PHYSEAL INJURIES

Alan S. Banks, D.P.M.

The presence of a growth plate in the child requires that one treat the injured limb as something other than an adult counterpart. Even digital injuries may be associated with disruption of the growth plate which may necessitate a different therapeutic approach. This presentation will deal with the more common physeal injuries seen in the foot and the treatment considerations for each.

Anatomy

There are three sections to most long bones (i.e., tibia, metatarsal) (Fig. 1). The primary growth center, or diaphysis, is the lengthy central aspect of the developing structure. The diaphysis expands at each end to form the metaphysis, which is more involved in active bone growth. Epiphyses, or secondary ossification centers, lie adjacent to the metaphysis and are separated from it by the growth plate or physis (Fig. 1). The opposite side of the epiphysis articulates with the adjacent joint. The epiphysis and physis are closely related, and may be termed an epiphyseal complex. There are two different types of epiphyseal complexes within the lower extremity; pressure and traction. Pressure complexes are located at the end of long bones as previously described and serve to produce rapid longitudinal growth for the body. Other functions include providing the proper configuration needed for joint function, correct axial alignment, and distribution of weight-bearing forces through the limb. Traction complexes (apophyses) serve as the site for tendinous insertion and are subject to tremendous tensile forces. They are non articular and do not contribute to longitudinal growth. However, they may provide additional shape or contour to the bone. An example is the calcaneal apophysis.

The physis is the radiolucent band between the epiphysis and metaphysis. Within the physis are cells responsible for the longitudinal growth of the bone. Disruption of the germinal cells will result in partial or total growth arrest. Trauma to the physis is commonly labeled as epiphyseal injury. This is actually a misnomer, as it is the growth plate which contains the germinal cells needed for growth, not the epiphysis (Fig. 2).

Within the physis is an orderly arrangement of cells which procede from cartilage on the epiphyseal side, to osseous tissue on the metaphyseal side (Fig. 2). The resting cells evolve into actively dividing chondrocytes which begin to organize into columns. Proceeding toward the metaphysis the chondrocytes begin to enlarge and hypertrophy. The previously rich intercellular matrix also becomes sparse. Because of the loss of intercellular and intracellular substances, this area of the physis is particularly susceptible to shearing, bending, and tension stresses. It is at this level that fracture occurs in the normal healthy individual. As the process continues the old chondrocytes begin to absorb hydroxyapatite crystals and eventually ossify.

Classification System

Salter and Harris' article in 1961 remains the classical work on physeal injuries (1). The classification is the most accepted and widely used to date (Fig. 3). Rang later described a Type VI injury where the soft tissues were stripped from the periphery of the physis resulting in partial growth arrest and/or osteochondroma formation (2). Ogden more recently has expanded and added subclassifications in an attempt to more thoroughly explain subtle differences which have been witnessed clinically (3).

Injuries in the Lower Extremity

Digits

Physeal fractures of the toes will probably represent the largest number of such injuries seen by most podiatrists. These fractures are generally either type 1 or type 2 with a relatively small metaphyseal fragment. These fractures are usually quite stable due to their transverse nature and the constitution of the periostium. The injury does not affect the joint and closed reduction with splintage of the toe to an adjacent member is usually sufficient.

Fractures which involve the physis of the proximal phalanx of the hallux may require more attention. A fair number of type 3 injuries will be seen, some of which may compromise the integrity of the first metatarsophalangeal joint. Open reduction may be necessary

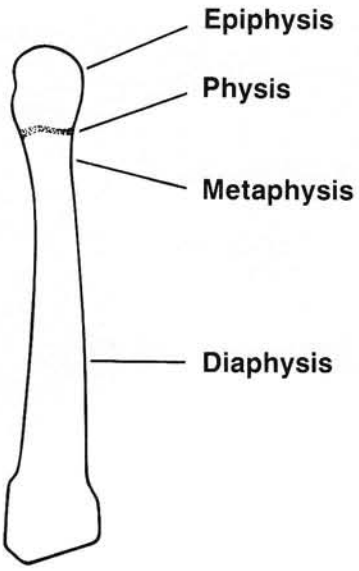

Fig. 1. Anatomy of typical long bone.

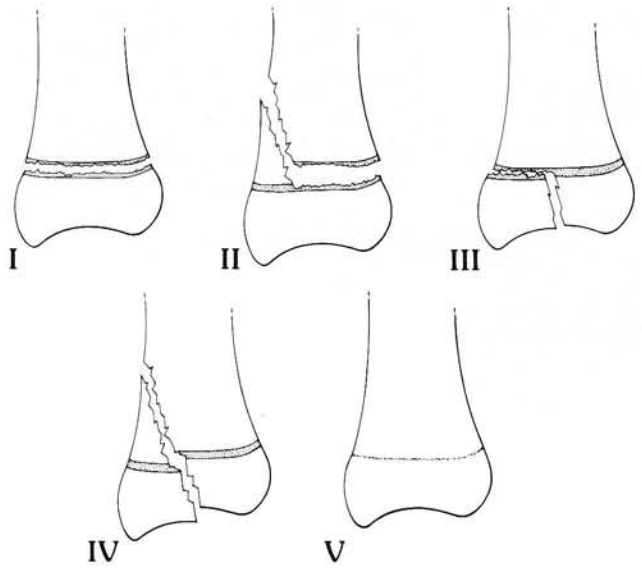

Fig. 2. Salter-Harris classification system.

to adequately reduce this intraarticular fracture. Joint congruity takes precedence over the status of the physis in this situation.

Another digital injury which requires more attention is seen when the nail has been avulsed from the proximal nail fold. A force of this magnitude is sufficient to fracture the physis of the distal phalanx, and radiographs are in order (Fig. 4). Seymour described this injury in the hand. He recommended that the nail be gently restored beneath the proximal nail fold and splinted in the reduced position (4). However, as the nail is avulsed there will usually be an associated laceration of the nail bed, thereby exposing the underlying phalanx. Engber and Clancey documented the potential difficulties one may encounter in using Seymour's technique (5). Two of their patients developed infection and premature fusion of the physis. Based on these experiences their recommendation was that the proximal nail be avulsed and the bed inspected for evidence of injury. Primary suturing of the nail bed should be performed when possible and radiographs taken to rule out fracture. A small drain may be placed beneath the proximal nail fold and oral antibiotics are prescribed as the bone is considered to have been contaminated. Our approach is essentially the same except that the exposed nail bed is covered with Adaptic with a small portion being placed beneath the eponychium as opposed to a separate drain. Oral antibiotics have been effective, and we have not found the need for other prophylactic measures to prevent infection (Fig. 4).

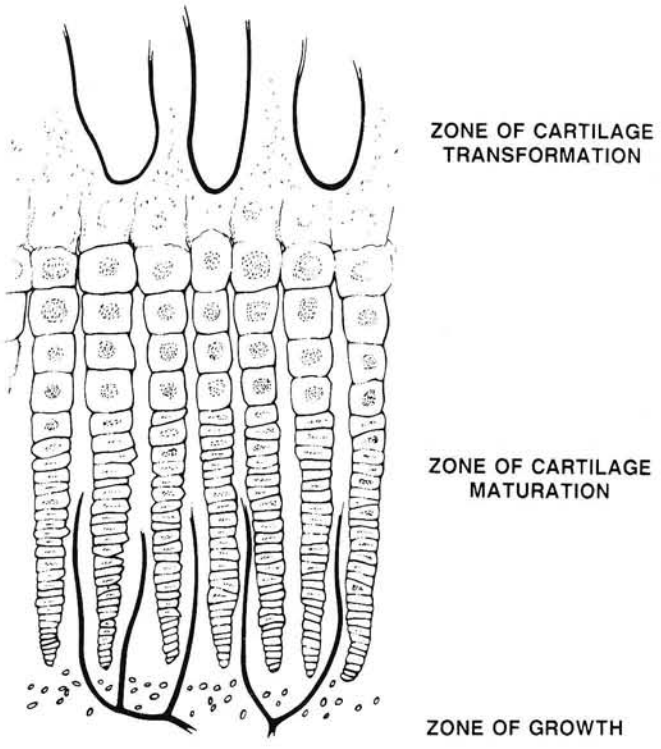

Fig. 3. Anatomy of physis. Cells proceed from germinal area adjacent to epiphysis and organize into columns. Chondrocytes start to swell and soon both intercellular and intracellular matrix is lost. Metaphyseal vessels then invade area to initiate ossification.

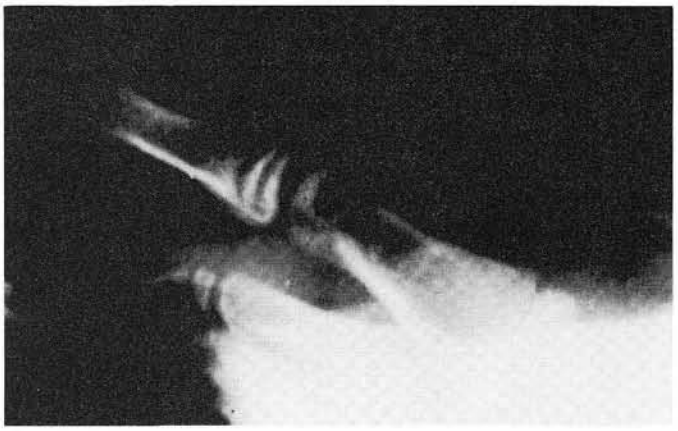

Fig. 4. Stubbed toe with proximal nail avulsion may be associated with fracture of physis of dital phalanx of hallux.

Fig. 5. Type 3 fracture of medial malleolus. This represents end-stage of supination-adduction injury. Either ligamentous rupture or physeal fracture must be present laterally.

Antibiotics may also be prescribed as a prophylactic measure following crushing injuries which result in physeal fracture. Ogden feels that there may be microscopic injury to the integument which may result in contamination of the growth plate.

Metatarsals

The lesser metatarsals may be injured by a variety of means. The most common fracture seen in our experience has been type 2. Although the child may have remarkable healing abilities and may remodel bone following a displaced fracture, metatarsals represent a special concern since small amounts of displacement in these weightbearing bones may predispose one to symptomatic lesions at a later time. Closed reduction will be successful in restoring many of these fractures to an acceptable level. This may be facilitated by the use of the chinese finger trap. However, one might seriously consider open reduction of the fracture when closed reduction fails to adequately reduce the fragment. Multiple fractures tend to be resistant to closed reduction as the metatarsal heads are connected via the deep transverse metatarsal ligament. Open reduction of just one of the metatarsals will typically result in a significant improvement in the position of the others by way of the Vassal principle.

The fixation of metatarsal physeal fractures is best accomplished by using the smallest possible smooth Kirschner-wire (K-wire). The use of smooth wires has been shown to be a safe technique of fixation even though the physis is crossed. Dissection must be performed with care and with a minimum of soft tissue dissection from the area of the physis. Stripping of the periostium from the periphery of the growth plate, simulating a Type VI injury, may result in premature fusion.

Physeal injuries involving the first metatarsal have been primarily type 2 in the experience of the author. In two instances we have seen a long greenstick metaphyseal fragment with slight lateral angulation of the first metatarsal. These are probably best treated in a closed reduction in hopes that the metatarsal will remodel if needed.

One must also be cognizant of the pseudoepiphysis which may be seen at the first metatarsal head. This is not a true ossification center, but an enlargement of metaphyseal ossification. It is a normal anatomic variant that may mimic a fracture in some acutely injured patients.

Ankle

Physeal injuries of the ankle may best be understood when classified utilizing the system devised by Dias and Tachdjian (6). This is a modification of the Lauge-Hansen methodology, and its purpose is to increase understanding of the fracture mechanism. This in turn enhances the opportunity for satisfactory closed reduction. Several points need to be discussed with regard to physeal injuries of the ankle. In a supination-adduction stage 2 fracture a Type III or IV injury is typically seen involving the medial malleolus. This may be seen without obvious injury to the fibula. However, we know that in order to have a medial injury some damage has to have been incurred laterally. One of two situations may be present. The first is that a Type I injury occurred at the fibular malleolus and spontaneously reduced. The other circumstance is that the lateral ligaments of the ankle are ruptured. Traditionally in children the ligaments were considered the strongest part of the joint anatomy. Therefore, with joint injury fracture pervaded over ligamentous rupture. However, we occasionally see children with lateral ankle ligament rupture who have no physeal compromise (Fig. 5).

Other patterns are seen which do not fit the Dias-Tachdjian classification are the triplane and anterolateral fractures of the distal tibia. As the distal tibial physis undergoes physiologic fusion, it will close first at the central portion, then medially, and finally laterally. When a strong external rotation force is applied to the adolescent ankle the physis will fracture at its weakest portion. At this point in the child's life it will be the anterolateral tibia. The result will be either a Type III fracture of the distal tibia (juvenile Tillaux fracture) or else a triplane fracture. The triplane fracture is actually a Type IV injury as it involves all three body planes, hence the name triplane. The hallmark is the appearance of a Type III injury on an anteroposterior radiograph and a Type II injury on a lateral radiograph.

Treatment for both types is generally closed reduction and casting. As the physis is almost through its growth cycle, premature fusion carries no real detrimental sequelae. However, one should ensure that the ankle mortise is well reduced. The joint congruity is the prime concern with any of the physeal ankle injuries.

Conclusion

The primary physeal injuries which may be seen in the foot have been reviewed. In many cases closed reduction with immobilization will be satisfactory. When intraarticular injury has occurred then attention should be directed toward preservation of the joint integrity.

References

1. Salter RB, Harris WB: Injuries involving the epiphyseal plate. *J Bone Joint Surg* 45A:587-622, 1963.
2. Rang M: *The Growth Plate and its Disorder*. London, Livingstone & Co, 1969.
3. Ogden JA: *Skeletal Injury in the Child*. Philadelphia, PA, Lea & Febiger, 1982.
4. Seymour N: Juxta-epiphyseal fracture of the terminal phalanx of the finger. *J Bone Joint Surg* 48B:347, 1966.
5. Engber WD, Clancey WG: Traumatic avulsion of the fingernail associated with injury to the phalangeal epiphyseal plate. *J Bone Joint Surg* 60A:713, 1978.
6. Dias LS, Tachdjian MO: Physeal injuries of the ankle in children. *Clin Orthop* 136:230-233, 1978.