CHAPTER **18**

EVALUATION AND TREATMENT OF ADOLESCENT ATHLETIC INJURIES

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Adolescence is an age of changing from a child into an adult and with this comes certain challenges in the treatment of the adolescent athlete. The osseous structures are changing and maturing and the demands placed on the body are greater as these young athletes begin even more rigorous training programs. The injuries sustained in this group of athletes are specific in nature due to the closing of growth plates and the strength of the tendinous and ligamentous structures transitioning to the osseous strength that will predominate in adulthood. Injuries affecting adolescent athletes can not be treated as if they are smaller adults and the specific injuries must be carefully identified and treated aggressively to limit long-term complications.

ANATOMIC CONCERNS

Physeal plates, or growth plates, develop at varying time periods in specific bones and fuse to complete the growth process at different times in each individual. Pain isolated to a growth plate region must be treated aggressively to allow for the most normal maturation possible. Damage to the physeal plates early in the maturation process can result in one portion of the bone fusing prematurely resulting in angulation of the bone or surrounding joint. Premature closure of a physeal plate may also result in leg length discrepancies that may need to be accommodated or surgically corrected through limb lengthening. Fractures involving the growth plate are most commonly classified by the Salter-Harris classification system (Figure 1). Intra-articular fractures (Type III and IV) often require manipulation and possible surgical reduction with internal fixation to restore joint congruity and prevent long term complications.

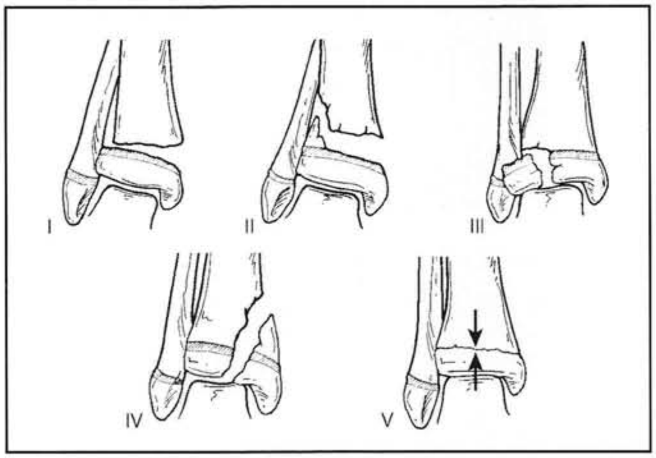

Figure 1. Salter-Harris classification of physeal fractures based on radiographic findings independent of mechanism of injury.

Many types of overuse injuries result in repetitive physeal trauma and the resulting pain must be aggressively treated to prevent progression to fractures. Calcaneal apophysitis and Osgood-Schlatter disease are 2 well-documented injuries resulting from traction on secondary ossification centers that can develop into stress fractures or chronic conditions, which may limit competition during the maturation process. Early diagnosis is key to allow incorporation of stretching and functional support to be used early in the rehabilitation process to allow the bones to ossify in a normal manner without continued strain at the physeal plate.

METABOLIC AND HORMONAL CONCERNS

The hormonal and metabolic balance that occur in the adolescent years is of critical importance in the treatment of both acute and overuse injuries. A young athlete's nutritional intake plays a role in the maturation process as well as the body's ability to heal from injury. The increased uptake of starch in today's youth and subsequent decrease in protein intake decreases the body's ability to restore osseous and soft tissue structures. The initiation of puberty and the muscular development that occurs impacts each individual in regard to how their body matures. Muscular development can impact the traction on secondary growth centers and result in avulsion or repetitive stress injuries.

Special attention must be paid to adolescent female athletes especially those in rigorous training programs. Young girls may restrict caloric intake to maintain an appearance and to gain a competivitve advantage. A decrease in dietary intake of calcium, which is often replaced with carbonated beverages results in a weakening of osseous structures and predisposes these young athletes to stress fractures and other overuse injuries. As a result of inadequate caloric intake and high energy requirements, the body is deficient in the materials necessary to cope with the high demand. The Female Athletic Triad is a common sequella of this process resulting in: amenorrhea, anorexia, and osteoporosis. This can be a delicate situation to discuss with a young athlete and an understanding of the underlying process is important to be able to discuss concerns with both athlete and parents (Figure 2).

FOREFOOT FRACTURES

Injuries to the forefoot must be carefully evaluated in young athletes as soft tissue structures are stronger and may lead to a variety of avulsion type injuries or growth plate disruptions. Younger athletes are more able to remodel their bone and compensate for slight angulations of fractures in the metatarsal region. Fractures of the digits and metatarsals that involve malalignment of the joint may require closed reduction or open reduction with internal fixation to anatomically restore the articular surface.

Fractures of the fifth metatarsal base must be evaluated carefully due to the secondary center of ossification that begins to develop there in the early second decade of life. Fractures are more likely to be transverse or oblique in nature while the normal physeal plate is directed longitudinally. These injuries must be suspected with any inversion twisting injury of the foot or ankle due to the insertion of peroneus brevis. Directed physical examination in combination with radiographic evaluation will reveal these injuries and allow for appropriate treatment. Nondisplaced fractures can be treated with immobilization non-weightbearing for 3 weeks followed by protected weightbearing for an additional 3 weeks while monitoring progress and healing radiographically and clinically (Figure 3).

FEMALE ATHLETIC TRIAD
Amenorrhea Anorexia Osteoporosis

Figure 2. Female Athletic Triad.

MIDFOOT INJURIES

The most common injury of the midfoot in adolescent athletes occurs in the navicular. High impact injuries can involve cuboid compression fractures but the majority of midfoot fractures involve avulsion fractures of the navicular. These occur due to the insertion of the posterior tibial tendon into the proximal medial portion of this bone and must be differentiated from an os tibiale externum. Symptoms are similar in both injuries and it is important to perform muscle testing in combination with palpation to establish the integrity of the tendon. Localized edema is often present and compression of the joint via "nutcracker sign" is pathomnemonic for intra-articular fracture of the navicular. (Figure 4)

Radiographic evaluation with plain film radiographs will often reveal acute fractures though the integrity of the joint and anatomic alignment of the joint may require CT scan for more specific evaluation. MRI may be used when attempting to differentiate an avulsion fracture, accessory bone or insertional tendon injury. Bone scan may also be helpful in a neglected or recurrent injury to determine the bone activity and healing potential in this region (Figure 5).

Treatment of nondisplaced navicular fractures or ligament injuries of the os tibiale externum complex involve immobilization with a non-weightbearing cast for 4 weeks followed by progressive weightbearing with protection as tolerated. Displaced fractures or non-healing avulsion fractures require surgical intervention to align

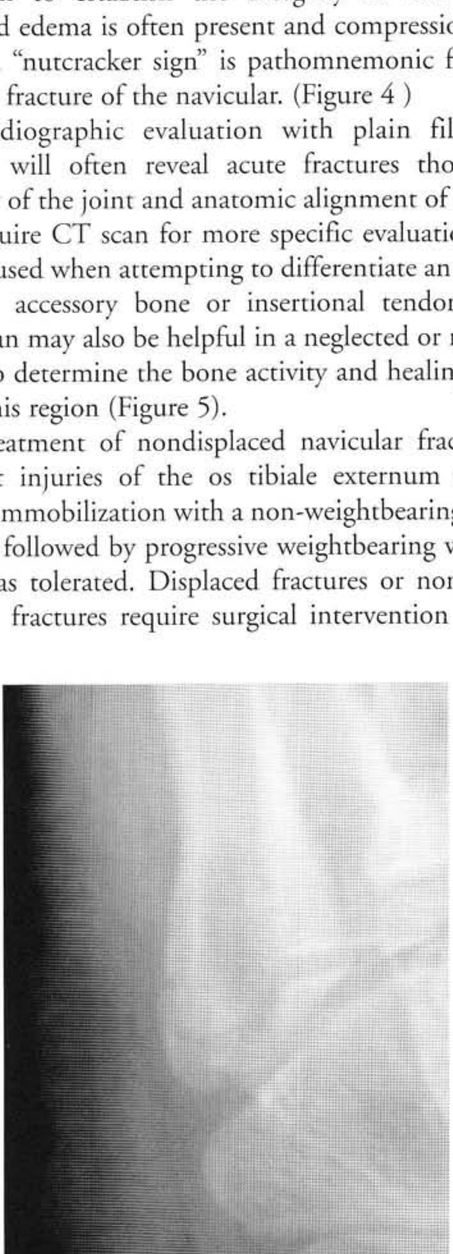

Figure 3. Medial oblique radiograph of fracture of fifth metatarsal base fracture in 13-year-old basketball player.

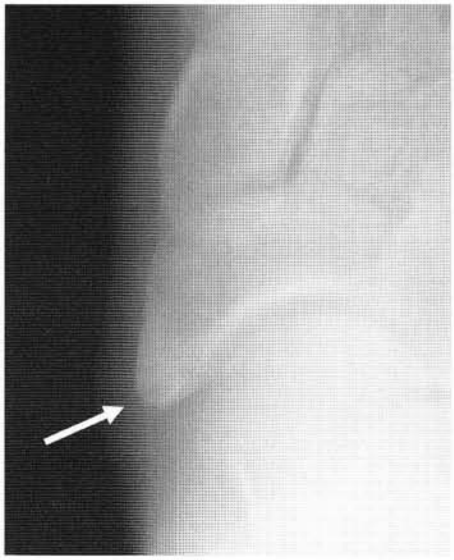

Figure 4. Dorsoplantar radiograph revealed avulsion fracture of navicular tuberosity.

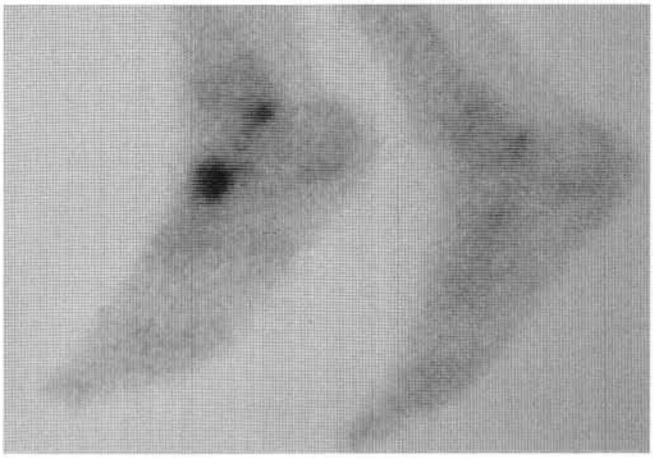

Figure 5. Bone scan revealed increased activity at site of navicular tuberosity fracture.

the fracture fragments and impart rigid internal fixation across the fracture line. Non-weightbearing for 4 weeks is recommended with initiation of passive range of motion as tolerated. Physical therapy is often indicated in the rehabilitation to increase muscle strength and improve propulsion and stabilization in stance.

ANKLE INJURIES

Injuries to the ankle joint are the most common lower extremity athletic injury and must not be dismissed as sprains in all situations. This is extremely important in adolescent athletes due to the tibial and fibular growth plates and their pattern of closure. Ankle injuries must be treated aggressively with initial non-weightbearing to evaluate the extent of the injury and to prevent further disruption of the growth plates. Triage on the field should include compression and ice and attention should be addressed to the growth plates with palpation over these sites. The relatively stronger soft tissues result in avulsion type injuries that may involve joint disruption and radiographs in combination with clinical examination are essential in identifying these classic types of fractures.

DISTAL FIBULAR PHYSEAL FRACTURES

Inversion injuries of the ankle are encountered commonly in athletes with play on uneven terrain. The stronger lateral collateral ligaments of the ankle joint create a traction injury to the physeal plate rather than the more common sprains that occur in adults. Injuries to the fibular physeal plate present with swelling localized approximately 2 cm superior to the tip of the lateral malleolus. Pain is palpated directly in this region and is not commonly experienced at the anterior talofibular. Injured athletes often are unable to fully bear weight on the extremity and should be non-weightbearing initially. (Figure 6)

Figure 6. Ankle radiograph revealed soft tissue swelling at distal lateral fibular physis without displacement consistent with Salter-Harris I fracture.

In most cases, radiographs of the ankle will not reveal any osseous displacement or pathology but may show increased soft tissue swelling over the distal fibular physis. This injury is classified as a Salter-Harris I fracture of the distal fibular physis. Treatment should be initiated with a non-weightbearing Jones compression splint with patient reevaluated in 1 week and placed in a below knee walking cast as tolerated. The cast may be removed at 4 weeks and alignment confimed radiographically prior to

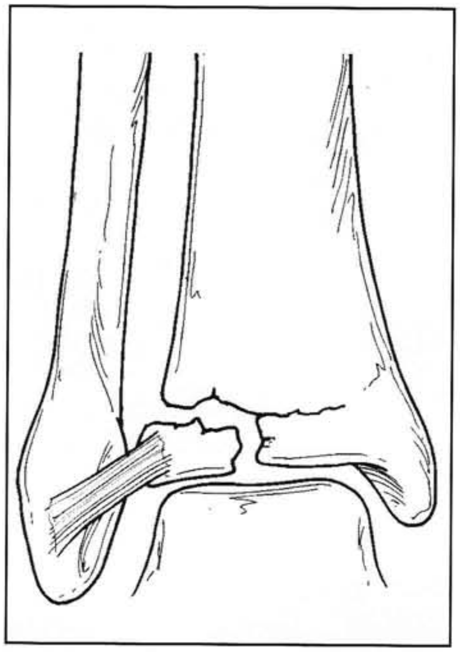

Figure 7. Juvenile Tillaux fracture.

progression into a removable walking boot. Physical therapy may be indicated to restore proprioception and strength to the ankle.

TILLAUX FRACTURES

A Tillaux fracture is the result of external rotation of the foot stressing the anterior tibiofibular ligament and resulting in an avulsion fracture of the distal anterolateral portion of the tibia. The epiphysis of the distal tibia unites from central to medial and then to lateral with the lateral component fusing last. This process takes approximately 18 months and the ligament is stronger than the physis during this time period. This is classified as a Salter-Harris III fracture as it involves the physis and the ankle joint surface (Figures 7-9).

A displaced fracture is close reduced through reversal of the causative mechanism and may require open reduction and internal fixation if a step-off is evident at the articular surface. Anteromedial directed pressure on the fragment will assist in reduction of the avulsed fracture fragment. Care must be taken to not compress across the physis with fixation and to avoid impingement at the anterior portion of the tibia. The patient should be non-weightbearing for 4 weeks followed by initiation of range of motion and protected weightbearing in a removable walking boot. Growth arrest is usually not an issue with a Tillaux fracture as the physis is already completely closed medially.

Figure 8. Ankle mortise radiograph status post ORIF of Tillaux fracture of distal tibia.

Figure 9. Lateral radiograph status post ORIF of Tillaux fracture of distal tibia.

TRIPLANE FRACTURE

A triplane fracture is caused by the same external rotation mechanism as the Tillaux fracture but with the addition of an axial compression force resulting in a posterior push-off fracture of the tibia. It may be multifragmented but is named as the fracture line travels in all three planes as it traverses the tibia. It has the same fracture pattern as a Tillaux fracture on an AP ankle radiograph while the lateral radiograph reveals the appearance of a Salter-Harris II fracture with posterior spike exiting at the posterior tibia in the metaphysis. The true classification of a triplane fracture is a Salter-Harris IV fracture as it enters the joint distally and travels through the physis while exiting in the metaphyseal region of the tibia (Figure 10).

Radiographic evaluation reveals the trademark fracture pattern as described. CT scanning is often helpful in visualizing the joint surface to insure anatomic alignment. Closed reduction through internal rotation and anteromedially directed pressure on the anterolateral distal tibial epiphysis may be adequate to realign the fracture and joint surface. Open reduction is performed if the joint is not reduced and may require multiple screws for fixation. The patient should be non-weightbearing in a cast for 4-6 weeks and based on clinical symptoms and radiographic consolidation may progress to a weight-beaing cast or removable walking cast at that time. Growth arrest is usually not an issue with a triplane fracture as the physis is already partially closed although inadequate reduction can create angulation of the joint surface (Figures 11-14).

STRESS FRACTURES

Stress fractures in young athletes are caused by the same combination of factors that result in overuse fractures in adults. Overtraining and increasing the intensity of training too rapidly are the most common cause of adolescent stress fractures. When this high activity level is coupled with poor dietary intake, the resultant decreased bone density places the athlete at higher risk for stress injuries. A high index of suspicion is necessary to ask the difficult questions of coaches, parents and athletes to

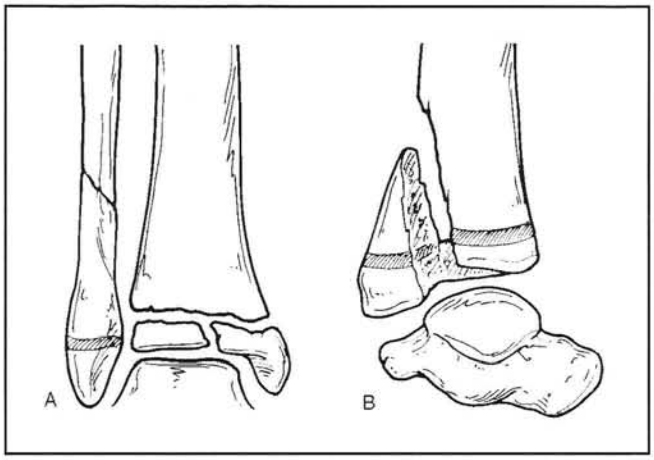

Figure 10. Triplane fracture

Figure 11. Plain film radiograph displaying Salter-Harris II fracture through distal tibial physis.

Figure 12. Lateral radiograph revealed posterior tibial metaphyseal fracture indicating Triplane fracture.

Figure 13. Corresponding CT scan demonstrates minimally displaced Triplane fracture.

Figure 14. CT sagital reconstruction demonstrates ankle mortise alignment of Triplane fracture

Figure 15. Tibial Stress fracture in 16 year old female runner. Note osteopenia despite significant bone callous formation.

identify underlying risk factors and not only treat the presenting injury but also the underlying cause. Appropriate referrals to nutritionists, endocrinologists, gynecologists and possibly even sports psychologists may be necessary to treat the entire problem while treating the injured athlete and providing them alternative activities to maintain their fitness.

Clinical symptoms of edema and pinpoint tenderness raise the index of suspicion for stress fractures that are common in adolescents in the tibia and metatarsals. Early diagnosis is key to prevent problems that can interfere with the athletes growth and in some cases result in avascular necrosis at the stress fracture site. Inadequately treated fractures may lead to significant arthritic concerns as the athlete ages and may require career-ending surgical intervention. Radiographic evaluation coupled with early utilization of bone scan or MRI evaluation allows for early diagnosis. Aggressive conservative treatment with immobilization is key to limiting the athlete's period of inactivity from their sport. Cross training plays an important role in the rehabilitation process to allow maintenance of fitness and return to the athletic field as early as possible (Figure 15).

SUMMARY

The treatment of children and adolescent athletes is very rewarding yet very challenging. Balancing the athlete's expectation with those of coaches and parents and ultimately doing what is best for the adolescent from the medical viewpoint can create dilemmas. These young athletes are pushing their bodies to the limit and often need guidance in how to mentally and physically deal with injuries. Acute injuries must be evaluated with a high index of suspicion for growth plate injuries. Overuse injuries and stress fractures must be evaluated to determine the causative factor and any underlying hormonal or nutritional deficiencies. Adolescent athletic injuries must be evaluated and treated aggressively to allow the young athlete to return to their sport expediently without risking further damage or limitations later in life.

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