Imaging Studies

MAGNETIC REASONANCE IMAGING (MRI) and computerized tomography (CT) technologies were studied, beginning around 2004, to assess their value in establishing accurate diagnoses of lower leg pathologies. Aoki et al. studied the use of MRI for differentiation between tibial stress fracture and MTSS. Among 22 subjects who presented signs of tibial injury, stress fracture cases demonstrated an abnormally high, wide signal in the bone marrow that was not evident for cases of MTSS.

In 2005, Gaeta et al. compared CT, MRI, and bone scintigraphy for diagnostic evaluation of 50 athletes with tibia pain and negative radiographic findings. They concluded that MRI provided the best method for assessment of patients with suspected tibial stress injuries. They reported MRI 88% sensitivity, 100% specificity, 90% accuracy, 100% positive predictive value, and 62% negative predictive value. A year later, Gaeta et al. compared the CT scans of 11 distance runners exhibiting MTSS (total of 14 affected tibiae), 20 asymptomatic distance runners, and 10 nonathletic subjects. The authors concluded that high-resolution CT had high diagnostic accuracy (90%) for identification of MTSS. These results were confirmed by Kaiser in 2006, who found that CT could reveal cortical abnormalities associated with a bone stress reaction in subjects with MTSS.

The results of these studies clearly indicate that MTSS is associated with bone abnormality. It is not simply a low-grade stress fracture, but a different injury that can be diagnosed with MRI or high-resolution CT scan. Bone abnormality in MTSS patients had been previously identified by biopsy studies, but these studies established that evidence of such pathology could be acquired without the use of an invasive procedure.

Etiological Studies

Recent investigations have focused on two factors: (a) foot pronation and (b) fascial traction. Pronation studies have produced conflicting results. In January 2006, Reinking and Hayes evaluated 63 athletes for self-report of exercise-related leg pain (ERLP) history, active ankle dorsiflexion with knee extended and flexed, navicular drop, and first ray length. The authors did not find any differences between athletes with ERLP history and those without ERLP history. Subsequently, Reinking prospectively monitored 76 female college athletes through their fall sports seasons for development of ERLP and found no differences between those who experienced ERLP and those who did not experience ERLP in terms of age, muscle length, eating behaviors, body mass index (BMI), menstrual function, or bone mineral density; however, athletes with ERLP did have significantly greater navicular drop values than those without ERLP.

In 2007, Plisky et al. prospectively monitored high school cross country runners throughout a competitive season. Navicular drop, foot length, height, BMI, previous running injury, running experience, and orthotic/tape use were evaluated. BMI was the only factor found to have an association with MTSS occurrence.

In 2007, Willems et al. analyzed plantar pressure measurements and three-dimensional gait kinematics to characterize the running gait patterns of 400 physical
education students. Subjects who were subsequently classified as having exercise-related lower leg pain (ERLLP) during the study period (N = 75) were compared to noninjured study participants. The subjects who developed ERLLP had previously demonstrated significantly greater pronation excursion and greater pressure beneath the medial portion of the foot during the stance phase of running gait. Delayed maximum pronation and greater supination acceleration during the transition from the stance to push-off phases of running gait were also demonstrated.

Various methods have recently been employed to study fascial traction, which is a distal/inferior traction force on the medial tibia at the fascial insertion of the medial soleus. In 2006, Madeley, Munteanu, and Bonanno9 studied 30 athletes diagnosed with MTSS to assess isotonic fatigue resistance of the plantar flexor musculature. They theorized that fatigue of the plantar flexor muscles would result in the imposition of a greater traction load on the bone, thereby creating injury. The subjects with MTSS were matched with 30 asymptomatic athletes on the basis of age, gender, BMI, and type of sport activity. Repetitive heel raises were used to determine the endurance of the plantar flexor muscles. The mean number of heel raises performed by the MTSS group was significantly less than that for the control group. The researchers cautioned that “it was unclear whether the lack of endurance was the cause or an effect of MTSS.”

Two recent studies used strain gauges that were inserted directly into body tissues to quantify bone and fascia strain at the medial soleus attachment. Milgrom et al.10 percutaneously inserted strain gauge staples into the medial aspect of the midtibial diaphysis of four subjects and measured their peak isokinetic torque for plantar flexion before and after exercise. They concluded that a fatigued state of the plantar flexors increased bone strain to a level exceeding that recorded in nonfatigued individuals. This finding supports the theory that muscle fatigue reduces stress dissipation and results in greater stress imposition to the underlying bone tissue.

To evaluate the fascial traction theory, Bouche and Johnson11 measured fascia strain at the distal medial tibial crest insertion during loading of three fresh cadaver specimens. As strain in the tibialis posterior, flexor digitorum longus, and soleus tendons increased, strain in the fascia increased in a consistent linear manner. The authors concluded that fascial traction may play a role in the etiology of MTSS. They also determined that circumferential tape did not dampen tension acting on the medial tibial crest.

**Clinical Practice Implications**

The body of research evidence that is pertinent to the etiology of MTSS does not provide clear clinical practice guidelines for the prevention and treatment of MTSS. The relative contributions of excessive pronation, soleus muscle tightness, and soleus muscle fatigue in the etiology of MTSS remain unclear. The research does clearly indicate that the tibia becomes overloaded, a chronic remodeling state results, and development of microfissures creates the signs and symptoms of MTSS. Thus, impact loading of the tibia must be reduced for resolution of the condition. Considering the collective findings of the available research, suggestions for clinical management of MTSS include the following:

1. Support the medial longitudinal arch to control pronation in athletes who have a history of MTSS. This should decrease the magnitude of the eccentric load placed on the medial soleus and the rate at which it is applied.

2. Train endurance of the plantar flexors while maintaining dorsiflexion range of motion. Nonimpact exercises, such as heel raises, are less likely to exacerbate MTSS symptoms than exercises that create impact loads, such as plyometric depth jumps.

3. Encourage coaches to implement cross-training into their weekly conditioning schedule. For example, nonimpact exercises performed in a swimming pool one day per week can maintain cardiorespiratory condition while allowing bone to recover from high-stress impact loading.

4. Once injured, allow the tibia a sufficient period of rest to terminate the chronic bone remodeling response and allow a return to bone homeostasis. Cross-training in a swimming pool during the nonimpact rest period can maintain cardiorespiratory condition and may actually improve it to a level that exceeds the preinjury state.

5. Taping for support of the medial longitudinal arch is much more likely to reduce MTSS symptoms than circumferential taping of the lower leg.