CHAPTER **30**

DIAGNOSTIC ULTRASOUND FOR EARLY DIAGNOSIS OF METATARSAL STRESS FRACTURES

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Stress fracture of the metatarsal bone is a common injury encountered by podiatric physicians. The injury is seen most often in athletes and post-menopausal women. Abnormal stresses through normal bone or normal stresses applied to abnormal bone can result in a stress fracture. The diagnosis is most often based on clinical findings of localized edema and point tenderness with palpation over the fracture site. Radiographic evidence of the fracture is delayed three to four weeks after the onset of the symptoms. This can lead to suspicion of other diagnoses instead of a stress fracture. Historically, bone scans and magnetic resonance imaging are used when the diagnosis is in question. Diagnostic ultrasound is an alternative imaging modality that has many advantages over the more traditional modalities used to diagnose stress fractures before radiographic signs appear. This article will discuss the various imaging modalities used to diagnose metatarsal stress fractures and compare them with diagnostic ultrasound.

PLAIN FILM RADIOGRAPHS

The most commonly used modality for any suspected bone injury is plain film radiography. The dorsal-plantar, lateral-oblique, and lateral views are typically ordered. Stress fractures of metatarsals rarely displace during the initial onset (Figure 1); therefore, it is difficult to identify this injury until the bone callus begins to form three to four weeks later (Figures 2, 3). This delay in diagnosis can often lead to inappropriate treatment. Other more sensitive modalities have been employed to arrive at a more timely diagnosis.

THREE-PHASE BONE SCAN

The three-phase bone scan is the most commonly used secondary modality to identify metatarsal stress fractures. The stress fracture of the metatarsal would show and increase in uptake of intravenously injected Technetium at the injury site (Figure 4). This

Figure 1. Dorsal-plantar view of a patient with a 2-day history of pain and swelling over the second metatarsal shaft. No signs of fracture noted.

Figure 2. Dorsal-plantar view of the same patient 4 weeks later. Notice the faint sign of the bone callus located midshaft on the second metatarsal.

Figure 3. Dorsal-plantar view 8 weeks after onset of symptoms. Notice the exuberant calcified bone callus.

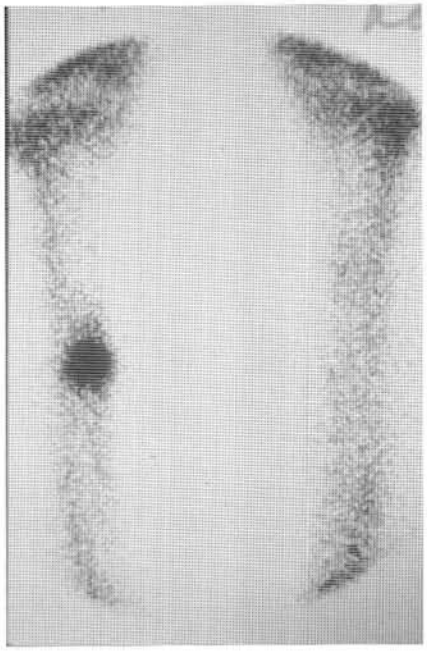

Figure 4. Three-phase bone scan of a tibial stress fracture demonstrated by increased uptake of radionuclide at the fracture site.

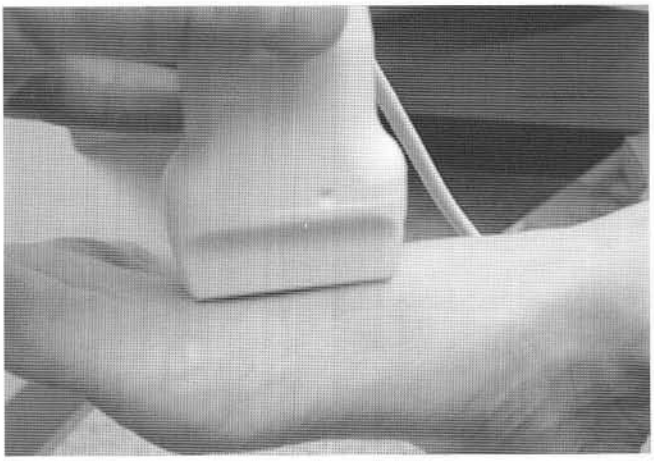

Figure 5. Proper transducer position for a longitudinal scan of the metatarsal region.

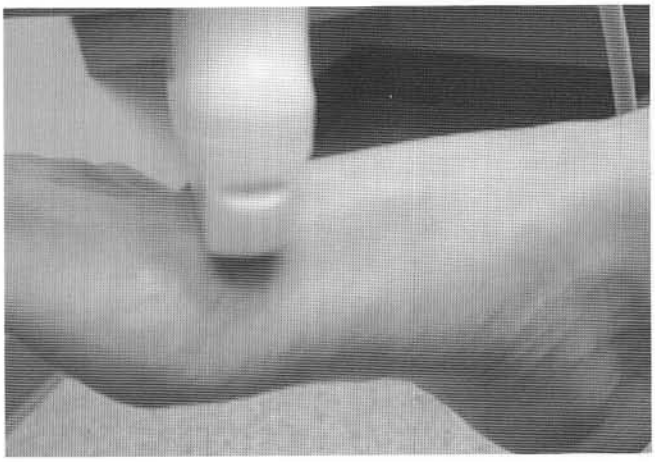

Figure 6. Proper transducer position for a transverse scan of the metatarsal region.

scan would be positive immediately after the injury. The bone scan is highly sensitive but not specific. Other diagnoses that could cause a false positive include arthritides, tumors, or osteomyelitis. The test must be performed at a hospital and takes approximately four hours to complete.

MAGNETIC RESONANCE IMAGING

Magnetic resonance imaging (MRI) has been used to diagnose stress fractures in the foot and ankle. The fracture line is visualized as well as intramedullary edema at the fracture site. The MRI will show the exact location of the injury. This test can be performed in the hospital or outpatient setting. Cost and patient comfort are the most common disadvantages of this test.

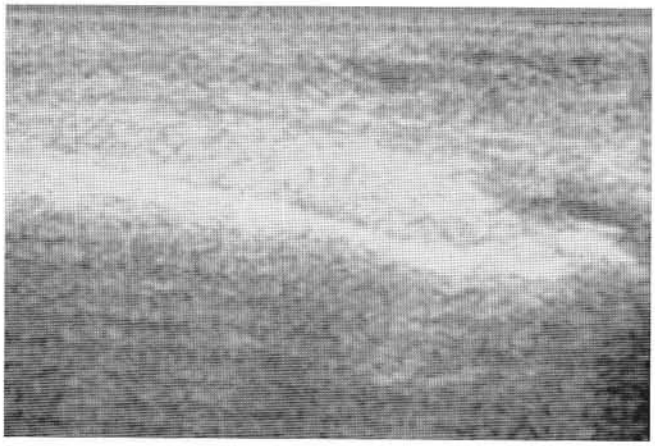

Figure 7. Longitudinal scan of a one week old stress fracture. The dark fracture line is seen running perpendicular through the bright dorsal cortex. The hematoma is seen as a darker fusiform area adjacent to the cortex at the level of the fracture.

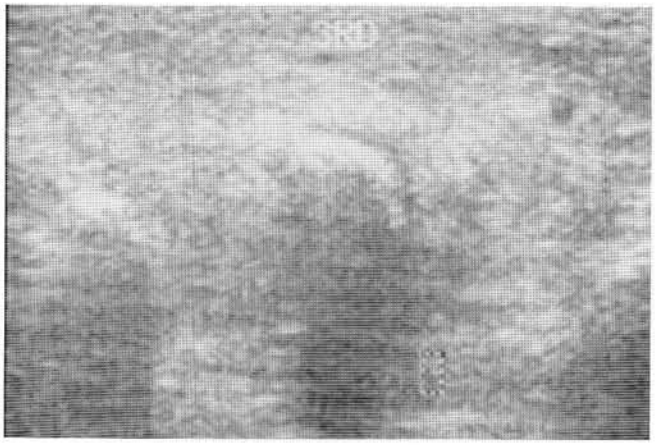

Figure 8. Transverse scan of the same patient. The bright crescent shape represents the dorsal cortex of the metatarsal. The dark crescent shaped area adjacent to the bright cortex is the hematoma. The dark shadow effect beneath the bright cortex is due to inability of the sound waves to pass beyond the cortex.

DIAGNOSTIC ULTRASOUND

Diagnostic ultrasound is very helpful in the diagnosis of soft tissue disorders of the foot and ankle. It has not been used often in the diagnosis of bone injuries because of limitations of the depth and clarity of the visual field of the study. Recent advances in the transducer technology have addressed these shortcomings. Two planes of imaging are recorded. The longitudinal scan is performed with the transducer parallel to the long axis of the metatarsal or in the sagittal plane (Figure 5). The transverse scan is performed with the transducer perpendicular to the long axis of the metatarsal creating a cross-section image (Figure 6).

During the acute inflammatory stage of the stress fracture, the hematoma that forms as a result of the injury can be seen on the ultrasound as a darker region adjacent to the brighter metatarsal cortex on both the longitudinal and transverse scans (Figures 7, 8). The fracture line can also be seen on the longitudinal scan as a darker line running from the periphery of the cortex into the medullary canal. The plantar cortex cannot be visualized from the dorsal approach because of the shadow phenomenon that occurs from the inability of the sound waves to travel through the dense cortex.

DISCUSSION

Diagnostic ultrasound is inexpensive and can be performed in the office. Examiner-patient interaction insures that the precise location of the injury is identified and examined. This reduces the time of examination. The study can also be performed in pregnant women and in patients with metallic implants and pacemakers.

The quality of the image obtained is directly related to the examiner experience and transducer frequency. With time the learning curve for obtaining and reading ultrasound images can be overcome. The introduction of higher quality transducers has already addressed the earlier problems of image clarity.

Diagnostic ultrasound has been underutilized in the early diagnosis of metatarsal stress fractures. This in-office modality has been found by the author to be both very sensitive and specific for this common foot injury. The most timely, accurate diagnosis and initiation of treatment at the lowest expense can be obtained with diagnostic ultrasound.