Stress Fractures in Children

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Abstract

Stress fractures are microscopic disruptions of bone integrity that can occur in both children and adults. In pediatric patients, these injuries most commonly affect the lower extremities, particularly the tibia and metatarsals. Children involved in high-impact, running-intensive sports are at increased risk. Diagnosis can be challenging, as the microscopic nature of stress fractures makes them difficult to detect on radiographs. Advanced imaging modalities such as MRI and bone scintigraphy offer greater sensitivity for early detection. Because stress fractures typically do not result in displacement, treatment is generally conservative and includes activity modification, rest, and, in some cases, immobilization.

Keywords: musculoskeletal, lower extremity, trauma

Case Summary

An adolescent male high-jumper presented with worsening bilateral lower leg pain.

Imaging Findings

Initial radiograph of the left lower leg (Figure 1) was normal. MRI performed 5 days later (Figure 2) demonstrated edema-like signal in the medial proximal tibial metaphyses bilaterally. A discrete fracture line was visible on the left but not on the right. Follow-up radiograph performed 1 month later (Figure 3) showed healing changes at the site of the left tibial stress fracture.

Diagnosis

Stress fracture.

Differential diagnoses usually are pain related to repetitive activities or in children with a variety of conditions that result in decreased mineralization. Common repetitive activities resulting in pain in children include repeated running, jumping, throwing, or falling. Meanwhile, etiologies of decreased mineralization in children include genetically inherited osteogenesis imperfecta, rickets due to long-term vitamin D deficiency, or osteomyelitis.

Discussion

Stress fractures are microscopic cracks within bone, resulting from repetitive mechanical stress or reduced bone strength. Unlike complete fractures, stress fractures are incomplete and do not extend through the full thickness of the bone. They are broadly classified into 2 categories: fatigue fractures and insufficiency fractures. Fatigue fractures result from repeated mechanical loading that exceeds the bone's capacity for repair, commonly seen in athletes involved in repetitive high-impact activities.[1,2] In contrast, insufficiency fractures occur when normal stress is applied to weakened bone, such as in children with vitamin D deficiency or underlying metabolic bone disease.[1,3]

Figure 1. Anteroposterior radiograph of the proximal left tibia is normal.

Stress fractures in children most commonly affect the lower extremities. In a retrospective analysis of pediatric lower extremity stress fractures, 28.4% were in the tibia, 24.1% in the metatarsals, 20.7% in the cuboid, 8.6% in the femur, 7.8% in the fibula, 6.9% in the calcaneus, and 3.4% in the cuneiform bones.[2] Stress fractures of the foot are frequently associated with long-distance running and high-impact sports such as basketball and soccer.[4] The

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Figure 2. MRI performed 5 days after the initial radiograph. (A) Coronal STIR sequence of the lower legs showing edema signal within the medial aspect of each proximal tibial metaphysis. (A) T2 hypointense fracture line (arrow) is present on the left. The periosteum (arrowhead) is uplifted at the site of stress fracture. (B) Coronal T1-weighted image of the proximal left tibia showing amorphous low signal in the proximal tibia metaphysis. The periosteum (arrowhead) is uplifted at this location.

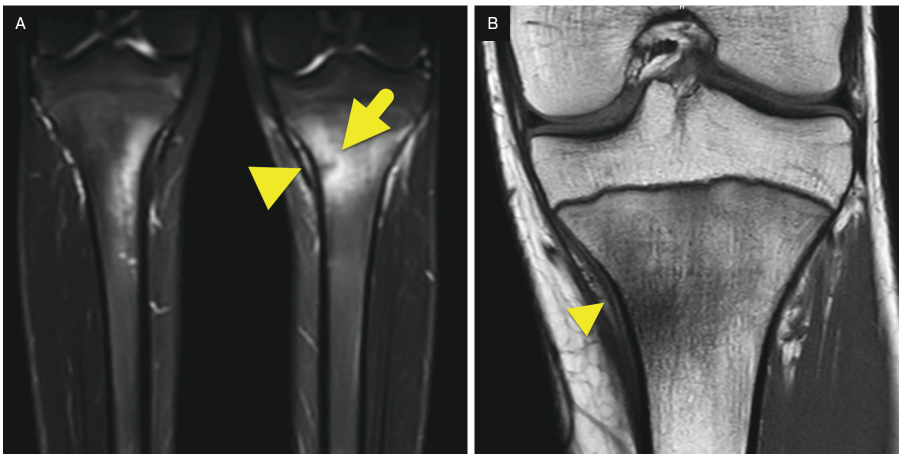
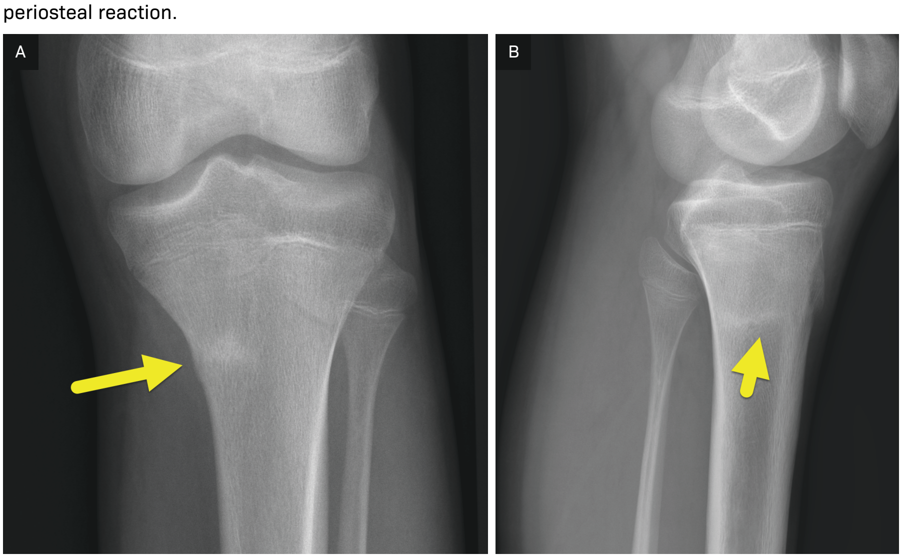


Figure 3. (A) Anteroposterior and (B) lateral radiographs performed 1 month later showing healing changes at the site of stress fracture with a linear band of sclerosis (arrow) and a healing periosteal reaction.



metatarsals are particularly vulnerable because they bear significant stress during the push-off phase of running.[4] Similarly, the tibia, fibula, and femur, as major weight-bearing bones, are at increased risk in children participating in high-impact activities like running and jumping.[4]

Although less common, stress fractures can also occur in the upper extremities. Examples include "little leaguer's shoulder," which involves the proximal humeral physis due to repetitive overhead throwing, and "gymnast's wrist," which affects the radial and/or ulnar physis from repetitive loading.[5] Additionally, stress fractures have been reported in the posterior column of the spine in young athletes performing repetitive spinning movements, such as figure skaters.[6]

On physical examination, stress fractures typically present with localized pain and guarding at the site of injury.[7] Because stress fractures do not cause displacement or angulation of the affected bone, skeletal deformity is not seen. Pain usually worsens with activity and improves with rest.[2] Soft tissue swelling near the fracture site may also be present.

Stress fractures can be challenging to diagnose radiographically, as fracture lines may not become visible until approximately 2 weeks after injury. Early radiographs have a sensitivity of only 15-35%, whereas MRI approaches nearly 100% sensitivity for detecting early-stage stress fractures.[1] When present, key radiographic findings include subtle lucency at the fracture site, trabecular blurring, and linear sclerosis.[1]

Advanced imaging techniques such as bone scintigraphy and MRI can improve early detection. A technetium-99m MDP bone scan can identify osseous injury 1-2 weeks earlier than radiographs.[8] On bone scintigraphy, areas of increased cortical uptake appear as hot spots, indicating osseous remodeling.[8] MRI findings include periosteal or adjacent soft tissue edema and band-like bone marrow edema.[1,3] A fracture line, when visible, appears as a hypointense band on T1-weighted sequences.[1]

The Fredericson grading system can be used to classify the severity of stress fractures on MRI, although the grading does not correlate with recovery time and is primarily used for documentation purposes.[9] The system ranges from grade 0 to grade 4b, as follows:

- **Grade 0**: normal.
- **Grade 1**: periosteal edema only, no bone marrow involvement.
- **Grade 2**: periosteal edema with bone marrow edema on T2-weighted imaging.
- **Grade 3**: periosteal edema with bone marrow edema visible on both T1- and T2-weighted imaging.
- **Grade 4a**: multiple focal intracortical signal abnormalities with bone marrow edema on T1 and T2.
- **Grade 4b**: linear intracortical signal abnormality with bone marrow edema on T1 and T2.

Because stress fractures are incomplete and cause minimal displacement, initial management is typically conservative. Treatment includes activity modification, rest, and physical therapy focused on stretching and strengthening the surrounding muscles.[7,10] If needed, immobilization with a cast for 3-6 weeks can be considered.[7] Surgical fixation with intramedullary nails or screws is reserved for high-risk fractures that may progress to complete fractures.[2]

Healing usually takes about 6-8 weeks, though recovery time varies depending on fracture location and treatment approach. Stress fractures in cortical-rich regions, such as long bone shafts, tend to heal faster than those in trabecular-rich areas, such as the epiphyseal ends.[3] Recovery time is typically longer when surgical intervention is required.[2] In one study, pediatric patients returned to activity at an average of 11.4 weeks, with recovery times ranging from 4.5 to 17.4 weeks.[2]

Conclusion

Stress fractures are microscopic disruptions of bone integrity that can occur in both children and adults. In pediatric patients, these injuries most commonly affect the lower extremities, particularly the tibia and metatarsals. Children involved in high-impact, running-intensive sports are at increased risk. Diagnosis can be challenging, as the microscopic nature of stress fractures makes them difficult to detect on radiographs. Advanced imaging modalities such as MRI and bone scintigraphy offer greater sensitivity for early detection. Because stress fractures typically do not result in displacement, treatment is generally conservative and includes activity modification, rest, and, in some cases, immobilization.

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