The case:

A 13-year-old boy presented to the emergency department with bilateral ankle pain and swelling following a 5-foot fall from a swing set.

Figure: Coronal (A) and sagittal (B) computed tomography scans of the right ankle.

Your diagnosis?

For answer see page 853
Diagnosis:
Bilateral Distal Tibial Transitional Ankle Fractures

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An otherwise healthy 13-year-old boy was brought to the emergency department after a 5-foot fall from a swing set. He reported bilateral ankle pain and had diffuse swelling and tenderness to palpation noted on examination. Plain radiographs of the ankles were obtained, identifying bilateral distal tibial epiphyseal injuries. To better delineate the fracture patterns, computed tomography (CT) scans of the ankles were obtained, demonstrating a right-sided triplane fracture (Figure 1) and a left-sided Tillaux fracture (Figure 2). Closed reduction was attempted but was unsuccessful. As such, open reduction and internal fixation was performed on both ankles.

At 1-year follow-up, the patient was doing well, with no activity limitations, residual pain, or evidence of growth arrest (Figure 3).

Etiology
Closure of the distal tibial physis occurs over an 18-month period. It begins centrally and then proceeds anteromedially, posteromedially, and to the lateral aspect of the epiphysis.1 During this time, children are susceptible to transitional ankle injuries.

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Figure 1: Coronal (A) and sagittal (B) computed tomography scans of the right ankle, consistent with a triplane fracture. The coronal cut demonstrates a Salter-Harris III injury, while the sagittal view depicts a Salter-Harris II injury.

Figure 2: Coronal (A) and sagittal (B) computed tomography scans of the left ankle, consistent with a Tillaux fracture. Both the coronal cut and the sagittal cut demonstrate Salter-Harris III injuries.
Triplane fractures occur in children 12 to 15 years old as they progress toward skeletal maturity. The triplane fracture is usually attributed to an external rotation force of the foot on the leg, and behaves like a Salter-Harris IV injury. It consists of sagittal, transverse, and coronal components that traverse the physis, entering the ankle joint.

Juvenile Tillaux fractures occur within a year of complete distal tibial physeal closure. At this time, only the anterolateral aspect of the physis is open. Like triplane fractures, Tillaux injuries are most often attributed to an external rotation force of the foot on the leg. However, the fracture pattern created in this setting most closely resembles a Salter-Harris III fracture.

Most patients who sustain these injuries are adolescent males with right ankle involvement. This is attributed to the later closure of the lateral distal tibial physis in boys as compared with girls, making them more vulnerable to this injury for a greater amount of time.

**DIAGNOSIS**

Diagnostic imaging is an essential component of the workup of pediatric ankle injuries. Plain radiographs should be obtained first and should include anteroposterior (AP), lateral, and mortise views of the ankle. The triplane fracture appears as a Salter-Harris III fracture on AP radiographs and a Salter-Harris II fracture on lateral radiographs. The juvenile Tillaux fracture appears as a Salter-Harris III on both AP and lateral radiographs.

When concern exists for a transitional ankle fracture, a CT scan must also be obtained to identify the true extent of the fracture and for potential preoperative planning. Horn et al compared CT scans with radiographs in the setting of Tillaux fractures and found that, although both modalities were accurate to within 1 mm 50% of the time, CT scans are more sensitive in detecting greater than 2 mm of fracture displacement, which is an indication for operative intervention. Additionally, a better understanding of fracture configuration, such as that provided by CT, correlates with improved outcomes following the treatment of transitional ankle fractures.10

**TREATMENT**

Although closed reduction may be attempted first, poor outcomes have been observed with closed treatment of pediatric transitional ankle fractures when greater than 2 mm of displacement or greater than 2 mm of articular step-off are present. This is attributed to the energy of the injury and soft-tissue interposition at the fracture. Open reduction and internal fixation is therefore warranted in such instances (Figure 3). Lateral fractures are approached through an anterolateral incision, while open reduction of more medial fractures is performed through an anteromedial incision. Fixation is achieved with either Kirschner wires or cannulated screws.

**COMPLICATIONS**

The development of posttraumatic arthritis is the primary concern with inadequately reduced transitional fractures of the distal tibial epiphysis. Premature physeal arrest, which is considered the most severe sequela of trans-physeal injuries, is unlikely in this setting because these fractures occur in patients close to skeletal maturity. The rate of premature growth arrest following triplane fractures has ranged from 0% to 21%. Tillaux fractures have even lower rates, as they occur in an older age group than triplane fractures.

**CONCLUSION**

Triplane and Tillaux fractures represent a continuum of pediatric transitional ankle fractures that occur during closure of the distal tibial physis. Closure, which occurs over an 18-month period, begins centrally and then proceeds in an anteromedial direction, then posteromedial, and ultimately to the lateral aspect of the physis. Despite similar mechanisms of injury (an external rotation force of the foot on the leg), triplane and Tillaux fractures are separate entities, as the former present as Salter-Harris IV injuries and the latter as Salter-Harris III fractures. Additionally, Tillaux fractures are traditionally seen in older children, occurring within a year of complete distal tibial physeal closure. This case illustrates the concept of asymmetric physeal closure, as the 13-year-old boy described sustained bilateral, simultaneous triplane and Tillaux fractures.
Although the diagnostic work-up and approach to treatment are similar, these fractures represent manifestations of distinct and different periods of skeletal growth. This is important to recognize because of the prognostic implications associated with these injuries.

**REFERENCES**