Foot and ankle problems in the young athlete

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ABSTRACT

OMEY, M. L., and LYLE J. MICHELI. Foot and ankle problems in the young athlete. Med. Sci. Sports Exerc., Vol. 31, No. 7(Suppl.), pp. S470–S486, 1999. In the U.S., greater than half of boys and one quarter of girls in the 8- to 16-yr-old age range are engaged in some type of competitive, scholastic, organized sport during the school year. Children and adolescents are becoming more involved in sports at earlier ages and with higher levels of intensity. Foot and ankle problems, in particular, are the second most common musculoskeletal problem facing primary care physicians in children under 10 yr of age next to acute injury. This report focuses on foot and ankle problems, trauma, and overuse in the young athletic population. Guidelines are given for both conservative and surgical management. Specific problems addressed include pes planus, tarsal coalition, adolescent bunion, os trigonum, accessory navicular, physeal fractures, sprains, peroneal tendon subluxation, metatarsal fractures, sesamoid fractures, turf toe, stress fractures, tendinitis, osteochondritis dissecans, ankle impingement, bursitis, Haglund’s deformity, sesamoiditis, plantar fasciitis, apophysitis, osteochondroses, cuboid syndrome, and reflex sympathetic dystrophy. An extensive review of the literature is performed and presented in combination with the extensive experience of a well-established sports medicine clinic at the Boston Children’s Hospital.

DEVELOPMENTAL PROBLEMS

Congenital skeletal variations of the lower extremity may be undetected until a child puts high demands on the extremities through sports participation (58).

Pes Planus

A patient with little or no longitudinal arch while standing is said to have a flatfoot or pes planus. At birth, most children have a foot that has a minimal longitudinal arch. Staheli et al. (116) confirmed that flatfeet are standard in infants and common in children up to the age of 6. A flatfoot is said to be flexible if the arch can be recreated with the patient standing on their toes.

Flexible pes planus has been reported to occur in 15% of the general population (6), with the majority being asymptomatic (44). If a flatfoot is painful, other causes must be sought out, such as tarsal coalition, vertical talus, or accessory navicular (125).

Most flexible flatfeet require no treatment (51–53,125), although an arch support may be prescribed. In young athletes involved in running or field sports, excessive pronation may be a risk factor for the onset of overall injury to the lower extremity, particularly the knee. Correcting the pronated foot with an orthotic may prevent future injury.

Tarsal Coalition

Tarsal coalition is a fibrous, cartilaginous, or bony connection of two or more bones in the midfoot or hindfoot (34,125). It usually presents during adolescence, at an average age of 13 yr (101), when the coalition is ossifying and...
subtalar motion becomes more limited. Most tarsal coalitions are bilateral (34,60) and have been reported to occur in less than 1% of the general population (34). Calcaneonavicular and talocalcaneal are the most common coalitions seen (34,93,101,122,125).

The young athlete with a tarsal coalition will usually present with pain that is vague and insidious in onset. They may present with a history of frequent “ankle sprains” or generalized hindfoot or midfoot pain (101). Symptoms often begin or are exacerbated by athletic training; thus, a relatively high occurrence is encountered in a sports-active population. Exam will show limited or no subtalar motion compared with the other foot and occasional tight peroneal muscles (52). Spastic peroneals have been reported to occur in less than 1% of these patients, however (122).

Plain radiographs should include AP, lateral, and oblique views of the foot (34,125). Lateral x-ray may show secondary signs of a decrease in subtalar motion (i.e., talar beaking; Fig. 1). The oblique view is usually diagnostic with calcaneonavicular coalitions, whereas an axial view may reveal a talocalcaneal bar (34,125). CT scanning, though, is usually necessary when the diagnosis is in question (Fig. 2).

The goal of conservative treatment of tarsal coalition is to reduce stress in the foot, relax the peroneal muscles, and support the foot. This can usually be accomplished with orthotics and physical therapy, although temporary casting may be necessary (34,125). If conservative treatment fails, however, a resection may be necessary in order to restore mobility and decrease pain, allowing for a complete return to athletics (34,101). If indicated, resection should be done early and not delayed until skeletal maturity, as is sometimes advised.

Adolescent bunion. Hallux valgus has been reported to affect 22–36% of adolescents (15,24,26,27,40,85,111), though we tend to find that percentage to be lower in our practice. With hallux valgus, the first metatarsal deviates medially and the great toe laterally with a resultant medial bulging of the first metatarsophalangeal joint (Fig. 3). There can be pain over this prominence, exacerbated with shoe wear. The cause is unclear, but various factors are cited such as tight shoes, metatarsus primus varus, pes planus, forefoot pronation, joint hyperlaxity, and heredity (40,85). Hallux valgus is seen more commonly in female subjects, particularly those involved in athletics or dance training, such as ballet. This athletic involvement alone may be a significant risk factor. In the dancer, one possible explanation for hallux valgus may be excessive rearfoot varus with increased pronation and increased abduction force on the first metatarsophalangeal joint, causing a hallux valgus (71).

Initial treatment of the adolescent bunion includes wider shoes, bunion pads, orthotics, and physical therapy (26,40,85). If pain persists, however, structural realignment of the first metatarsal varus is usually necessary. We prefer a distal first metatarsal osteotomy with medial capsulorrhaphy, as do others (2,3,40). Simple bunionectomy is rarely successful in this age group. Recurrence after metatarsal osteotomy has been reported to be as high as 20–60% (3,10,40,85,111). Approximately one third of these patients will not return to a complete range of shoe wear and activity level may decrease (85).

ACCESSORY OSSICLES

Os Trigonum

The posterior aspect of the talus often exhibits a separate ossification center, appearing at 8–10 yr of age in girls and 11–13 yr of age in boys. Fusion usually occurs 1 yr after its appearance (12,86). When fusion does not occur, an os trigonum is formed (Fig. 4). It has been reported to be present in approximately 10% of the general population and is often unilateral (12,68,69,81). The origin of this os sicle may be congenital or acquired. Congenially, it can be a persistent separation of the secondary center of the lateral tubercle from the remainder of the posterior talus secondary to repeated microtrauma during development (12,81). The acquired form may be secondary to an actual fracture that has not united (12,61,81). With either form, the os trigonum is asymptomatic in most. However, it can become symptomatic in those young athletes who actively plantarflex their ankle, such as the ballet dancer, gymnast, ice skater, or, on occasion, soccer players (12,55,68,81,139). An os trigonum can cause mechanical impingement of the posterior talus between the posterior tibia and the calcaneus. Repetitive impingement of the soft tissues in this interval can also result in hypertrophic capsulitis (12,69).

The young athlete with a painful os trigonum will usually present with pain in the posterolateral ankle (12,32,49,134),
The incidence in the general population has been reported to be 4–14\% (18,125), but few actually become symptomatic. A histologic study by Grogan et al. in 1989 (45) suggested that tensile failure in the cartilaginous synchondrosis was the cause of pain.

In the adolescent athletic population, symptoms may arise secondary to pressure over the bony prominence, a tear in the actual synchondrosis, or tibialis posterior tendonitis (18). The athlete will present with pain and a prominence over the navicular in a pronated foot. There is local tenderness to palpation and pain with foot inversion against resistance (125). It has been hypothesized that the tibialis posterior tendon inserts into the accessory navicular, a weaker insertion point, thereby causing a drop in the medial arch of the foot, resulting in a pes planus (72). However, Sullivan and Miller (126) found that there was no difference in the longitudinal arches of those with an accessory navicular and those without.

Physical examination is supplemented by radiographic assessment. The AP view or a 45° eversion oblique view is usually diagnostic (125).

We treat our young athletes with orthotics, trial of casting, physical therapy, and eventual removal if symptoms continue (7,18,45,60,125,126,135). Conservative treatment is usually quite successful; however, we will excise the accessory navicular more often in the adolescent athlete because of persistence of symptoms with sports.

Figure 3—Juvenile hallux valgus.

posterior to the peroneal tendons. Pain is reproduced with plantarflexion. Associated posteromedial pain (12,49,55) may indicate a concurrent flexor hallucis longus tendonitis.

Plain x-rays should include a lateral of the ankle, as well as a lateral view in plantarflexion. A bone scan may be used to determine the reactivity of the os trigonum (12,14), but absence of uptake does not exclude impingement.

Differential diagnosis includes posterior ankle impingement, Achilles tendinitis, peroneal tendinitis, and flexor hallucis longus (FHL) tendonitis (12). Conservative treatment begins with rest, anti-inflammatories, avoidance of plantarflexion, physical therapy, casting, and injection (12,55). The pain, however, usually returns once the young athlete resumes their sport, particularly the ballet dancer.

We feel a resection is necessary in the competitive young athlete. We prefer a lateral approach (103), unless there is a concomitant flexor hallucis longus tendonitis when a medial approach is necessary. Some authors prefer the medial approach only (55).

Accessory Navicular

The accessory navicular is the most common accessory bone in the foot. It occurs on the medial, plantar border of the navicular at the site of tibialis posterior tendon insertion (125).
Medial Malleolus Ossification Center

The medial malleolus ossification center (MMOC) appears between 1 and 2 yr of age and usually fuses by age 11 or 12. Persistence into adulthood is uncommon. When it does persist, however, the source of pain is thought to be related to repetitive microtrauma at the chondro-osseus junction with the main body of the medial malleolus. This tends to be more evident in our young athletes.

In a study by Stanitski and Micheli in 1993 (119), 11 cases of symptomatic MMOC were examined. All patients were involved in some type of vigorous athletic activities. All complained of isolated medial ankle pain without a history of direct trauma. The ossification center was well visualized on AP ankle x-ray. There was swelling and point tenderness over the medial malleolus. Treatment included eliminating athletics for 3 wk. If the patient was still symptomatic, a short leg cast was tried for another 3 wk. If symptoms still persisted, the cast was continued another 10 d. In this particular study, every single patient improved with this treatment plan. However, if symptoms still persist, arthroscopic removal of the fragment is indicated.

INJURIES

Ankle Injuries: Acute—Fractures

Physeal. In the child or adolescent, the distal tibial and fibular growth plates form a plane of weakness, resulting in injury patterns markedly different from those seen in adults. Ligaments in the skeletally immature may be stronger than the physis, increasing the risk of physeal injury over liga-

mentous sprain. Childhood fractures also rarely disturb the talotibial relationship itself (28,88).

Fractures of the distal tibial and fibular physes constitute 4% of all ankle injuries (28). However, the degree of displacement does not always correlate with premature physeal fusion. Goldberg and Aadalen (42) reported on 53 fractures of the distal tibial physes; 31 of 53 occurred while patients were participating in athletic events. When examining the skeletally immature athlete, AP, lateral, and mortise view x-rays are necessary. A comparison view is often needed for clarification.

Physeal fractures can be divided into the Salter Harris classification system: (28)

I: fracture through the physes without a metaphyseal fragment;
II: fracture through physes and exiting out through the metaphysis with a fragment;
III: fracture through the physes and exiting out through the epiphysis with a fragment;
IV: vertical fracture through the epiphysis and out through the metaphysis with a fragment; and
V: axial compression crush injury to the physes, not evident on initial plain x-rays.

In general, the higher the class of fracture, the greater the likelihood of significant disruption of growth.

Physeal ankle injuries involve different mechanisms. Supination/external rotation, pronation/eversion/external rotation, and supination/plantar flexion all can cause varying stages of ankle ligamentous and bony injury with Salter Harris I and II fractures of the distal fibula and tibia (Fig. 5). Salter I and II fractures of the distal fibula are among the
most common fractures seen in the athletic child (60). A supination/inversion mechanism usually causes a Salter Harris III or IV fracture of the distal tibia and has a greater chance for growth arrest. It is necessary to reduce displaced fractures and follow the athlete closely and long-term for possible physeal arrest (28).

**Juvenile tillaux fracture.** The juvenile tillaux fracture is an isolated fracture of the lateral portion of the distal tibial physis that occurs with external rotation (28). As the medial aspect of the distal tibial physis closes at the end of adolescence, external rotation athletic injuries may result in a fracture of the anterolateral quadrant of the tibial physis, resulting in a Salter III injury (60). This fracture can be seen on plain x-rays of the ankle and usually needs internal fixation with greater than 2 mm of displacement (28,60), because it involves the articular surface.

**Triplane ankle fracture.** As the distal tibial physis begins closing, the anteromedial portion begins first, followed by the posteromedial physis. This whole process takes about 18 months. A fracture occurring during this time period usually takes the form of a triplane fracture. Three fragments are included: the anterolateral distal tibia physis (SH III), the remainder of the anterolateral physis, and a posterolateral spike of the distal tibia metaphysis (SH III), and the remainder of the distal tibia metaphysis. These fractures can be seen in the young athlete and usually require internal fixation (28).

**Sprains**

Ankle sprains have been reported to make up 10–28% of all athletic injuries (4,66). In dealing with the adolescent athlete, be reminded that serious ankle sprains are unusual in the skeletally immature because the ligaments are usually stronger than the bone (28,60,88). Think of a physeal fracture until proven otherwise.

The most common mechanism of an ankle sprain is one of inversion and plantar flexion, injuring both the anterior talofibular and calcaneofibular ligaments. The young athlete will commonly have tenderness over the anterolateral ankle, as opposed to the distal fibular physis, which can be reproduced with an inversion stress. With eversion and external rotation, the deltoid and/or syndesmosis ligaments can be injured. Tucker recommends treating these medial and central injuries more aggressively with a nonweightbearing cast for 10–14 d (132).

Ankle sprains can be graded. Grade I sprains are painful, but do not have swelling or instability. The adolescent athlete can usually return to sports in 1–2 wk. Grade II sprains have marked swelling, pain, and slight laxity. These athletes usually require 8–12 wk to return to their sport. Grade III sprains have gross instability, marked swelling, and significant pain. These athletes are at greater risk for chronic instability or osteochondral lesions (28,137), requiring future surgery.

Treatment of an ankle sprain usually begins with rest, ice, compression, and elevation (RICE). The athlete usually can advance their weightbearing as tolerated. We find an Aircast ankle stirrup to be helpful in promoting early weightbearing. Physical therapy can also be helpful with particular emphasis on active motion, peroneal strengthening, and proprioception. The management of most sprains of the ankle should be conservative for at least 6 months before operative intervention is considered. Chronic problems after ankle sprains usually fall into three categories: instability, impingement, and articular lesions (98) (Fig. 6). These will all be discussed later.

**Peroneal Tendon Subluxation**

Subluxation of the peroneal tendons is an uncommon but potentially disabling condition that can affect young athletes (92). It is a frequently overlooked cause of persistent lateral ankle pain after trauma (22). Among the cases of acute dislocation reported in the literature, more than 90% were the result of athletic injuries from snow skiing, ice skating, running, basketball, soccer, or football (21).

The peroneal tendons lie behind the lateral malleolus in a fibro-osseous tunnel formed by a groove in the fibula and the superficial peroneal retinaculum. The peroneal retinaculum and the posterior calcaneofibular ligament form the posterior wall of this tunnel. The peroneal muscles serve as both plantarflexors and evertors of the foot (11,22).

In some young athletes, there may be an anatomic predisposition to peroneal tendon subluxation, which would include an absent or shallow fibula groove (22,36,88,96), possibly combined with pes planus, hindfoot valgus, or lax/absent peroneal retinaculum (11,22,36,107,123). The retinaculum can also traumatically rupture from a violent forced dorsiflexion of the ankle with reflex contraction of the peroneal muscles and dislocation (1,11,22,33,68,88,123).

Peroneal tendon subluxation can be an acute episode that turns into a chronic problem due to misdiagnosis. Many of these are incorrectly diagnosed at the acute stage as simple ankle sprains (113). The young athlete may present acutely after a supposed ankle sprain with pain and swelling over the posterolateral aspect of the ankle. More commonly, though, the initial presentation may be weeks to months after the injury (68). The adolescent may complain of recurrent inversion ankle sprains and lateral ankle instability with a painful snapping across the ankle (115). Chronic ankle instability can also contribute to chronic peroneal tendon subluxation with the development of an incompetent superficial peroneal retinaculum (22,115).

On physical exam, subluxation may be provoked with forceful ankle dorsiflexion and eversion. There may be pain posterior to the lateral malleolus in an acute situation, as well as a negative anterior drawer test. This can also be confused with the rare isolated injury to the posterior talofibular ligament (11,22,96,123).

Plain ankle x-rays are useful to rule out other fractures but may show a bony, shell-like avulsion fracture off the posterolateral border of the lateral malleolus, a so-called “rim fracture,” indicating an avulsion of the superior peroneal retinaculum (96,107) that occurs with dislocation of the
peroneal tendons. This may be seen in up to 50% of acute peroneal tendon dislocations (22,31).

If the diagnosis is made acutely, casting in mild plantarflexion and inversion for 6 wk (22,33,97) may be sufficient for healing. However, it has been our experience and has been documented in the literature, that high-demand young athletes usually come to surgery because of persistent symptoms with sports (22,33,68,81,87,92,113,123). However, a felt pad may be taped over the tendons temporarily if the athlete wishes to complete their season (68).

Many different surgical procedures have been described for chronic peroneal tendon subluxation (22,33,59,65,70,83,92,113,114,120,123,140); however, we prefer advancing a shelf of bone distally off the fibula (92). This can be combined with reconstructing the peroneal retinaculum. The patient must be skeletally mature to do the bony part of the procedure, so that injury to the growth plate will not occur. In the skeletally immature athletes who have disabling symptoms, we will commonly do a Chrisman-Snook ankle reconstruction procedure instead, which works quite well.

Foot Injuries: Acute—Fractures

Metatarsal fractures. Metatarsal fractures are common in children participating in sports (60). These usually occur indirectly as a result of torsional forces and avulsions or from direct trauma (102).

The incidence of first metatarsal fractures is highest with children under 5 yr of age. This has been called the "bunk bed fracture" because of its common mechanism (47). The fifth metatarsal, however, is the most common metatarsal fracture in children, occurring 45% of the time and in 90% of the children greater than 10 yr of age. Knowledge of the anatomy here is important. The fifth metatarsal has its epiphysis distally and its apophysis located proximally. An inversion stress can cause the peroneus brevis to avulse the base of the metatarsal, resulting in a transverse fracture. This is usually treated with a short leg walking cast for 3–6 wk. The normal apophysis is diagonal in nature, aiding in its distinction from a fracture.

A Jones fracture occurs at the junction of the metaphysis and diaphysis. This is less common in the skeletally immature athlete, though. The average age of occurrence is 15–21 yr, and the subjects are usually involved in athletics. The usual mechanism is a vertical ground force on a weightbearing foot. This fracture is notorious for nonunion due to the vicarious blood supply of this area; hence, it should be treated in a nonweight-bearing cast for 6 wk (47,60,102) ORIF with bone graft may be necessary in the competitive young athlete (60) (Fig. 7). The young athlete with a simple metatarsal fracture can usually wait to return to sports until the fracture has healed, because the healing time is relatively quick.

Sesamoid fracture. Acute sesamoid fractures are rare in the young athlete. Sports at risk include those requiring rapid acceleration and deceleration, jumping, and running.

The usual clinical presentation is a several-week history of pain about the MP joint of the great toe. Swelling is usually present. An acute event of MP hyperextension is sometimes remembered (104).

X-rays include AP, lateral, oblique and sesamoid views of the foot. Bone scan or CT scan may be necessary when the diagnosis is in question.

The usual treatment is a short leg cast for 4–6 wk. However, because this is a fracture under distraction, de-
are being seen with increasing frequency by the PCP, as well as the sports medicine specialist. The physician treating these injuries must be acquainted with the biomechanics of the particular sport as well as the tendency these young athletes have to continue activities that are painful. An analysis of the six S's will allow one to pinpoint the overuse source: shoes, surfaces, speed, structure, strength, and stretching.

In the adolescent athlete, bones may grow quicker than muscle-tendon units, resulting in poor flexibility and overuse injuries. Stress fractures, tendonitis, muscle strains, and apophysitis all have a common denominator: the structure involved is stressed beyond the limits of its ability to repair.

### Ankle Injuries: Overuse

**Stress fractures.** Stress fractures represent the ultimate overuse injury. They have also been referred to in the literature as “fatigue fractures” and “insufficiency fractures.” Stress fractures in young athletes present as a

Conservative treatment can proceed if displacement of the metatarsals on x-ray is less than 2 mm. This would include an orthotic or a fracture boot if the patient is unable to bear weight comfortably. Physical therapy is instituted when the foot is comfortable. A stiff shoe is recommended for return to athletics.

**Sinus tarsi syndrome.** Sinus tarsi syndrome is a sprain of the subtalar joint. This usually occurs after an ankle injury and is sometimes difficult to distinguish from a routine ankle sprain. The adolescent athlete will usually present with swelling in the dorsal/anterior/lateral portion of the foot, just anterior to the lateral malleolus. There will be pain with palpation and pronation, usually due to scarring in the soft tissue elements of the sinus tarsi. Treatment may include an orthotic to limit pronation. Selective cortisone injection into the subtalar joint can also be diagnostic and therapeutic.

### OVERUSE INJURIES

Repetitive, unrepaired microtrauma in the young athlete results in manifestations of “overuse injury.” Overuse injuries...
mechanical pain, increasing with activity and decreasing with rest. This is the hallmark of a stress fracture (118).

Specific risk factors in young athletes include female gender (13, 39, 63), white race (13, 39), sudden increase in training level (63), menstrual irregularity (5), and certain anatomic factors (41), such as tibia vara and decreased hip internal and external rotation.

Distal fibular stress fracture. Stress fractures of the distal fibula are rare because it is a nonweightbearing bone but do occur in young athletes, particularly ballet dancers. The patient will complain of lateral leg or ankle pain, and exam will often show tenderness over the distal fibula (75, 94). Differential diagnosis includes exertional compartment syndrome and peroneal tendinitis (57). X-rays may show medial bowing of the fibula, a break in the normal trabecular pattern, or even periosteal reaction with healing (75). A bone scan may aid in the diagnosis as well (75, 94). (Fig. 10) Treatment is conservative with a decrease in the offending activity, and fracture boot or ankle stirrup, if there is pain with walking. Fibular stress fractures usually heal within 6 wk (94).

Tendonitis

Overuse tendonitis in the tendons spanning the ankle can be seen with training errors, muscle-tendon imbalance, anatomic malalignment, improper footwear, or a sudden growth spurt (88). Tendonitis can also be seen in the adolescent that resumes play after a period of decreased training (107).

Flexor hallucis longus tendonitis. FHL tendonitis will usually present itself in the young athlete as pain with resisted great toe flexion, as well as pain posterior and inferior to the medial malleolus. We have also seen pain along the tendon’s course distal to the medial malleolus. Ballet dancers who assume the repeated plantar flexion posture of demipointe or pointe are particularly susceptible to FHL tendonitis. It can also be seen in runners, gymnasts, and field sport players.

Treatment involves correcting improper techniques, icing, stretching, and strengthening (128). We have good success with tenosynovectomy after failed conservative treatment.

Peroneal tendon tenonitis. The young athlete with peroneal tendonitis will usually present with pain behind and distal to the lateral malleolus (107). There may be associated swelling in the acute phase. There will also be pain with resisted foot eversion. Peroneal tendonitis is particularly common in young dancers and ice skaters but can be seen in any running athlete.

Treatment for peroneal tendonitis includes a program of stretching, strengthening, icing, and sometimes, ankle bracing (107) during contact sports. We do not recommend corticosteroid injection as part of our treatment plan, however (107). Tenosynovectomy is sometimes necessary in recalcitrant cases (107).

Achilles tendonitis. Achilles tendonitis is most frequently encountered in young athletes who have had a sudden increase in training quantity or intensity (23, 54, 79, 112). Additional contributory risk factors may be a rapid growth spurt with a tighter gastrocnemius-soleus complex, hyperpronation of the foot, or inadequate footwear. The patient will present with pain along the Achilles tendon, sometimes with associated swelling.

Sporting activities that tend to put undo stress across the Achilles tendon are those that involve running, jumping, or standing up while cycling. Young gymnasts and dancers are at risk with sudden deceleration from jumps or vaults. Dancers who use pointe technique are also prone to Achilles stress (128).

Treatment for Achilles tendonitis includes Achilles stretching, strengthening, orthotics, and the addition of a
Osteochondritis Dissecanes

Osteochondritis dissecanes (OCD) of the talus may result from an inversion stress to the ankle. This is actually a "transchondral fracture" secondary to trauma (88). More commonly, onset of pain is insidious, and some prior macrotrauma is evident. Young athletes may present with pain over the anterolateral or posteromedial talus. They often report recurrent ankle effusions or weakness. Plain x-rays of the ankle will usually show the lesion (Fig. 11), but sometimes bone scan or MRI is necessary for diagnosis (124). The Berndt/Harty (8) classification of talus OCD is as follows:

Type I: small area of compression of subchondral bone;
Type II: partially detached osteochondral fragment;
Type III: completely detached osteochondral fragment but remaining in its crater;
Type IV: displaced osteochondral fragment.

Berndt and Harty (8) reported that 43% of OCD lesions involve the middle third of the lateral talus, with 57% involving the posterior third of the medial talus (88). A study by Canale and Belding (16) concluded that acute trauma caused all of the lateral lesions and half of the medial lesions. The rest of the medial lesions were thought to be
Yet another form of impingement seen in the young athlete is a hypertrophied anterior talofibular ligament. This is not usually due to acute trauma, but rather repetitive microtrauma in the young active patient. The athlete will have point-tenderness over the ATF ligament with a dramatic increase in their pain with ankle dorsiflexion. All studies will be negative for an OCD lesion. We treat this problem with debridement of the ATF ligament through an arthroscopy.

**Posterior Ankle Impingement**

Posterior ankle impingement or talar compression syndrome (12) is seen most often in young female dancers, ice skaters, or gymnasts. These sports require excessive plantarflexion of the ankle, compressing the posterior structures of the ankle (12,49).

On physical exam, the athlete will have pain on palpation of the posterior ankle, dramatically increased with forced plantarflexion. Plain x-rays of the ankle can be taken to rule out a bony etiology (i.e., os trigonum) (12). Soft tissue etiology includes FHL irritation, thickened or invaginated posterior capsule, synovitis, and calcific debris (49,58,62).

**FHL tendinitis.** Our young athletes with FHL tendinitis will usually present with pain along the posteromedial ankle. With chronic inflammation and hypertrophy, the tendon gets compressed in plantarflexion over the posterior talar tubercle (49). With dorsiflexion, however, the FHL is stretched between the posterior talar tubercle and the sustentaculum tali. We see this condition most often in the young dancers. The tendon can actually lock in demipointe and become unable to release in plié (71). FHL tendinitis, with pain posterior to the medial malleolus, is most often confused with posterior tibialis tendinitis (49).

Koleitis et al. (73) reported incidences of stenosing FHL tenosynovitis in a study involving ballet dancers. They all had crepitus and triggering exacerbated by the en pointe position. Nonoperative treatment included decreased activity, physical therapy, and NSAID. Operative intervention included releasing the tendon sheath. All of their dancers went back to their previous levels of dancing.

**Bursitis**

**Retrocalcaneal bursitis.** Retrocalcaneal bursitis is a distinct entity denoted by pain that is anterior to the Achilles tendon, just superior to its insertion on the os calcis (64). The bursa becomes inflamed, hypertrophied, and adherent to the underlying tendon (35). The young athlete with this condition will have pain with a two-finger squeeze just superior and anterior to the Achilles insertion. Retrocalcaneal bursitis should be distinguished from Achilles tendinitis or bursitis, where pain would be posterior to the tendon and beneath the skin occurring from shoewear (110).

We see retrocalcaneal bursitis most often in our young figure skaters. We treat them with physical therapy and rarely bursectomy with associated resection of the posterior superior margin of the os calcis.

**Anterior ankle bursitis.** Anterior ankle bursitis is commonly seen in the young figure skater and ice hockey player in our practice and is affectionately known as a “skate bite.” This condition can present with swelling over the anterior ankle or over the malleoli. A doughnut pad inside the skate over the irritable area will usually decrease the pressure at this point. Sometimes, however, we will aspirate or surgically remove the bursa.

**Haglund’s Deformity**

Haglund’s deformity is an abnormal prominence of the posterosuperior surface of the calcaneus, also known as a “pump bump” (29,56,121,127). This can be commonly seen in adolescent females because of shoewear (77) but is also seen in young male and female ice skaters, soccer players, and runners.

On physical exam, the bump is usually located more to the lateral side of the heel. The young athlete will sometimes have an associated retrocalcaneal bursitis or Achilles tendinitis, as well, with the appropriate tenderness. There will
usually be an accompanying thickening of the overlying skin. Sometimes a varus hindfoot is found.

Treatment of Haglund’s deformity involves relieving the friction imposed by the shoe counter by increasing shoe size by one half, padding the prominence, or using a heel lift to actually raise the heel out of the shoe (121,127). We prescribe physical therapy as well for Achilles stretching and strengthening. Quite often, with persistent symptoms in the young athlete, we will surgically excise the deformity (29,67,121) (see Tables 1 and 2, and Algorithm on posterior ankle pain).

**FOOT INJURIES: OVERUSE**

Most pediatric foot problems in sports are related to abnormal biomechanics of the foot and lower extremity (88,108).

**Stress Fractures**

**Calcaneus.** Calcaneal stress fracture can be a frequent and often misdiagnosed cause of heel pain (76). We do not see this condition in the young athlete very often, but it should be included in the list of differential diagnoses of heel pain. Because most heel pain resolves with conservative treatment, we may not know the actual incidence of this entity. For persistent heel pain in the adolescent athlete, consider a bone scan to rule out calcaneus stress fracture.

**Navicular.** Navicular stress fractures are uncommon but when present deserve specific attention. The young athlete with a navicular stress fracture will present with the insidious onset of vague pain on the dorsum of the foot and/or medial aspect of the longitudinal arch. Tenderness to palpation of the midfoot may be the only physical sign (94). This condition is most commonly seen in basketball players and runners (68). Hurdlers seem particularly prone to this stress fracture, as well.

Increased stress across the navicular may be secondary to a short first metatarsal, metatarsus adductus, or limited dorsiflexion or subtalor motion. Microangiographic studies have shown the central portion of the navicular to actually be avascular (130).

To confirm the diagnosis, bone scan or CT scan may be necessary, as plain films are rarely diagnostic. In a study of 21 navicular stress fractures, Torg et al. (130) found that in 12 cases (57%), the standard x-ray did not show the fracture.

Treatment begins with non-weightbearing for 6–8 wk (88,130) If the fracture fails to heal or is displaced, then fixation with compression screw must be considered. Additional bone grafting may sometimes be needed (88,130). Return to sport may take as long as 16–20 wk (94). The young athletes’ symptoms guide their return to activity.

**Metatarsal.** Metatarsal stress fractures are seen with increasing frequency in children and adolescents. They usually occur with an increase in activity level or change in sport. The second and third metatarsals are the most frequently injured (94).

The young athlete will present with point tenderness directly over the appropriate metatarsal. Occasionally, there may be induration, swelling, and palpable mass (47,94). A bone scan can be very helpful in early diagnosis when plain x-rays are negative. If the fracture is only painful with sports, then the treatment should include refraining from the sport for 2–4 wk is used (47,94). Most young athletes will return to their sport by 4–6 wk.

**Proximal second metatarsal.** The proximal second metatarsal stress fracture differs from other metatarsal stress fractures in so far as it can be difficult to heal, and may result in chronic nonunion. The anatomy in this area is such that the base of the shaft is countersunk into the bony arch of the foot and is therefore rigid (Lis Franc’s joint). This tends to place an abnormal amount of stress across this area, particularly in young ballet dancers (50). Stress fractures are a frequent injury...
Treatment of the second metatarsal stress fracture usually consists of 6–8 wk of rest in a hard shoe or cast (50,100), with gradual return to dance when the tenderness resolves. Follow-up CT scan in 8–12 wk is necessary to ensure healing.

An unusual type of second metatarsal stress fracture that we have seen in our young ballet dancers is one that can involve Lisfranc’s joint, consisting of an oblique fracture at the base of the metatarsal. A study by Micheli et al. (91) showed that the dancer will present with pain in the middle part of the foot, particularly en pointe. Plain x-rays are usually negative as well. An oblique x-ray, tomogram, or bone scan can aid in the diagnosis. A short-leg cast is the initial successful conservative treatment; however, non-union was found in one of his patients, requiring surgical debridement.

**Sesamoid stress fracture.** The young athlete with a sesamoid stress fracture will present with the insidious onset of pain and swelling over the plantar aspect of the first metatarsophalangeal joint (9,68). This is usually aggravated by activity and relieved with rest. Differential diagnosis includes metatarsalgia, bursitis, sesamoiditis, and bipartite sesamoid (9).

Initial evaluation should include plain x-rays with a sesamoid view. Keene and Lange (68) showed in his study that 5–30% of people have bipartite sesamoids with 75% occurring unilaterally.

If the diagnosis is still in question, a bone scan or CT scan should be obtained. The intensity of uptake could help distinguish between bipartite sesamoids and actual fractures.

We begin initial treatment with a short leg cast and a CT scan at 8 wk to detect signs of avascular necrosis. If avascular necrosis is present and the young athlete has persistent symptoms, resection may be necessary (104). If resection is done, a microsurgical dissection with plantar approach is used, and the resultant defect in the flexor tendon must be carefully closed to prevent subluxation of the opposite sesamoid.

**Strains**

**First metatarsophalangeal joint.** The first metatarsophalangeal joint is most often strained with young ballet dancers who engage in pointe work. On exam, normal first MTP joint range of motion in dorsiflexion is 60°. Ballet dancers need at least 80–100° of dorsiflexion to permit full relevé onto demi-pointe (71). Treatment includes avoiding pointe work, physical therapy, and taping.

This injury can also be encountered in field sports (turf toe). A rigid orthotic or stiffened forefoot of the shoe may help resolve symptoms, but this can be a course of persistent symptoms, and early hallux rigidus may result.

**Sesamoiditis**

Sesamoiditis can usually be seen in those young athletes who push off the ball of their foot, to include jumping sports, tennis, or ballet. On physical exam, there will often be swelling and pain on palpation under the first metatarsal...
Plantar Fasciitis

Plantar fasciitis in the young athlete usually coincides with calcaneal apophysitis and rarely exists by itself. In the adolescent athlete with closed physes, the presentation will be one of medial arch or heel pain (109,128). Pain typically occurs during weightbearing and may be exacerbated by climbing stairs or going up on the toes. Morning pain and stiffness are common as well. This inflammation is usually secondary to repetitive stretching of the plantar fascia between its origin at the anterior plantar rim of the calcaneus and its insertion into the metatarsal heads. There will be tenderness to palpation along the medial edge of the fascia or at its origin on the anterior edge of the calcaneus. Young athletes involved with jumping, hill running, or speed work are at a higher risk for getting plantar fasciitis (109,128). Certain anatomic factors including pes cavus or a rigid varus hindfoot may also put the athlete at risk (109).

X-rays usually do not contribute to the diagnosis, and though heel spurs may be a result of this condition, they are not the source of the pain (128). Treatment of plantar fasciitis in the young athlete includes rest (with alternative conditioning programs (136), ice, Achilles stretching, heel cups, NSAID, correcting training errors, orthotics, and occasional steroid injection (109). Plantar fascia release (37) is reserved for extremely recalcitrant cases.

Apophysitis

Sever's disease (calcaneal apophysitis). The calcaneal apophysis serves as the attachment for the Achilles tendon superiorly and for the plantar fascia and the short muscles of the sole of the foot inferiorly (79). This os calcis secondary center of ossification appears at age 9 and usually fuses at 16 yr of age.

Sever's disease is the preadolescent equivalent of Osgood-Schlatter's and is a common cause of heel pain in the athletically active child; 61% occur bilaterally (90). The average age of onset for this condition is 8–13 yr (118).

Factors involved in the etiology of Sever's disease include beginning a new sport or season, foot pronation, and a tight gastrocnemius-soleus complex (89). There usually is a history of an increase in running activity, beginning a new sport, or the beginning of a new season. The tight Achilles tendon is usually associated with a recent growth spurt and is not related to a specific injury.

On physical exam, there can be swelling and induration over the calcaneal apophysis, and/or tenderness with medial and lateral heel compression. The young athlete may also have an associated Achilles tendinitis. X-rays are not recommended unless symptoms continue for a greater length of time. Treatment of Sever's disease begins with stretching the heel cord and heel cups or heel wedges and avoiding barefoot walking until becoming asymptomatic (88).

Iselin's disease. Iselin's disease is a traction apophysitis of the tuberosity of the fifth metatarsal. It is more commonly seen in athletically active older children and adolescents. The secondary center of ossification appears as a small, shell-shaped fleck of bone oriented slightly oblique to the metatarsal shaft and is located on the lateral plantar aspect of the tuberosity of the fifth metatarsal. This apophysitis is located within the insertion site of the peroneus brevis tendon. The center appears in girls at an average of 9 yr and in boys at 12 yr and usually fuses to the shaft by 11 and 14 yr, respectively. This apophysis is best viewed on the oblique x-ray of the foot.

The patient will usually be a young athlete involved in sports with running, cutting, and jumping, resulting in an inversion stress to this area. They will have pain over the area and usually no specific history of trauma. Resisted eversion should reproduce the pain. A bone scan will usually be positive. Iselin's disease can be differentiated from an avulsion fracture of the base of the fifth metatarsal because the apophysis is located parallel to the long axis of the shaft and an avulsion fracture is usually transverse in nature.

Treatment for Iselin's disease includes immobilization for acute pain and physical therapy for strengthening of the peroneal tendons. Bony union will then occur (17).

Osteochondroses

Kohler's disease. Kohler's disease is an idiopathic ischemic necrosis of the tarsal naviculare. This is usually caused by repetitive microtrauma to the maturing epiphysis. It is largely found in male, active children age 4–7 yr. Pain will be aggravated by activity, and x-ray will show a narrowed, radiodense navicular with occasional fragmentation. This condition is self-limiting and should not require any type of surgery. Initial treatment involves decreased activity or a short leg cast for 3–6 wk (80) Orthotics may be necessary to maintain the longitudinal arch.

Freiberg's infraction. Freiberg's infraction is avascular necrosis of the second metatarsal epiphysis. The epiphysis is located at the distal end of the metatarsal. Etiology can be secondary to the repetitive trauma of athletics or foot pronation with a hypermobile first metatarsal, resulting in transfer of pressure to the second metatarsal (88). The average age of presentation is 13 yr and 75% are female. Physical exam of the young athlete will usually show unilateral pain over the second metatarsal head. Less commonly, this can also occur at the third, fourth, or fifth metatarsal heads as well. An x-ray will show osteosclerosis progressing to osteolysis (46). This condition is usually self-limiting and requires only conservative treatment in the form of an orthosis to correct pronation (53) or a short leg cast for more severe acute pain. Physical therapy is used to restore motion to the joint. Surgical debridement or metatarsal head resection are used only in refractory cases (46) or in cases where loose bodies have formed.
Osteochondritis dissecans of the first metatarsal. OCD of the metatarsal head is part of the differential diagnosis of first metatarsophalangeal joint pain. Plain films may show the lesion, but CT or MRI will often be diagnostic.

Cuboid Syndrome

Marshall and Hamilton (82) report that cuboid subluxation is common but poorly recognized. We do not tend to see many cases in our young athletes, however. The etiology has been proposed to be secondary to overuse or an ankle or lateral foot sprain (82).

The young athlete with cuboid syndrome will usually present with lateral midfoot pain and pain with plantar pressure on the cuboid (82). A subtle forefoot valgus may also be present, as well as a tight peroneus longus tendon. This tightness can produce torsion around the cuboid, causing a rotatory subluxation (71,95). Marshall and Hamilton (82), however, rarely found a cuboid in this position. They do believe, though, that the peroneals are tight. Newell and Woodie (95) found 80% of cuboid subluxation in athletes occurred in pronated feet. Marshall and Hamilton (82), however, did not feel this to be true in dancers. Dancers with this condition will usually experience pain when going from flat to demi-pointe.

The diagnosis of cuboid syndrome in young athletes is primarily subjective, and x-rays usually are not helpful (82). Treatment for this condition includes stretching the peroneal tendons and strapping or plantar padding (71). Marshall and Hamilton (82) largely feel that manual reduction is necessary. After reduction in their dancers, the abducted position of the foot in relevé must be corrected to prevent recurrence.

REFLEX SYMPATHETIC DYSTROPHY

Reflex sympathetic dystrophy (RSD) is "a complex disorder of pain, sensory abnormalities, abnormal blood flow, sweating, and trophic changes in superficial and deep tissues" (78). The disease is underdiagnosed in children because the pattern of presentation can be different from adults. Adults usually present after a fracture or trauma with immobilization. With children, it is seen most often in athletic girls (1:6 boys to girls) with an average age of 12 yr (74). Most of the cases are in the lower extremity, to include the foot and ankle, and usually have a history of minor trauma. The more classic patient will present with severe regional pain, swelling, dysesthesia to light touch (allodynia), and vasomotor instability (30).

RSD, in effect, is a pain cycle that has the potential to spin out of control if not diagnosed and treated promptly. The physical exam will be one of pain out of proportion to the degree of injury. Early physical therapy is important as well as referral to a pediatric pain clinic for possible sympathetic nerve blocks or neurosuppressive medications.

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113. Slatias, P., S. Santavirta, and J. Sandelin. Surgical treatment of