Computed Tomography of Stress Fractures


Abstract: Three cases of stress fractures of the lower extremities are presented with corresponding CT. Findings of increased medullary cavity density, endosteal sclerosis, callus formation, and soft tissue swelling are demonstrated even though they are thought to be nonspecific in differentiating stress fracture from infectious or neoplastic processes. Only when actual failure lines are demonstrated by CT can stress-related injury be specifically suggested. Index Terms: Bones, fractures—Legs, wounds and injuries—Computed tomography.

Although stress fractures of the extremities have become increasingly well recognized, the patient with periostitis, an abnormal bone scan, and only a vague history of skeletal trauma may still present a diagnostic dilemma. Subsequent follow-up examinations often reveal the etiology of the painful extremity but may subject the patient to weeks of uncertainty and inadequate treatment. In addition, stress fractures may progress to complete fractures if appropriate casting, fixation, or limb rest are not provided (1,2). Recently the value of CT for assisting in the diagnosis of stress fractures has been demonstrated (3). We report three cases of occult fractures of the lower extremities. In two cases CT aided in establishing the diagnosis, and in one case CT was unable to distinguish between stress fracture and malignancy.

CASE REPORTS

Case 1

A 7-year-old boy was referred because of a 4 week history of right thigh pain. Roentgenography revealed middiaphyseal periosteal reaction of the right femur (Fig. 1a), and a gallium scan demonstrated increased tracer uptake in this region. A radionuclide bone scan also showed increased 99mTc-pyrophosphate accumulation at the same location. Although there was a history of minor thigh trauma, the patient’s weight loss and anorexia raised the clinical suspicion of an early Ewing sarcoma of the right femur.

Computed tomography of the right femur revealed circumferential cortical thickening with moderate increased density of the medullary cavity. In addition, lucent fracture lines of the anteromedial and posteromedial cortex of the right femur were defined (Figs. 1b and c). With CT making stress fracture the most likely diagnosis, the clinicians elected conservative management rather than open biopsy. Follow-up films showed resolution and consolidation of the periosteal reaction compatible with a healing stress fracture.

Case 2

An 8-year-old girl presented with a history of several weeks of left shin pain and a warm, tender, swollen left midleg after taking up “break-dancing.” Roentgenography of the tibia and fibula showed significant focal sclerosis of the midtibial region with periosteal reaction focally around an area of permeated lucent cortex. A radionuclide bone scan displayed a focal, sharply margined area of increased activity of unknown etiology in the left leg. Subsequent CT revealed increased density within the medullary cavity, endosteal sclerosis, and areas of cortical rarefaction in the left midtibia (Figs. 2a and b). Because no distinct fracture line was defined, CT could not distinguish with certainty between stress fracture and neoplasm. Continued clinical suspicion of a neoplasm led to an open biopsy of the lesion. Pathologic specimens disclosed fragments of bone with reactive new bone formation, loose fibrous tissue, chronic inflammation, and perivascular edema of the periosteum (Fig. 2c). Pathologic interpretation was that of a healing stress fracture. The periosteal reaction and biopsy site healed uneventfully on follow-up radiography and the patient’s symptoms abated over several weeks.

Case 3

A 55-year-old woman, recently treated for deep venous thrombosis, had undertaken a vigorous walking program
and presented with diffuse left calf pain and swelling. Plain roentgenography showed diffuse periosteal reaction, cortical thickening, and an area of radiolucency in the left tibia (Fig. 3a). Because of the focality of the leg pain, a bone scan was obtained and demonstrated diffuse tracer uptake along the lateral tibial cortex of both legs with no focal accumulation. This was felt to be secondary to stress-related change or venoocclusive disease, with no evidence of stress fracture. Subsequent CT revealed endosteal thickening, increased density of the marrow cavity, as well as a focal area of irregularity of the inner cortical margin suggestive of an incomplete fracture (Figs. 3b and c). Follow-up plain radiography showed resolution of these changes after nonweight bearing treatment.

DISCUSSION

Plain radiography is notoriously insensitive in the initial evaluation of stress-related injury. Ideally, a continuum of changes with subtle early, blurring of trabecular margins, followed by small speckles of new bone formation, fluffy clusters of new bone, sclerotic bands along fracture sites, and, finally, callus formation with periosteal reaction would be seen with sequential examinations (4). Unfortunately, positive plain radiography at acute presentation was found in only 22–40% of three major series (5–7). Even several weeks after the clinical and scintigraphic confirmation of stress fractures, the estimated frequency of continued negative plain radiography is 20–50% (2,4,6,8,9). Because of this well-recognized insensitivity, plain roentgenography alone may provide inadequate evaluation of stress-related trauma.

Radionuclide bone scanning has become the sine qua non of stress-related injuries. Most radiologists have adopted the Wilcox conviction that a normal

**FIG. 1.** Case 1. A 7-year-old boy with a 4 week history of right thigh pain. a: Plain film of right femur demonstrates periosteal reaction without evidence of a fracture line. b: CT scan through midfemur demonstrates evidence of a fracture line with adjacent periosteal reaction (arrow). The image is at window width 2,500 and center 1,400. c: Image at soft tissue windows demonstrates increased medullary density of right femur when compared with the left femoral medullary cavity.

**FIG. 2.** Case 2. An 8-year-old girl with a history of several weeks with a painful, swollen left midleg. a: CT scan at soft tissue window settings demonstrates increase in medullary density of cortex of left tibia. b: CT scan at bone setting demonstrates irregularity of cortex with diffuse lucency seen within cortex. The pattern suggests a permeated lesion. No fracture was seen. c: Reactive bone formation at fracture site. Note the irregular spicules of woven bone with associated osteoblast activity (arrows). Hematoxylin/eosin stain. ×115.
bone scan excludes the diagnosis of stress fracture (10). In Matin's study of scintigrams following acute fractures, 80% were positive within 24 h after injury, and 95% positive within 72 h (11). With stress fractures there generally is a later clinical presentation (average 15.4 days), by which time the bone scan is routinely positive (5). Roub et al. described a progression of injury on bone scintigraphy from a nondescript, poorly defined area of slightly increased uptake to a sharply marginated fusiform area of activity in cases proceeding from "injury" to actual stress "fracture," with reversal of this pattern after proper treatment (8). Unfortunately similar bone scan findings may be seen with focal metastases, early osteomyelitis, periostitis, osteoid osteomas, bone infarcts, primary bone tumors, and dysplasias of bones (1,4,8). Even with a history of trauma, soft tissue injury with hemorrhage, ligamentous injury, bone abrasions, and acute fracture may produce abnormal bone scans, as can traumatic myositis ossificans and rhabdomyolysis (10,12). Nearly all of the authors reporting abnormal bone scans in stress fractures describe their findings as areas of increased uptake but report no specific diagnostic features (1,4–6,9,13,14). Because of this, all of the authors emphasize the need for roentgenographic correlation and heed Roub's admonition "to remember that diagnoses other than bone stress must also be considered with this radionuclide appearance" (8). However, since confirmatory roentgenograms are seen in less than 50% of cases of abnormal bone scans, the differential diagnosis must still include diseases such as early osteomyelitis, subtle osteoid osteomas, Ewing sarcoma, as well as the nonfracture traumatic entities discussed above.

Recently, Somer and Meurman in a survey of 12 patients demonstrated the successful use of CT in diagnosing stress fractures (3). They found endosteal as well as periosteal callus formation, increased density of the bone marrow cavity, and soft tissue edema at the site of the stress fractures in the majority of their cases (3). The bony callus formation occurred at the sites described earlier as most common for stress fractures; however, a visible fracture line was seen in only one of their 12 cases (3). Murcia et al. reported a single case of a tibial stress fracture in which multiple linear infarctions were seen within the tibial cortex at CT, although plain films were negative (15).

Somer and Meurman's finding of increased bone marrow density with stress fractures has been demonstrated in cases of osteomyelitis, fibrous dysplasia, Gaucher disease, Ewing sarcoma, osteosarcoma, and other neoplasms (3,16–19). The findings of localized homogeneous endosteal and periosteal callus formation may be seen with osteoid osteomas, osteomyelitis, as well as with stress fracture, but demonstration of a nidus and the clinical history may separate the three (16,20). Demonstration of thin linear infarctions in the bony cortex in the absence of other "malignant" findings seems most specific for stress fractures although the potential for misdiagnosing pathologic fractures of bone remains (3,15). Although fracture lines have been reported to be better seen on plain radiography than on CT, obscuration on plain films by periosteal bone and callus formation may permit CT demonstration of otherwise occult stress fractures. Thus CT, although often nonspecific for stress fractures, may occasionally assist as a third line modality for the differentiation of stress fracture from...
neoplasm. We confirmed Somer and Meurman's findings of increased bone marrow density, endosteal and periosteal new bone formation, and soft tissue edema, all nonspecific findings, in our three cases of stress fractures. In addition, fracture lines were visualized in two of the three cases, thereby supporting the diagnosis of stress fracture. In the third case the CT findings were nonspecific and an open biopsy was required to rule out a neoplasm. Finally in one case a bone scan failed to demonstrate a localized focus of activity within a background of diffuse uptake, although CT revealed a subtle inner cortical fracture.

In conclusion, in those cases where a distinct fracture can be demonstrated, CT may be able to make the definitive diagnosis of stress fracture when neither plain film nor radionuclide bone scan is sufficiently specific. It is important to note, however, that in many instances, CT will demonstrate only the nonspecific findings associated with stress fractures, and that in such cases the differential diagnosis will continue to include neoplasms and infectious processes.

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REFERENCES