Radiology of Postnatal Skeletal Development

VIII. Distal Tibia and Fibula

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Abstract. Initially the distal tibial physis is a relatively transverse structure. As the epiphysis matures, undulations develop within the physis and lappet formation occurs peripherally. Within the first two years a significant physeal undulation develops anteriorly above the medial malleolus. This undulation must not be misinterpreted as premature epiphyseodesis following distal tibial fracture. Secondary ossification in the distal tibia begins centrally and initially expands to fill the area over the tibial plafond. At the lateral side of the tibial epiphysis the ossification center may be wedge-shaped. The medial margin adjacent to the medial malleolus is often irregular and may show small peripheral foci of ossification. By seven to eight years, the secondary center extends into the medial malleolus, with complete distal extension often not occurring until adolescence (although usually complete by ten to eleven years). The malleolar tip may exhibit an accessory ossification center. However, this center also may be a traumatic avulsion in the symptomatic patient. Physiologic epiphyseodesis begins over the medial malleolus and subsequently extends laterally. This pattern of closure appears to predispose to fracture of the lateral portion of the distal tibial epiphysis (fracture of Tillaux), as well as to triplane fractures.

The articular surface curves onto the lateral side of the distal tibia to form an articulation with the lateral malleolus (distal tibiofibular joint). A similar extension occurs along the medial side of the fibula. These surfaces extend proximally as a recess to the level of the distal tibial physis, at which point the syndesmosis begins.

The initially transverse distal fibular physis becomes a convoluted structure, with extensive peripheral lappet formation. Within these regions of physeal overlap there may be small areas of accessory ossification (both medially and laterally) that should not be misinterpreted as fractures. This overlapping also minimizes specific physeal separation and displacement (especially when compared to the incidence of distal tibial physeal injuries). Stress views may be necessary to show such an undisplaced fracture. The fibular physis normally is level with the tibial articular surface or distal extent of the tibial ossification center, especially after the second year of life (however, it may be more proximal in infants). As in the medial malleolus, there may be accessory ossification at the tip of the fibula. While this usually is a normal variant of secondary ossification, occasionally it also may result from trauma. Extensive porosity of the distal fibular metaphysis predisposes to buckling or torus injuries that may have severe, multiangular deformation.

Key words: Accessory ossification – Ankle – Fibula – Malleolus – Syndesmosis – Tibia

Since the ligaments about the ankle are biomechanically stronger than the tibial or fibular physes prior to skeletal maturity, ligamentous ankle injuries are rare in children. In contrast, chondro-osseous injuries involving the developing physes are common. Eleven percent of all physeal injuries involve the distal tibial physis, a region which contributes 40 to 45% of the growth of the tibia [6, 14, 27, 29]. The shape of the ankle joint predisposes the epiphysis and physeal involvement to shearing and twisting injuries that may variably disrupt normal growth plate morphology. Accordingly, fractures involv-
ing the distal tibial epiphysis are particularly worrisome because of the potential sequela of leg length discrepancy or angular deformity [5, 10, 14].

There are many sources of diagnostic confusion concerning the developing distal tibia and fibula [1, 2, 7]. Proximal extension of the anteromedial, distal tibial epiphysial ossification center toward the metaphysis may be misinterpreted as a fracture fragment, or subsequently misconstrued as a bony bridge complicating a physeal fracture. This particular undulation usually is a normal anatomic finding. Presumed accessory ossification centers are common at the tip of the tibial malleolus. Similar accessory ossification may also occur at the tip of the fibular ossification center. An extra ossicle or ossicles at the periphery of the distal metaphysis of the fibula may be mistaken for a fracture or osteochondrosis.

This study of the distal tibia and fibula continues the series concerning radiographic aspects of postnatal skeletal development [11, 12, 18–22], specifically concentrating on accessory ossification at the tips of the malleoli, the spatial relationships of the physes, the undulation of the tibial physis above the anteromedial malleolus, and the pattern of closure of the tibial physis (with its particular effect on fracture patterns during adolescence).

**Materials and Methods**

Thirty-three pairs of distal tibiofibular composites were removed from skeletally immature cadavers ranging from full-term stillborn to fourteen years. There were 22 males and 11 females. Seven unilateral tibiofibular composites were removed from limb specimens amputated for more proximally located skeletal sarcomas; these children (six males, one female) ranged from 11 to 15 years. In addition, five commercially prepared immature skeletons (bone only) were assessed for osseous morphology; the estimated skeletal ages ranged from five to fifteen years (sex unknown).

The composite chondro-osseous morphologic units were dissected free of soft tissues and roentgenographed intact using Kodak RP-M2 film. Air was introduced to outline ankle joint contours. The tibiae and fibulae were separated and roentgenographed using air/cartilage interfacing, which allowed excellent visualization of the articular and hyaline cartilage of the epiphyses. Specimens were placed directly on the covered film to avoid magnification. The morphologic specimens were also immersed completely in water and roentgenographed. This technique, using water/cartilage interfacing, reasonably duplicated the clinical situation of radiolucent epiphyseal cartilage. The specimens were then sectioned at quarter-inch intervals in the sagittal plane and radiographed using the aforementioned air/cartilage and water/cartilage interfacing. All specimens (intact and slab section) were photographed. The commercial osseous preparations were roentgenographed and photographed intact.

Representative slab sections were fixed in 10% formaldehyde, decalcified in 5% formic acid, and embedded in paraffin or celloidin for histologic sectioning and staining with hematoxylin and eosin. The details of histologic development will be reported in a subsequent publication.

**Results**

In the neonate the growth plates are transversely oriented, with the fibular physis being located more distally than the tibial physis (Fig. 1). However, at this stage of development, the fibular phy-