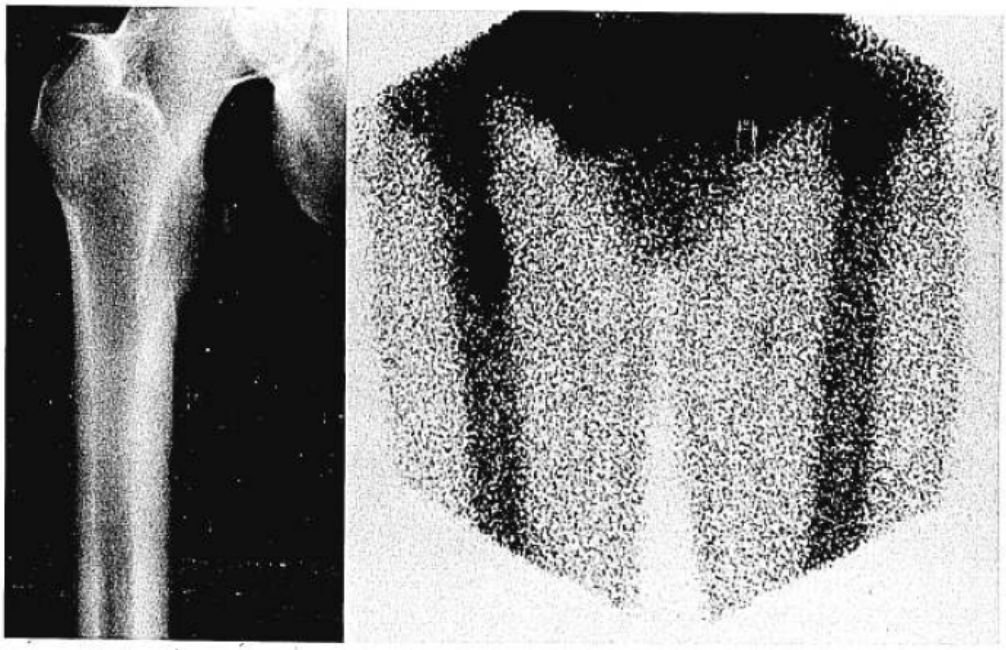

**FIGURE 4.** (Patient 12) *(Left)* Anteroposterior roentgenogram of right femur shows stress fracture just below lesser trochanter on medial side. *(Right)* Scintiscan of both proximal femurs shows increased tracer activity at fracture site.

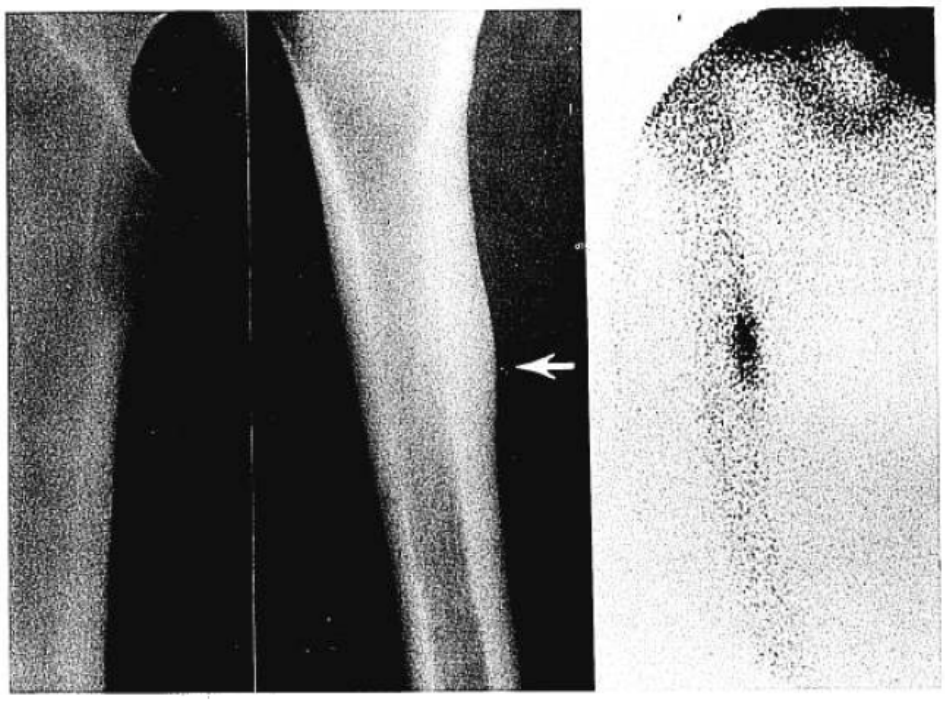

**FIGURE 5.** (Patient 10) *(Left)* Oblique roentgenogram of right femur shows no fracture. *(Center)* Delayed anteroposterior roentgenogram shows focal area of periosteal new bone formation (stress fracture) just below lesser trochanter (arrow). *(Right)* Scintiscan shows focal area of increased activity just below lesser trochanter at stress fracture site.

clude localized or diffuse areas of increased bone resorption. In the study of Spencer et al[8] of bone scan abnormalities in shin splints, one patient had a focal area of increased uptake in both tibias, two had uneven uptake in both tibias and fibulas, and one had increased uptake in the lateral malleoli and bones of the feet.

Geslien et al[9] did bone scans on 200 Army recruits 17 to 30 years of age between their third and fifth weeks of exercise and again one to two weeks after symptoms developed. There was evidence of increased activity on bone scan in 70%. At the time of the bone scan, 60% had normal initial roentgenograms; two to three weeks later, 40% had roentgenographic evidence of stress fracture. Reformation of bone more appropriate to stress may occur, particularly if the patient exercises less to allow new bone to reinforce the weakened remodeled bone enough to prevent fracture.[9]

Roub et al[10] described a model of bone response to increasing levels of stress and suggested that the term *stress fracture* be used to refer to the entire range of bone pathology resulting from stress that exceeds bone strength and produces pain and positive findings on bone imaging. It is our opinion, however, that the term *stress fracture* should be reserved for those cases that have positive bone scans and roentgenographic evidence of fracture;

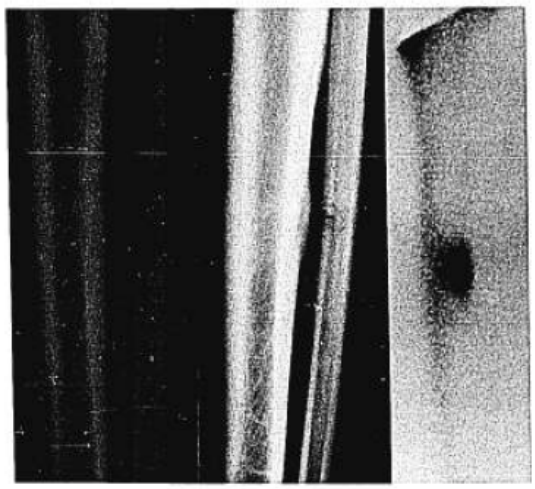

**FIGURE 6.** (Patient 26) *(Left)* Lateral roentgenogram of right tibia shows no fracture. *(Center)* Same view two months later shows stress fracture of posterior midshaft. *(Right)* Scintiscan of lower leg shows localized area of increased tracer activity at stress fracture site.

we believe the term *stress reaction* should be used in cases with positive bone scans, but without evidence of fracture on either initial or delayed roentgenograms. It should also be noted that stress reaction may be seen on roentgenograms as well. For example, Figure 2 shows a stress reaction posteriorly that involves the middle third of the diaphysis of the right tibia, as well as a stress fracture of the posterior portion of the tibial midshaft.

Rupani et al[11] examined 238 patients with sports-related injuries and found that 79 (33%) had stress fractures and 111 (47%) had bone stress lesions (stress reaction). In descending order of frequency, the regions of injury were the tibia and/or fibula, foot, lumbar spine, femur, pelvis, and hip. The authors concluded that bone scans were helpful in patients with unexplained pain and roentgenograms that appeared normal. Though a specific diagnosis could not be made, objective evidence of a bone abnormality could be obtained along with anatomic localization of the stress reaction.

## CONCLUSIONS

The diagnosis of stress injury to bone can be documented by either a focal or diffuse area of increased uptake of radionuclide (stress reaction) on bone scan.[12,13] If clinically indicated, a roentgenogram should be done to see if there is evidence of a stress fracture or (on a delayed roentgenogram) evidence of a healing fracture. Bone scan alone should not be used to diagnose fracture; other injuries such as ligamentous injury, bone abrasion, and soft tissue trauma can cause increased radionuclide activity in bone. Some injuries caused by repeated stress show a stress reaction on bone scan with no abnormalities on either initial or delayed roentgenogram. Rarely, stress reaction shows on x-ray film as linear periosteal new bone formation (Fig 2). Most repeated stress injuries to bone severe enough to cause the patient to consult a physician will lead to fatigue and fracture; they are manifested by a positive bone scan and either an initial or a delayed roentgenogram positive for fracture.

An appreciation of the imaging continuum of stress reaction to stress fracture is helpful in understanding the pathophysiology of these injuries. In the diagnostic evaluation of patients who have pain after strenuous exercise, it is sometimes helpful to obtain bone scans as well as bone roentgenograms. When the index of suspicion is high in a patient with characteristic "bone pain" that occurs after exercise-related stress and is relieved by rest, and roentgenogram is normal, then a bone scan may be done. The patient should avoid the provoking stress for two or three weeks, after which additional roentgenograms are made. If these delayed roentgenograms are normal, stress fracture can be excluded. Once stress reaction has been suspected clinically, a cautious approach, having the patient proceed gradually with activity, is indicated.

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