

When the Physeal Scar Becomes a Weak Point: Proximal Tibial Stress Fracture in a Young Adult

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Abstract

Stress fractures result from repetitive mechanical loading that exceeds the capacity of bone remodeling and most commonly involve the tibial diaphysis in young active individuals. Stress fractures of the proximal tibia are less common, and fractures specifically occurring along the remnant of a completely fused growth plate are exceptionally reported.

We present the case of a 24-year-old woman who developed progressive knee pain over several weeks following an unusual increase in physical activity, including prolonged hiking. There was no history of acute trauma. Plain radiographs demonstrated a transverse linear abnormality involving the proximal tibia at the level of the physeal scar. Magnetic resonance imaging confirmed a stress fracture centered on and following the course of the completely fused proximal tibial physeal scar, with associated bone marrow edema.

The spatial correspondence between the fracture line and the physeal scar raises the possibility that the residual architecture of the former growth plate may influence stress distribution within the proximal tibia even after complete skeletal maturation. This case highlights an unusual pattern of stress fracture in a young adult and emphasizes the importance of recognizing the physeal scar as a potential site of stress-related osseous injury.

Keywords: stress fracture; fatigue fracture; proximal tibia; physeal scar; epiphyseal scar; growth plate; magnetic resonance imaging; young adult.

Introduction

Stress fractures represent a spectrum of osseous injuries resulting from an imbalance between repetitive mechanical loading and the ability of bone to adapt through remodeling. Fatigue fractures occur when abnormal or repetitive stress is applied to otherwise normal bone, whereas insufficiency fractures result from physiological loading of structurally weakened bone [7-9].

The tibia is among the most frequently affected bones in athletes and physically active individuals. However, most tibial stress fractures involve the diaphysis, particularly its posteromedial aspect. Stress fractures involving the proximal tibial metaphysis or epiphysis are substantially less common [7, 9, 14].

During skeletal maturation, the proximal tibial growth plate undergoes progressive ossification and ultimately disappears as a functional cartilaginous structure. Following physeal closure, however, a residual physeal or epiphyseal scar may remain visible radiographically and on magnetic resonance imaging (MRI). Such remnants are common in young adults and should not be interpreted as evidence of an incompletely fused growth plate [1, 2].

Although proximal tibial stress fractures have occasionally been described adjacent to the physeal scar, stress fractures whose trajectory appears to coincide with a completely fused physeal scar are poorly documented. We report an unusual case of a proximal tibial fatigue fracture in a skeletally mature 24-year-old woman, in which the fracture line followed the remnant of the proximal tibial growth plate [3-6, 15].

Case Presentation and Imaging Findings

A 24-year-old woman presented to the emergency department with lower-limb pain following a recent hiking excursion. She reported no fall, direct trauma, or other identifiable injury during the hike. Clinical examination was unremarkable, with preserved knee range of motion and no evidence of joint instability or significant soft-tissue abnormality. However, focal tenderness was elicited on palpation over the proximal tibial metaphysis.

Initial plain radiographs of the knee demonstrated a transverse linear abnormality in the proximal tibia. The line was located at the level of the residual proximal tibial physeal scar and showed no evidence of displacement. The proximal tibial physis was completely fused, consistent with skeletal maturity.

Magnetic resonance imaging (MRI) of the knee demonstrated a linear low-signal-intensity abnormality within the proximal tibia corresponding to the radiographic finding. The fracture line followed the expected course of the former proximal tibial physis and was surrounded by bone marrow edema, which was most conspicuous on fluid-sensitive fat-suppressed sequences. The fracture line was hypointense on T1-weighted images, with surrounding high signal intensity on T2-weighted images consistent with reactive bone marrow edema. No residual physeal cartilage was identified.

The combination of the clinical history, absence of acute trauma, recent increase in mechanical loading associated with hiking, and characteristic imaging findings supported the diagnosis of a **fatigue-type stress fracture of the proximal tibia occurring along the scar of the completely fused proximal tibial physis**.

Management and Outcome

Given the absence of fracture displacement and the favorable mechanical characteristics of the lesion, conservative management was chosen. The patient was instructed to remain completely non-weight-bearing on the affected limb for 45 days. During this period, thromboprophylaxis with low-molecular-weight heparin (LMWH) was administered because of prolonged lower-limb unloading and reduced mobility. Appropriate analgesic therapy was also prescribed, resulting in progressive improvement of her symptoms.

After the initial 45-day period of non-weight-bearing, a gradual rehabilitation program was initiated. This included progressive weight-bearing with walking aids, followed by physiotherapy aimed at restoring full knee range of motion, muscle strength, and normal gait mechanics. Weight-bearing and physical activity were gradually increased according to pain tolerance and clinical improvement.

The clinical course was favorable. At follow-up, the patient reported complete resolution of pain and had regained a full, painless range of motion of the knee. Independent ambulation was progressively restored without recurrence of symptoms. No surgical intervention was required.

Discussion

Stress fractures result from repetitive submaximal loading that produces microscopic bone damage exceeding the capacity of physiological remodeling. In young adults with otherwise normal bone, these lesions are generally classified as fatigue fractures. In our patient, the recent unusual physical exertion, progressive onset of symptoms, absence of acute trauma, and characteristic radiographic and MRI findings strongly support this mechanism [7-9, 12-14].

Proximal tibial stress fractures

Although the tibia is a common site of stress injury, most fatigue fractures involve the tibial shaft, whereas proximal metaphyseal and particularly epiphyseal stress fractures are considerably less common [3-9, 14]. Proximal tibial stress fractures may present as nonspecific knee pain and mimic more

common conditions such as meniscal disease, pes anserine bursitis, ligamentous injury, or other periarticular disorders. Radiographs may initially be normal, while MRI is highly sensitive for detecting bone marrow edema and the fracture line [8-11].

Previous reports have described proximal tibial stress injuries near the physeal scar, with radiographic sclerosis and a horizontal low-signal-intensity line surrounded by extensive bone marrow edema on MRI. Medial tibial plateau stress fractures have similarly been associated with sclerosis on either side of the physeal scar [3, 5, 6]. Rare epiphyseal stress fractures have also been reported, including bilateral posteromedial tibial epiphyseal stress fractures following intense physical training in a young adult [4].

The physeal scar after skeletal maturity

The distinctive feature of our case is the close correspondence between the fracture trajectory and the scar of the former proximal tibial physis. Physeal closure is a gradual process in which the cartilaginous growth plate is replaced by bone, and residual morphological evidence of the former physis may persist after skeletal maturity and remain visible on radiographs and MRI [1, 2].

This distinction is important because the present lesion should not be interpreted as a stress injury of an active growth plate. The proximal tibial physis was completely fused, with no residual functional growth cartilage. Therefore, terms such as “physeal stress injury” or “growth plate stress fracture” would be misleading; a more accurate description is a **stress fracture occurring along a fused physeal scar** [1-3].

Could the physeal scar represent a site of mechanical vulnerability?

The close anatomical relationship between the fracture line and the former physis raises the possibility that the physeal scar may influence fracture propagation after skeletal maturity. The scar represents the osseous remnant of the former growth plate and a transition between epiphyseal and metaphyseal trabecular architecture. Although completely ossified after skeletal maturation, its trabecular organization may remain morphologically distinct from the surrounding cancellous bone [1, 2].

Previous observations provide indirect support for this hypothesis. Stress fractures have been described adjacent to the proximal tibial physeal scar, and acute fractures propagating through physeal scars have occasionally been reported, suggesting that the former physis may influence fracture trajectory under certain loading conditions [3, 4, 15].

However, direct biomechanical evidence demonstrating that the proximal tibial physeal scar represents a persistent zone of weakness in skeletally mature adults is lacking. The correspondence observed in our patient may therefore reflect local stress distribution and trabecular architecture rather than intrinsic mechanical weakness. Our case does not establish the physeal scar as the cause of the fracture, but suggests that

its residual architecture **may provide a preferential plane for stress-related fracture propagation** under repetitive mechanical loading [1-4, 15].

Role of abnormal mechanical loading

Our patient developed symptoms following an unusual episode of prolonged hiking. A sudden increase in the duration or intensity of weight-bearing activity is a recognized precipitating factor for fatigue fractures [8, 12-14]. During prolonged walking, the proximal tibia is exposed to repetitive axial and bending forces transmitted across the knee, potentially generating progressive microdamage within the cancellous bone [9, 13, 14].

In this setting, the physeal scar may have represented a transition in trabecular orientation or local mechanical properties along which accumulated microdamage preferentially propagated. The lesion may therefore reflect the interaction between increased repetitive loading and local proximal tibial architecture [1-4, 15].

Fatigue fracture versus insufficiency fracture

Distinguishing fatigue from insufficiency fracture is particularly relevant in this location. Subchondral insufficiency fractures of the knee predominantly affect older individuals and are commonly associated with impaired bone quality and degenerative changes [7-9].

In contrast, our patient's young age, the temporal relationship with increased physical activity, and the absence of known metabolic or bone disease favor a fatigue mechanism. Nevertheless, unusual stress fractures in young adults should prompt consideration of predisposing factors such as vitamin D deficiency, menstrual disturbances, low energy availability, reduced bone mineral density, endocrine abnormalities, or medications affecting bone metabolism [4, 7-9, 12-14]. Assessment of calcium, phosphate, alkaline phosphatase, 25-hydroxyvitamin D and, when clinically indicated, bone mineral density may further support the diagnosis of a true fatigue fracture in otherwise normal bone [4, 7, 8].

Differential diagnosis

The main imaging differential diagnoses include an acute nondisplaced fracture, residual physeal abnormality, subchondral insufficiency fracture, and, less commonly, osteochondral or inflammatory processes [7, 9-11]. The absence of acute trauma, progressive onset after repetitive loading, complete physeal closure, and MRI evidence of a fracture line with surrounding marrow edema support the diagnosis of a fatigue-type stress fracture occurring along the physeal scar [7-11].

Clinical and radiological relevance

Recognition of this pattern has practical implications. Proximal tibial stress fractures should be considered in young adults with persistent knee pain following an abrupt increase in physical activity, even when symptoms are centered around the knee rather than the tibial shaft [4, 8, 9]. Careful correlation between radiographs and multiplanar MRI helps define the

relationship between the fracture line, marrow reaction, and residual physeal scar [9-11].

Importantly, radiologists should avoid describing such lesions as "growth plate fractures" in skeletally mature patients. The distinction between an active physis and a residual physeal scar is fundamental. In our case, the unusual feature is precisely that stress-related fracture propagation occurred along the remnant of a **completely fused** growth plate [1-3, 15].

Treatment and Outcome

In the absence of displacement or features requiring surgical stabilization, conservative treatment is appropriate for many proximal tibial stress fractures, with the primary aim of reducing mechanical loading and preventing fracture progression [3, 7, 8, 12-14].

Our patient was treated with strict non-weight bearing for 45 days, together with low-molecular-weight heparin thromboprophylaxis and adequate analgesia. This was followed by progressive weight bearing with walking aids and structured physiotherapy. The outcome was favorable, with complete pain resolution, restoration of full knee mobility, and recovery of independent ambulation.

Weight-bearing restriction should nevertheless be individualized according to fracture location and severity, patient-related risk factors, and clinical evolution. Progressive rehabilitation after prolonged unloading is essential to restore muscle strength, joint mobility, proprioception, and normal gait before unrestricted physical activity is resumed [3, 8, 12-14].

Conclusion

We report an unusual fatigue-type stress fracture of the proximal tibia in a 24-year-old woman following an abrupt increase in physical activity. Radiographs and MRI demonstrated a fracture line closely following the scar of the completely fused proximal tibial physis.

While proximal tibial stress fractures have previously been described near the physeal scar, the close correspondence between the fracture trajectory and a completely fused physeal remnant in a young adult is unusual. The case raises the possibility that residual trabecular architecture at the site of the former growth plate may influence stress distribution and provide a preferential plane for fracture propagation under repetitive loading [1-6, 15].

Further observations would be necessary to determine whether this association represents a reproducible biomechanical phenomenon or an incidental anatomical relationship. Awareness of this pattern may nevertheless facilitate diagnosis and prevent confusion with persistent physeal cartilage or other causes of proximal tibial abnormalities in young adults [1-4, 15].

Learning Points

- Stress fractures of the proximal tibia are uncommon compared with tibial diaphyseal stress fractures.
- A physeal scar may remain visible after complete skeletal maturation and should not be mistaken for persistent growth cartilage.
- A stress fracture may occur in close anatomical relationship with, and potentially propagate along, a completely fused physeal scar.
- MRI is particularly useful for confirming the fracture line, demonstrating associated bone marrow edema, and establishing its relationship with the physeal scar.
- In a young adult with an unusual stress-fracture location, clinical and biological assessment for factors affecting bone health should be considered.

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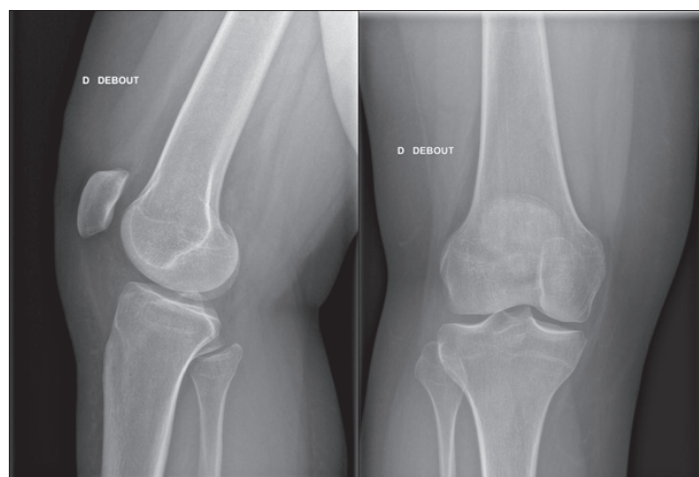


Figure 1: Initial X-Ray obtained at presentation to the emergency department.

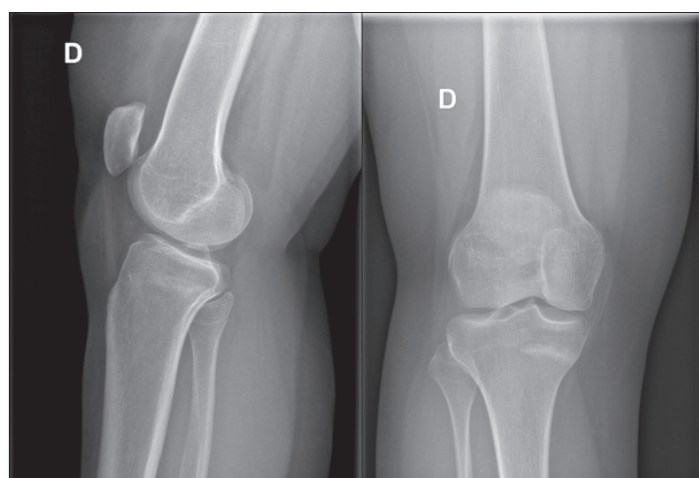


Figure 2 : X-Ray obtained at the 3-month follow-up.

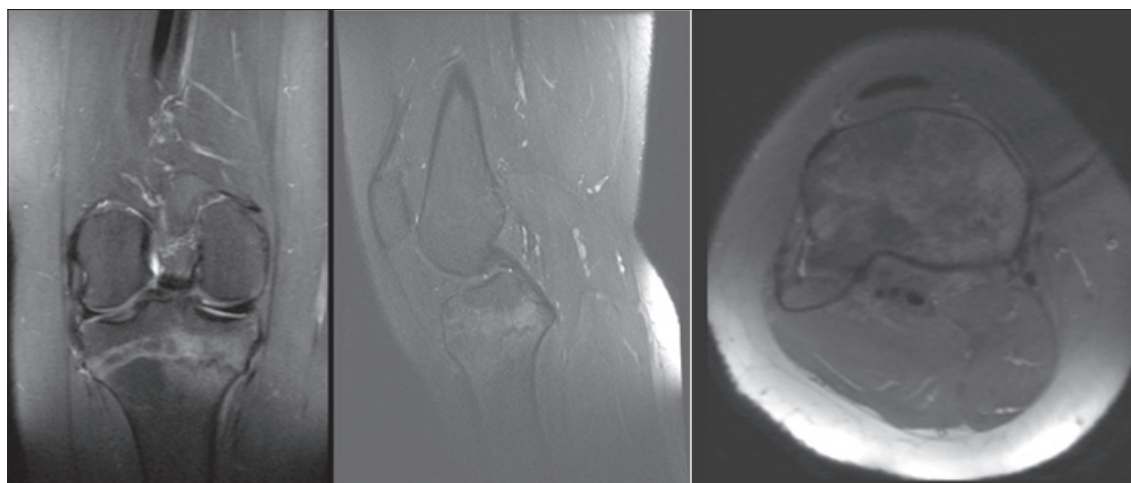


Figure 3 : Magnetic resonance imaging (MRI) of the right knee showing bone marrow edema with increased signal intensity on T2-weighted images.

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