Shin Splints: MR Appearance in a Preliminary Study

**PURPOSE:** To investigate the magnetic resonance (MR) imaging appearance of activity-related lower leg pain (shin splints syndrome) and evaluate the relative involvement of bone and soft tissues.

**MATERIALS AND METHODS:** Nineteen patients with activity-related lower leg pain and tenderness on palpation along the posteromedial tibia (shin splints) underwent clinical examination and MR imaging. Five also underwent plain radiography. MR findings were compared with patient demographics, clinical findings, and plain radiographs when available.

**RESULTS:** Four MR patterns were identified: normal appearance \( (n = 7) \), periosteal fluid only \( (n = 5) \), abnormal marrow signal intensity \( (n = 5) \), and stress fracture \( (n = 2) \). Increased symptom duration correlated strongly with a normal MR image \( (P = .002) \). Plain radiographs appeared normal in all five patients for whom they were available.

**CONCLUSION:** Patients with acute shin splints have a spectrum of MR findings, which suggests this clinical entity is part of a continuum of stress response in bone. The strong association between chronic symptoms and a normal-appearing MR image implies that this modality has less utility in these patients.

**STRESS** injuries involving the tibia are common and accounted for approximately 75% of exertional leg pain in one large series (1). Various terms such as shin soreness, shin splints syndrome, medial tibial stress syndrome, and soleus syndrome have been used to describe this activity-related pain, which typically is associated with diffuse tenderness along the posteromedial tibia in its middle to distal aspect (2–6).

The causes of activity-related lower leg pain are varied, and the exact pathophysiology of this syndrome remains controversial. Some authors postulate that it results from fatigue damage in bone (atypical stress fracture) or a traction periostitis relating to the origin of the tibialis posterior muscle or insertion of the crural fascia ("soleus bridge") along the posteromedial tibia (4–9). Others suggest it is related to a compartment syndrome, and still others argued it is not (10,11). In 1986, Detmer (12) proposed a classification system for patients with chronic shin splints that included bone and soft-tissue causes and emphasized that optimal treatment depends on an accurate diagnosis. Differentiating between the various causes of exertional leg pain on the basis of clinical findings alone can be challenging, however, and diagnostic imaging may help in this regard.

Regarding shin splints, plain radiographs usually appear normal, but they may depict longitudinal periosteal new bone formation along the distal tibia during later phases of the process (7,13). The three-phase radionuclide bone scan has proved useful for detecting the bony and/or periosteal changes that typically manifest as abnormal linear uptake in a longitudinal fashion along the posterior or posteromedial tibial cortex on delayed images (13,14). A less common pattern also has been described in which the abnormal activity is depicted along the proximal anterolateral tibia (15).

With classic shin splints, the radionuclide angiogram and blood-pool phases of the study are normal, unlike those of a stress fracture, in which abnormal activity is depicted during all three phases (13). This argues against shin splints principally being an inflammatory process.

Magnetic resonance (MR) imaging is extremely sensitive in detecting the marrow edema or hemorrhage that is associated with fatigue damage in bone as well as any periosteal fluid (16,17). The exquisite contrast and spatial resolution of this imaging modality also allow for detailed depiction of any soft-tissue involvement. The purpose of this study was to determine the spectrum of MR findings in a diverse group of patients with shin splint syndrome and to determine the relative involvement of the bone and soft tissues.

**Index terms:** Athletic injuries, 456.415 • Bones, MR, 456.121411, 456.121413, 456.121416 • Fractures, stress, 456.415 • Periostitis, 456.4194 • Tibia, fractures, 456.415

**Abbreviations:** FOV = field of view, IR = inversion recovery, SE = spin echo.

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MATERIALS AND METHODS

Subjects
This study was approved by the Human Subjects Review Committee at our institution. Patients with a history of symptomatic shin splints were recruited from the community as well as from local colleges and universities from April through September 1994. Both oral and written consent were obtained from 19 patients (11 female and eight male patients) who ranged in age from 17 to 54 years (mean age, 34.4 years). Four patients were involved in competition at the high school or collegiate level, eight were involved in adult competitive activities, and seven were involved in recreational activities. Thirteen patients participated in running or walking, two in track and field, and one each in basketball, volleyball, softball, and soccer. Seventeen patients described a recent change in their training regimen (intensity, volume, or equipment), whereas two denied any recent changes.

All patients underwent a thorough history and physical examination. Criteria for inclusion in this study were (a) history of exercise-induced pain in the lower leg, (b) diffuse tenderness on palpation along the posteromedial tibia over a length of at least 5 cm, with or without tenderness elsewhere, and (c) no clinical evidence of compartment syndrome or fascial dehiscence suggesting muscle herniation. The duration of symptoms in these subjects ranged from 2 to 84 months (mean duration, 23.8 months).

Diagnostic Imaging
MR imaging was performed with a 1.5-T system (Signa; GE Medical Systems, Milwauk ee, Wis.). With use of the body coil, fast spin-echo (SE) inversion-recovery (IR) images of both lower legs were obtained in the sagittal plane and in the axial plane in 16 patients. Repetition time was 3,000–5,000 msec, echo time was 51–76 msec, and inversion time was 140–160 msec (3,000–5,000/51–76/140–160). Axial T1-weighted images (500–800/10–20) were also acquired in one patient. For sagittal images, the section thickness and gap were 4 mm and 1 mm, respectively, and the field of view (FOV) was 30–48 cm. Axial section thickness was 5–10 mm with a gap of 1.0–2.5 mm (most often 1.0 mm), and the FOV was 22–48 cm (typically 25–30 cm).

Other parameters included a matrix of 256 × 160–256 (in most cases, 256 × 192) and one to four signals acquired (in most cases, two signals acquired). If abnormal signal intensity was identified in the tibial marrow, additional axial fast SE IR and T1-weighted images were acquired, with use of either the head coil (FOV, 20–30 cm; matrix, 256 × 192) if bilateral or a dedicated extremity coil (FOV, 10–21 cm; matrix, 256 × 160–256) if unilateral for improved resolution.

Five patients also underwent plain radiography of the affected extremity within 3 weeks before or after MR imaging.

Figure 1. Axial fast SE IR image (3,200/57/140) in a 17-year-old female volleyball player with a 12-month history of shin splints. Note the thin rim of high-signal-intensity periosteal fluid tracking along the anterior margin of the tibia (solid arrows) with extension along its posteromedial margin near the attachment of the soleus fascia (open arrow).

Image Analysis
Images were analyzed by a single radiologist (M.W.A.) experienced in musculoskeletal MR imaging, with attention directed to the tibia and adjacent soft tissues. MR findings were recorded and compared with patient demographics, clinical findings, and plain radiographs when available.

Statistical Analysis
The mean and standard deviation of symptom duration were calculated for each group of MR findings. Analysis of variance was used to compare symptom duration between individuals with normal MR findings and individuals with abnormal MR findings. Multiple comparisons with the Scheffé method were performed for the four groups of MR findings and symptom duration.

Regression analysis was used to determine the relationship of symptom duration with sex, total time the patient had participated in the sport overall, and history of prior shin pain. x2 analysis was used to compare normal versus abnormal MR findings with sex, total time spent in the sport, and history of prior episodes of shin pain. Analysis of variance also was used to compare MR findings with age. A P value of less than .05 was considered to indicate a statistically significant difference.

RESULTS
Four MR patterns were identified in these 19 patients. These patterns were (a) normal appearance in seven patients, (b) periosteal fluid only in five patients, (c) abnormal marrow signal intensity compatible with bone marrow edema in five patients (two had periosteal fluid as well), and (d) stress fracture in two patients.

In five patients, periosteal fluid was the only abnormality that was identified, and in four of these five, the fluid occurred along the anteromedial surface of the tibia, with variable extension along the soleus bridge (Fig 1). In the fifth patient, minimal fluid was identified along the posterior surface of the tibia.

Abnormal marrow signal intensity was identified in five additional patients (Fig 2). In four of these five, the middle third of the tibia was involved; in the other patient, the proximal tibia was involved. Overlying periosteal fluid was identified in two of the five patients, again along the anteromedial surface.

Stress fractures were identified in two patients. These fractures manifested as abnormal marrow signal intensity with a linear signal abnormality extending...
through the anterior tibial cortex in a longitudinal fashion (Fig 3). In one patient, the middle third of the tibia was involved; in the other, the middle to distal tibia was involved. Overlying periosteal fluid was present in both patients.

**Figure 3.** MR images in a 54-year-old man with a 2-month history of left lower leg pain who had been running 100–200 miles per week during peak training. (a) Coronal fast SE IR image (3,000/60/140) shows strikingly increased marrow signal intensity in the middle of the left tibia. (b) Axial fast SE IR image (3,000/60/140) at the middle of the left tibia reveals the marrow signal abnormality as well as a vertically oriented, high-signal-intensity fracture line traversing the anterior cortex (arrow). (Reprinted, with permission, from reference 26.)

There was a statistically significant difference in symptom duration and patient age, sex, total time spent in the sport, or prior history of shin pain. Similarly, no statistically significant differences were found between patients with normal and patients with abnormal MR findings with regard to age, sex, total time spent in the sport, or prior history of shin pain.

Plain radiographs appeared normal in all five patients for whom they were available. MR images in two of these patients appeared normal, but MR images in the other three showed periosteal fluid only, periosteal fluid and abnormal marrow signal intensity, and stress fracture, respectively.

**DISCUSSION**

Shin splints is a nonspecific term used to describe exertional lower leg pain from almost any cause. It often implies a relatively innocuous prognosis; however, considerable evidence suggests that it may represent a type of fatigue damage to bone that can progress to a more serious injury if not treated appropriately. This highlights a potential role for imaging in this clinical setting. While recreational runners will probably limit their activity level in response to pain during the early stages of fatigue damage, more competitive athletes may attempt to "push through" their symptoms, thereby placing themselves at risk for a stress fracture.

The findings in our study support those of Fredericson et al (16), who demonstrated a continuum of changes depicted on MR images in patients with activity-related lower leg pain, from periosteal fluid to marrow edema to stress fracture, that paralleled findings on radionuclide bone scans. Our results also support Detmer's classification scheme (12), at least to some degree. Abnormal marrow signal intensity suggests fatigue damage to bone (Detmer type 1) and periosteal fluid, sometimes tracking along the insertion of the soleus fascia, could relate to a traction periostitis in that region (type 2). Chronic compartment syndrome (type 3) is difficult to depict with MR imaging, however.

A relatively high percentage of our patients had normal MR images despite the presence of classic, and often severe, clinical symptoms. The statistical correlation with more long-standing symptoms suggests that chronic shin splints may result from a different mechanism than the acute variety, or that the condition has moved into a different pathophysiological phase. In addition, it implies that MR imaging will probably be less useful in this setting.

In this way, our findings differ from those of Fredericson et al (16), who report a normal MR image in only two of their 20 patients, one of whom described a history of repeated symptomatic episodes spanning several years. As a result, they recommended use of MR imaging over radionuclide bone scanning to evaluate tibial stress syndrome in runners. Our results, however, suggest that this recommendation should be tempered for patients with more chronic symptoms. This discrepancy probably results from differences in our patient populations and study designs. All but one of their patients were young, competitive, collegiate runners, and their entrance criteria included a positive radionuclide bone scan. Our patients had a broader age range, participated in a variety of activities, and were less highly selected (through clinical findings only).

Periosteal fluid is believed to be an early marker on MR images for stress injury (16). Unlike Fredericson et al, who found consistent periosteal changes depicted at the attachments of the posterior tibial, flexor digitorum longus, and soleus muscles, periosteal fluid was depicted on the MR images of all but one of our patients along the anterior tibial cortex, which is a site having no muscular attachments. This
additional discrepancy could relate to differences in our respective patient populations; however, that the fluid tracks along the anterior, tensile surface of the tibia suggests the fluid may relate to periosteal buttressing, which occurs as the underlying cortex is weakened through accumulating fatigue damage (18,19). Extension of fluid, in some cases to the posteromedial corner of the tibia near the attachment of the soleus fascia, suggests that fluid in these cases may relate to a traction periostitis (5,6,12).

Abnormal signal intensity within the bone marrow is a nonspecific finding and may be seen in patients with direct injury (bone contusion or bruise) or fatigue damage to bone (17,20). With fatigue damage, the abnormal signal intensity most likely is secondary to edema or hemorrhage related to accumulating microdamage and the associated reparative response. This has been well documented in previous reports describing areas of stress reaction and stress fractures as depicted on MR images (17,21-23). An area of intense signal abnormality within the marrow is probably a useful indicator of a developing stress fracture.

A stress fracture is the end point for the pathophysiologic continuum of fatigue damage to bone, and it occurs when accumulating microdamage exceeds the ability of the reparative mechanisms. The relationship between shin splints and stress fractures is controversial, but these clinical entities may be related along this continuum. Evidence supporting such a relationship was provided by a series of 20 patients with shin splints (9); 22 of 35 tibial biopsy specimens from these patients revealed changes of increased bone metabolism that were most compatible with fracture healing.

The two stress fractures in our series were of the longitudinal variety, and they involved the anterior tibial cortex. Longitudinal stress fractures are less common than the transverse and oblique varieties, but they have been shown on both computed tomographic scans and MR images (24-26). Plain radiographs are less helpful, however, because the x-ray beam rarely is tangential to the fracture line (27). It is not clear why both of our patients with focal anterior tibial tenderness and the typical posteromedial tenderness of shin splints developed this type of fracture.

As mentioned, plain radiographs of the five patients for whom they were available appeared normal. Although this sample size is too small to allow for any substantive conclusions to be made, prior studies have shown that the sensitivity of initial radiographs may be as low as 15% in the early stages of fatigue damage (28,29). In one of these series, only 46% of follow-up plain radiographs showed evidence of stress injury (28).

There are some weaknesses and limitations to our study. First, the number of patients is small, so our findings may not extrapolate to a larger population. We believe that the MR findings in this series are valid, however, because for the most part, they mirror those of Fredericson et al. (16). The lack of asymptomatic control subjects and correlative radionuclide bone scans are definite limitations, but we are addressing these issues in an ongoing, prospective study.

In conclusion, patients with activity-related, posteromedial tibial pain have a spectrum of findings depicted by MR imaging. These findings suggest that shin splints are part of the continuum of fatigue damage in bone, but in some cases, the distribution of periosteal fluid implies that a traction periostitis along the insertion of the soleus fascia may also play a role. The lack of abnormalities on MR images in patients with chronic symptoms, however, suggests that this modality has little diagnostic utility in this setting.

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References