Current Concepts Regarding Athletic Stress Fractures and Low Bone Density

David M. Kahler, MD
Department of Orthopaedic Surgery
University of Virginia

Of all the overuse injuries seen in athletes, stress fractures are among the most perplexing to diagnose and treat. Stress fractures range from the mildly symptomatic athlete with normal x-rays and a positive bone scan (stress reaction) to the relatively acute painful injury with an obvious fracture through an area of remodeling bone.

In this article, I hope to clear up some of the misconceptions about stress fractures and will explore the risk factor of abnormally low bone density. Much of the early literature on stress fractures came from military boot camps, where relatively unconditioned recruits were exposed to temporary restriction from painful activity until healing is documented. Nondisplaced stress fractures of the fifth metatarsal or femoral neck sometimes require surgery to promote healing within a time frame that is acceptable for the competitive athlete.

Any delay in diagnosis of a stress fracture may result in its progression to a complete fracture. Fractures that are allowed to progress and displace almost always require surgical stabilization with plates, screws, or intramedullary rods. Stress fracture of the femoral neck generally has a poor prognosis, particularly in cases requiring surgery after displacement of the undiagnosed fracture.

Female athletes are more susceptible to certain acute injuries and stress fractures than male athletes in equivalent sports. A large study (Matheson et al., 1987) shows that the tibia accounts for about half of the stress fractures seen in athletes.

Most stress fractures are innocuous injuries that require only temporary restriction from painful activity until healing is documented. Nondisplaced stress fractures of the fifth metatarsal or femoral neck sometimes require surgery to promote healing within a time frame that is acceptable for the competitive athlete.

The Etiology of Stress Fractures

True stress fractures are always preceded by an increase or change in activity. The athlete with a stress fracture typically presents with pain in the lower extremity after a change in training, such as an increase in miles run every week when preparing for a marathon. The change in activity may be as subtle as a new pair of running shoes, adding hills to the training route, or strenuous stretching or plyometrics to the training routine. The symptoms of stress fracture typically begin about 3 weeks after beginning the change in activity.

It used to be thought that stress fractures were caused by muscle fatigue and that the fractures resulted from transmission of abnormal loads to normal bone. Although fatigue fractures may occur when normal bone is abnormally stressed, it is now known that true stress fractures occur through an area of bone that has been weakened by the process that normally strengthens bone in response to increased stress.
Wolff’s Law dictates that the body will reinforce an area that is subjected to increased stress by laying down new bone along the lines of stress. In order to deposit new bone, the body first reabsorbs some of the old bone that is not well suited to absorb stress.

For a short time the absorption of old bone outstrips the deposition of new bone, weakening the bone in the region of the new stress. This imbalance peaks out at about 3 weeks after an increase in activity. The previously dense cortical bone becomes relatively porous and is unable to withstand repetitive loading without mechanical failure.

In biomechanical terms, the bone is repeatedly stressed beyond the point of normal elasticity to the yield point. Microscopic fractures occur in the remaining weakened bone, and an aggressive inflammatory healing response ensues. These changes are initially manifested as well localized pain and tenderness, with or without swelling. Within a few weeks the changes usually become evident on x-rays, and new bone formation can be seen within or outside of the bone. If the repetitive stress is allowed to continue, it may progress to a complete fracture.

Osteoporotic bone in the elderly or in amenorrheic female athletes is more porous than normal bone. Although the substance of the remaining bone is just as hard as before, there is simply not enough remaining bone to withstand normal stresses. Microscopically, osteoporotic bone looks identical to bone that is undergoing remodeling in response to increased stresses or disuse, and it is equally susceptible to fatigue fracture.

Insufficiency fractures are a subset of stress fractures that occur in abnormal bone that is subjected to normal stresses; they are seen almost exclusively in either the very elderly or in amenorrheic female athletes.

A study by Myburgh et al. (1990) showed that athletes suffering from stress fractures had significantly lower bone densities in the lumbar spine and femoral neck when compared with controls matched for age, sex, and athletic participation. Amenorrhea due to overtraining is associated with osteoporosis. Barrow and Saha (1988) have shown that the amenorrheic athlete has approximately twice the risk of stress fracture as a normally menstruating athlete in the same sport.

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**Figure 1** This stress fracture of the calcaneus was diagnosed about 3 weeks following the onset of pain in a middle distance runner. He had increased his training miles 6 weeks previously, from less than 20 miles a week to about 30 in anticipation of a marathon. This pain had initially been diagnosed as plantar fasciitis. The healing process is seen as a dense line of new bone within the calcaneus. Note that the stress fracture is diagnosed by the presence of the healing response, rather than a visible fracture line.

**Diagnosis of Stress Fractures**

Radiographs (x-rays) should always be the first test used to diagnose a stress fracture. They are inexpensive and require little radiation exposure. It often becomes important to have a baseline study available for comparison when an athlete has persistent symptoms.

The most common x-ray findings are sclerosis, endosteal callus, or a periosteal reaction indicating an active healing process (Figure 1). Unfortunately, it is sometimes several weeks or months before this healing process becomes evident on standard x-rays. Athletes generally demand an immediate diagnosis, prompting more specialized and expensive diagnostic testing.
The so-called "Jones fracture" is usually a stress fracture of the base of the fifth metatarsal that has finally progressed to a complete fracture. In this case, an acute fracture line may be seen superimposed upon a chronic healing response (sclerosis around the fracture site with spur formation at the edges). This soccer player had an 8-week history of pain prior to feeling the sharp snap associated with the acute fracture. Surgical fixation with a screw allowed return to competition within 5 weeks.

The bone scan ($^{99}$Tc-MDP scintigraphy) has been called the gold standard for diagnosis of stress fractures. The bone scan is often positive for a fracture long before the x-rays show evidence of a healing response.

Although bone scanning is sensitive for detection of a stress fracture, it is not specific. In particular, a hot bone scan in the tibia may be associated with pes anserinus bursitis, medial tibial stress syndrome, venous insufficiency, or benign tumors of bone. Of great concern is the fact that the bone scan may sometimes be negative even in the face of significant clinical symptoms.

Sterling et al. (1993) have reported a case of stress fracture of the femoral neck in which the bone scan was negative after the onset of symptoms, even though later films clearly documented the stress fracture.

The bone scan's lack of specificity and occasional lack of sensitivity has prompted increased interest in magnetic resonance imaging (MRI) for early diagnosis of stress fractures. MRI usually allows a clear distinction between stress fractures and the other processes that can result in a positive bone scan. In addition, the test is extremely sensitive.

Historically, MRI has been about twice as expensive as bone scanning. Recently, however, some radiology departments began offering MRI screening with limited studies through the symptomatic area at about the same price of bone scanning, with improved specificity. If the cost can be brought down, it is likely that MRI will replace the bone scan for diagnosis of stress fractures when the athlete presents with significant clinical symptoms and normal radiographic studies.

Recognition of the Serious Stress Fracture

The most common type of stress fracture is diagnosed before a fracture line actually appears. Either a healing response is seen on x-ray studies, or an abnormal bone scan or MRI confirms the diagnosis. With early diagnosis, a period of restricted activity or bracing is usually all that is needed to get the athlete back to competition.

A delay in diagnosis can be disastrous. If the athlete is allowed to compete in pain without an accurate diagnosis, the stress fracture may progress to a complete fracture. When this occurs, healing is unpredictable and surgical correction is often necessary (Figure 2).

The stress fracture with the greatest potential for disaster occurs in the femoral neck. Typically
the athlete who suffers from this type of stress fracture is a female distance runner because she often carries the risk factors of amenorrhea, eating disorders, and osteoporosis. The symptomatic athlete may have recently increased training miles or added hills.

The pain is usually perceived in the anterior groin and may radiate to the medial thigh or knee. The first few steps in the morning are most painful, but the pain often subsides with modest activity or light training. The pain of a stress fracture of the femoral neck often becomes unbearable a mile or two into a run.

Failure to diagnose a stress fracture of the femoral neck in time can lead to a complete fracture. The femoral head may then lose its blood supply, leading to loss of the hip joint due to collapse of the bone. For this reason, stress fractures that involve the superior aspect of the femoral neck are generally treated surgically to avoid displacement (Kahler, 1995).

The endurance athlete complaining of renewed groin pain should be evaluated with x-rays. If these are negative, he or she should be placed on protected weight bearing with crutches pending evaluation with MRI or bone scan (Figure 3). It should be noted that an elite athlete with a stress fracture of the femoral neck has a poor prognosis for return to his or her previous level of competition, regardless of whether or not the fracture actually displaces (Johansson et al., 1990).

**Summary**

A proper understanding of the etiology of stress fractures can help in making the diagnosis. Stress fractures usually occur about 3 weeks after a significant increase in activity. The amenorrheic athlete with low bone density appears to be at particular risk of stress fracture. In fact, diagnosis of a fatigue fracture in the absence of an increase in activity should raise suspicion of low bone density.

Early diagnosis of stress fractures with the use of appropriate diagnostic testing can allow appropriate treatment by restriction of activity, and may prevent progression to a complete fracture that requires surgery.

**References**


David M. Kahler, an associate professor of orthopaedic surgery at the Univ. of Virginia, has expertise in detection and treatment of osteoporosis in athletes, and minimally invasive surgery in orthopedic trauma and sports medicine.