Pediatric Ankle Fractures

Concepts and Treatment Principles

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KEYWORDS

• Ankle fracture • Salter-Harris • Growth plate injury • Physis • Transitional fracture • Pediatric sports injury • Ankle trauma • Leg length discrepancy

KEY POINTS

- Pediatric ankle fractures account for 15% of all physeal injuries.
- The Salter-Harris classification is the most widely adopted system.
- Salter-Harris type III and IV fractures more frequently require operative treatment and may result in growth arrest.
- Local soft tissue swelling and inability to bear weight should prompt radiographs to assess for fracture.
- Tillaux and triplane injuries are specific fracture patterns that occur as the physis closes, may be missed on plain radiographs, and frequently require surgical management to restore congruency of the articular surface.

SCOPE OF REVIEW

The present review discusses pediatric ankle fractures, defined as tibia and fibula fractures distal to the metaphysis in patients with open physes. Most of these fractures are caused by sports injuries or low-energy trauma.[1] The pediatric ankle with open physes and incomplete ossification presents distinct mechanical and biological properties compared to the skeletally mature ankle. Thus, children have unique ankle fracture patterns and require specific treatment to preserve and monitor the physis.

EPIDEMIOLOGY

Ankle fractures represent around 5% of all fractures, 15–20% of all physeal injuries in children, and are the most common physeal injury in the lower extremity.[2–5] Ankle

Institutional Review Board approval was obtained for this study.
The authors have nothing to disclose.

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Foot Ankle Clin N Am 20 (2015) 705–719
http://dx.doi.org/10.1016/j.fcl.2015.07.004 **foot.theclinics.com**
1083-7515/15/$ – see front matter

fractures also occur in adolescents and more frequently require surgical management than distal radius fractures and other fractures. There is a higher incidence of ankle fractures in children with increased body mass index.[6,7] Basketball, soccer, football, and scooters are the most common activities associated with ankle fractures.[8–11]

PEDIATRIC ANKLE ANATOMY

Of all physeal injuries, fractures of the distal tibial physis have among the highest rates of complications, including premature physeal arrest, bar formation, angular deformity, and articular incongruity.[12,13] The physis contains 4 zones, from the epiphysis to the metaphysis, with decreasing mechanical strength caused by decreasing matrix-cell ratio: the reserve zone, the proliferative zone, the hypertrophic zone, and the provisional calcification zone. Fracture typically occurs through the hypertrophic zone, which has the largest cells and less extracellular matrix than the other zones. For most fractures, this in turn preserves the reserve zone, which is located on the epiphyseal side of the fracture and contains the progenitor cells for physeal growth.[14,15] Fractures that cross the physis into the epiphysis (Salter-Harris [SH] types III and IV), however, may damage the reserve zone and, thus, are at higher risk of causing physeal growth disturbance.

The distal tibial physis provides 40% of the growth of the tibia and 17% of lower extremity growth, with 3 to 4 mm of growth per year in childhood. Distal tibial growth occurs proportionately to the proximal tibia in young patients; but in adolescents, the proximal tibia growth becomes more rapid and distal tibial growth tapers off.[16] Thus, injury to the physis at a young age can result in significant leg length discrepancy. The distal tibial ossification center appears around 6 months of age and the distal fibula around 1 to 3 years of age. Distal tibial and fibular physeal closure occurs around 12 to 17 years of age in girls and 15 to 20 years of age in boys.[17,18] In contrast to other physes, tibial physeal closure occurs slowly and eccentrically, beginning around the Poland hump, and then anteromedially, posterolaterally, and finally anterolaterally. This pattern of closure explains the specific tibial physeal fracture patterns seen in adolescent triplane and Tillaux fractures. Physeal arrest is generally not a concern for triplane and Tillaux fractures, because the physis is already closing in these fracture patterns. Abundant blood supply is provided to the distal tibial physis, so posttraumatic avascular necrosis of the plafond is very rare.

The distal fibula is contained in a groove on the lateral distal tibia and has significant ligamentous constraint with the anterior and posterior tibiofibular and calcaneofibular ligaments. Ligamentous structures in children are quite robust, whereas the physis is biomechanically vulnerable to shear and rotational forces. Thus, the same injury mechanism that may result in an ankle sprain in adults can present with physeal or avulsion fractures in children. The distal fibula physis becomes undulating during childhood, which does provide it with additional stability.[18] The distal fibula frequently has a secondary center of ossification that can mimic an avulsion fracture on radiograph. The medial os subtibiale is more prevalent than the lateral os subfibulare.[19,20] Clinical examination findings may be used to distinguish a nondisplaced avulsion fracture from an ossification center.

Growth of the fibula is evenly distributed between the proximal and distal fibular physis in childhood, although the proximal fibular growth becomes predominant in adolescents.[21] Isolated physeal arrest of the fibula is rare but can lead to ankle valgus and an external foot progression angle.