# STRESS FRACTURES

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Stress fractures have been described by a variety of terms including march fracture, bone exhaustion, fatigue fracture, and insufficiency fracture. Previously, the literature has focused on stress fractures and their prevalence among military personnel. However, stress fractures are not selective and recent literature documents the occurrence in those ranging from athletes (professional and amateur) to housewives.

## Incidence

The incidence of stress fracture varies. Tibial, calcaneal, and metatarsal fractures represent almost 80% of those documented. The second and third metatarsals are the most common metatarsals effected. Stress fractures of the first, fourth, and fifth metatarsals have been reported; however, these fractures were noted to be rare (1). The tarsal bones are infrequently involved except the calcaneus. A few reports have been published documenting stress fractures of talus and navicular (2, Devas, 1975, 4). Stress fractures of the cuneiform bones, although infrequent, may not be as rare as some earlier literature indicates. Meurman (1, 5) has reported several stress fractures of the cuneiforms. Occasionally, the sesamoids are involved as reported by several authors (3, 6) (Fig. 1).

**Fig. 1.** Fibular sesamoid stress fracture. Note radiolucent line extending from proximal, lateral cortex to distal, medial cortex.

## Symptoms and Differential Diagnosis

There is usually no history of acute trauma. Symptoms will vary depending on the location of the stress fracture. Localized edema and pain exacerbated by activity and relieved by rest are the classical presentation. However, symptoms may be similar to those associated with sesamoiditis or shin splints depending on the location of complaint. Diagnosis of a stress fracture requires a high degree of suspicion.

### *Pathogenesis*

A stress fracture has been described as a partial or incomplete fracture resulting from inability of the bone to withstand low intensity stress that is applied in a rythmic subthreshold fashion. Bone responds to stress in excess of the accustomed amount by a process known as osteonal remodeling or osteonization. Circumferential lamellar bone is resorbed and subsequently replaced by dense osteonal bone as described by Sweet and Allman, 1971. Thus, following the onset of stress there is a time when the cortical bone is weakened prior to osteonal new bone formation. These cortical sites of bony resorption are more likely to become micro-fractures and continued stress may encourage gross fractures.

This sequence occurs since bone replacement is a slow process, whereas resorption occurs quickly producing a cortex temporarily weakened. This process can be interrupted if stress is eliminated or decreased enough to allow bone formation to occur at a greater rate than resorption. Utilizing this concept it is thought stress fractures are part of a continuum and not an isolated occurrence as an acute, traumatic fracture would be described. Stress fractures result during remodeling of normal bone when resorption of bone exceeds repair, making it a process not an event.

The forces which act on bone to produce stress have been described as either bending or compression forces. Stress fractures of cortical bone (metatarsals) are usually secondary to bending forces; whereas, compression forces are most frequently responsible for fractures of soft, cancellous bone (tarsal bones).

### *Diagnosis*

Diagnosis of a stress fracture depends on clinical as well as radiographic findings. Symptoms as previously described are usually classic, but may be misleading. A high

degree of clinical suspicion as well as appropriate use of radiographic modalities will increase the rate of proper diagnosis.

A confirmed diagnosis of a stress fracture is dependent on one or more of the following radiographic findings: periosteal new bone formation, endosteal thickening or a radiolucent line extending through at least one cortex. More specifically, as outlined by Savoca (2) cortical defect and periosteal new bone formation are seen in the shaft of long bones. Medullary sclerosis is classically seen in short bones such as the calcaneus and in the metaphysis of long bones such as the first metatarsal. These findings usually appear several weeks after injury. Tibial and fibular stress fractures commonly appear later radiographically than is true in the bones of the foot. A delay in diagnosis may not necessarily be a problem since conservative therapy focused at reducing bone stress will usually relieve the symptoms while awaiting the results of serial radiographs performed on a weekly basis.

However, athletes in training and those individuals who are unable to reduce activity may continue to produce stress so that symptoms continue or overt fracture occurs. Considering this scenario, rapid identification of any pathologic changes in bone would seem important.

Conventional radiography was found to be positive in only 22-40% (at acute presentation) by several major studies (Fig. 2A). It has been well documented with scintigraphic confirmation of a stress fracture, that even several weeks after injury continued negative conventional radiography is estimated to be at a rate of 20-50%.

Radionuclide bone scanning has become the definitive diagnostic exam for stress injuries (Fig. 2B). Wilcox states that a normal bone scan excludes the diagnosis of stress fracture. Following acute fracture Matin (7) concluded 80% were positive within 24 hours and 95% within 72 hours. When evaluating stress fractures there is usually a later clinical presentation by which time the scan is consistently positive.

The technique of choice involves the use of technetium, 99m methylene diphosphonate in a triphasic manner. The three phase exam should include:

1. the radionuclide angiogram
2. blood pool images
3. delayed image for complete evaluation.

Although a positive bone scan has become the definitive diagnostic modality, Roub (8) warns that diagnoses other than stress fracture must be considered. These include osteoid osteoma, Ewing's sarcoma, hematogenous osteomyelitis, periostitis, and focal metastases. Since bone scanning is extremely sensitive for stress fracture but not specific for detail or location, conventional radiographic

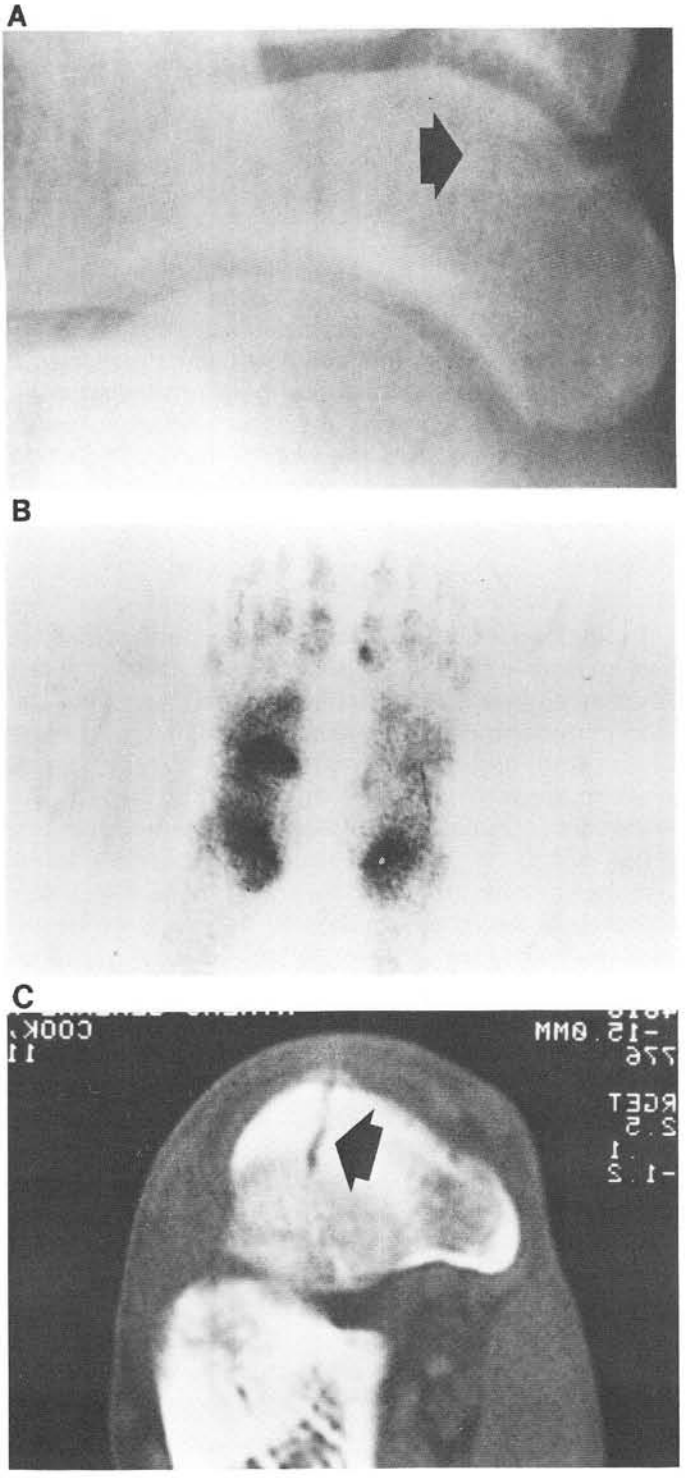


**Fig. 2.** Navicular stress fracture. **A.** Note questionable cortical break on medial navicular surface. **B.** Technetium-99m MDP bone scintigraphy demonstrating increased uptake in the region of the left navicular. **C.** Computed tomography (CT) provides further detail and identifies specific location of navicular stress fracture.

correlation should be performed several weeks after clinical presentation.

In most cases the diagnosis of a stress fracture is evident based on bone scans or plain radiographs with clinical correlation. As stated previously, confirmatory radiographs are seen in less than 50% of those cases with positive bone scans. Thus when painful symptoms continue and radiographic or clinical correlation is non-confirmatory, further diagnostic examination may be necessary. Routine tomography may be utilized to add further specificity to a diagnosis. However, where sufficient doubt concerning the diagnosis exists or further detail is desired computed tomography (CT) is most appropriate (Fig. 2C).

CT diagnosis of a stress fracture is based upon the visualization of cortical fracture lines and marked endosteal callus formation. Erosions and periosteal new bone formation below 1-2 mm are not visible on CT. Conventional radiographs are more appropriate for slight periosteal callus or minor cortical fissures. CT reveals subtle differences in tissue density especially useful when ruling out malignancy. Although CT is usually able to make a diagnosis where uncertainty exists further evaluation may be necessary such as biopsy or arteriography. Computerized tomography should be used when sufficient doubt concerning the diagnosis still exists. Table 1 summarizes an organized approach for the diagnosis of stress fractures.

### *Treatment*

Treatment consists of a few fundamental principles. Reduction of activity, limited weightbearing or non-weightbearing if necessary and compression to reduce edema. These modalities are individualized to type and location of the fracture as well as the patient. Treatment plans can be summarized according to anatomic location.

## Forefoot

### *Sesamoids*

1. Reduce activity.
2. Apply compression: Jones compression dressing or Gelocast/Unna boot.
3. Dancers cut-out pad for first metatarsophalangeal joint, or
4. Wear surgical shoe with half inch felt liner (cut out for first metatarsophalangeal joint).

### *Metatarsals*

Essentially same as above. When pain persists or fracture is questionable a below-knee non-weight-bearing cast may be necessary in the treatment of metatarsal stress fractures. Fifth metatarsal stress fractures of the shaft (Jones fracture) may require internal fixation as described by DeLee (9) due to a high incidence of nonunion (Fig. 3). However, avulsion fractures involving the tuberosity of the fifth metatarsal usually heal well with a non-weight-bearing below-knee cast (Fig. 4). Rarely is internal fixation required for this type of fifth metatarsal fracture (Fig. 5).

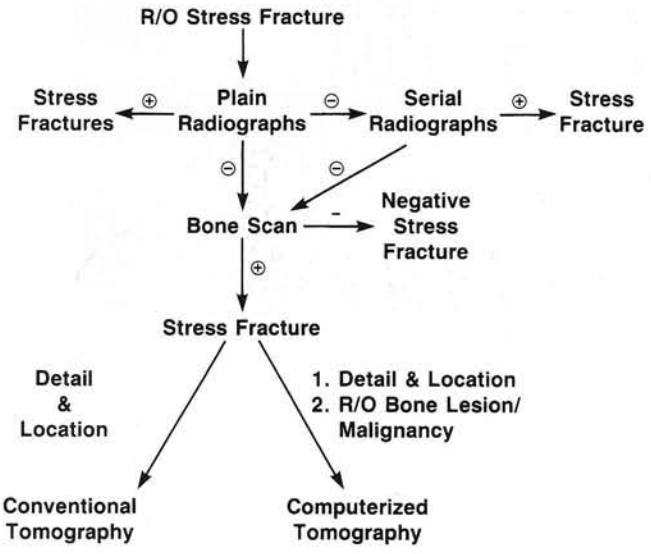


Table 1

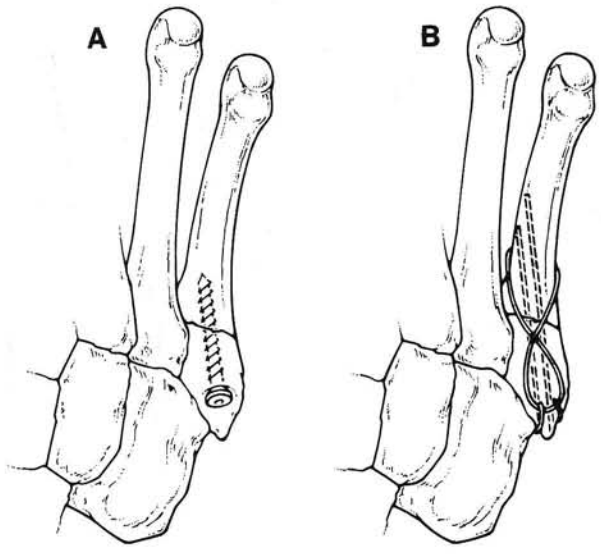


**Fig. 3.** Jones fractures of fifth metatarsal are successfully fixated with either **A.** AO screw fixation or **B.** Tension band technique.

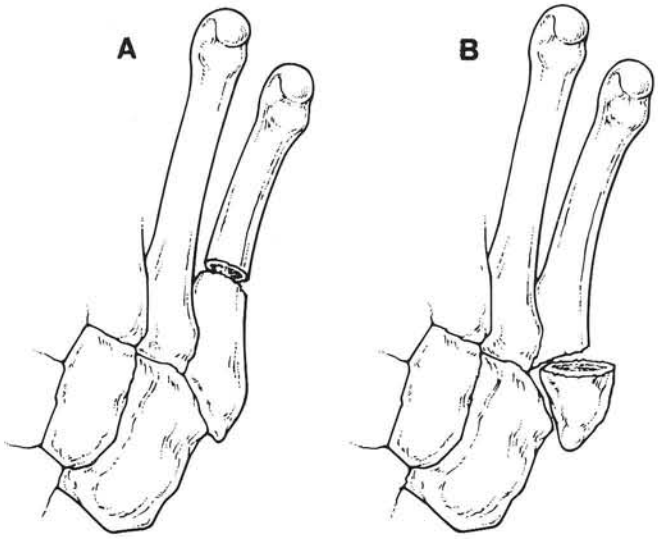


**Fig. 4. A.** Jones fractures are located at proximal diaphyseal-metaphyseal junction and are susceptible to nonunion. **B.** Avulsion fractures involve tuberosity and usually heal without complication.

### *Cuneiforms*

1. Reduce activity.
2. Apply compression initially.
3. May require partial or non-weight-bearing below-knee cast.

### *Rearfoot*

Navicular/Calcaneus:

1. Reduce activity.
2. Apply compression initially.
3. Apply below-knee cast with non-weightbearing for six weeks or evidence of healed fracture.
4. May require open reduction with internal fixation of fracture if displacement exists.

## Summary

The pathogenesis, diagnosis, and treatment of stress fractures have been reviewed. Appropriate radiographic studies with clinical correlation should make the diagnosis straight forward in most cases. Treatment consists of reduction of activity, compression, and non-weightbearing if necessary.

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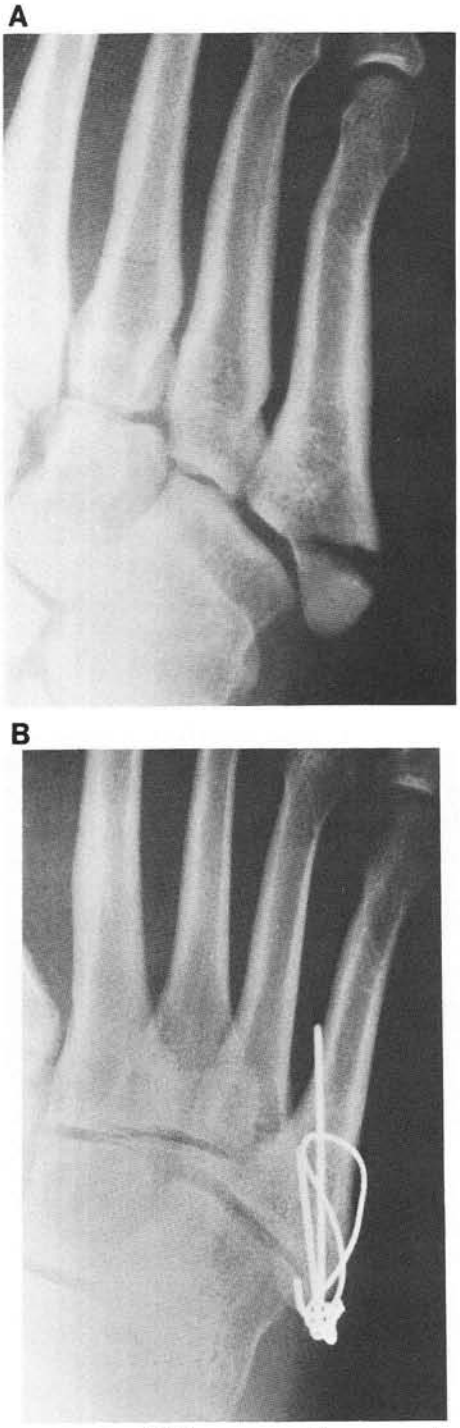


**Fig. 5. A.** Avulsion injuries of fifth metatarsal base usually do not require fixation, however severely displaced avulsion fracture requires open reduction internal fixation to prevent malunion or nonunion. **B.** Tension band technique was utilized for internal fixation.

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