CHAPTER 2

Talocrural and subtalar joint
2.1. Ankle sprain, clinical aspects

Ankle sprain is a common injury [1]. Many simple ankle sprains resolve with conservative treatment while others linger on with persistent pain, weakness, “giving way sensation” and symptoms of functional instability [2]. Most patients could relate the onset of the symptoms to an acute or recurrent sprain of the ankle and persistent symptoms will exist after the injury such as stiffness, swelling and pain aggravated by weightbearing or activity [3].

Despite adequate treatment, approximately 40% of the patients suffer from residual symptoms after sustaining this injury [4]. Often there are more factors to the sprained ankle than only injury to the lateral collateral ligaments [5]. After a sprain, structural damage not only occurs to the ligamentous tissue, but also to the musculotendinous, nervous and vascular structures around the ankle complex. They manifest clinically as impaired balance, reduced joint position sense, musculotendinous disbalance, slowed nerve conduction velocity, strength deficits and decreased dorsiflexion.

Additionally the formation of scar tissue after injury may lead to sinus tarsi syndrome or impingement syndromes [1]. Assessment of patients with ankle sprain must address not only joint laxity and swelling but should include examination for neuromuscular deficits as well. The treatment and rehabilitation goals must be directed to restoration of mechanical stability to the injured joint, as well as restoration of neuromuscular function [1].

2.2. Developmental anatomy and embryology

The development of ankle and hindfoot originates from a solitary block of tissue at the age of 7 weeks and begins to separate into its components by 10 weeks [6]. The adult-like shapes of the tarsal bones develop before the formation of the actual joint clefts [7]. Tarsal coalitions are assumed to be congenital in origin. It is believed that the coalition results from a failure of differentiation and segmentation of primitive mesenchyme, with resultant lack of joint formation [8,9]. During the embryonic stage, the fibula undergoes rapid growth and brings the foot in marked adducto-equinovarus position. During the fetal stage, tibial growth corrects this position. Ossification of the ankle bones occurs in sequence, beginning with the talus, followed by the fibula and ending with the tibia. The talus ossifies in 3 to 8 months of intrauterine life. The horizontal portion of the distal epiphysis of the tibia appears between 6 and 10 months of age. The distal fibular epiphysis ossifies between 11 to 18 months. The talus shows a torsion of the neck from fetal to adult life, creating a long axis of the foot, and rotation of the forepart (Fig. 1 and 2) [9]. During development the ankle joint is subjected to stresses that may have a profound influence on its formation and function [6]. These stresses may be abnormal in situations in which
there are alterations in mobility, due to intrinsic or extrinsic factors. Tarsal coalition is an intrinsic condition with an abnormal fusion of two or more independent bones of the hindfoot. Due to the rigidity of the “abnormal fused joints” the gliding motion of the joint is hampered, causing abnormal stress on the articular surfaces and the subchondral bone of the joint adjacent to the fusion. Immobility of the hindfoot can cause compensatory excessive mobility in the ankle joint [6]. Extrinsic factors causing restricted motion of the limb are hydramnion and casting for a long time.

2.3. Functional and clinical anatomy; a few characteristics of the ankle and hindfoot

The ankle joint is formed by three bones: the tibia, fibula and talus. The foot has been divided traditionally into the hindfoot (talus and calcaneus), midfoot and forefoot (Fig. 3). The ankle or talocrural joint consists of the mortise (tibia and fibula) and the trochlea tali (Fig. 4). High congruity between the articular surfaces, together with the close relationship created by the ligamentous complexes gives the talocrural joint a high degree of stability (Fig. 4) [10]. The subtalar joint is formed by talus and calcaneus and is divided in two
synovial lined independent joints: the anterior and posterior subtalar articulations (Fig. 5). These are separated by the sinus tarsi and the tarsal canal. The posterior talocalcaneal articulation is formed by the posterior facet of the inferior surface of the talus and the corresponding posterior facet of the calcaneus. These facets are convex-concave, thus increasing the stability of the joint. The anterior subtalar articulation is formed by anterior part of the talus, the posterior surface of the navicular, and the anterior portion of the calcaneus. The very complex multifaceted surfaces of these joints make evaluation clinically and radiologically difficult.

Movements of the ankle and hindfoot
Sideways tilting of the ankle joint is prevented by the cone shaped talar trochlea which is wider anterior than posterior (Fig. 6A), and a concave shaped distal tibial (Fig. 6B) [11]. The talus neither has tendinous attachments nor muscular origins and relies for its stability on a system of opposed articulating surfaces together with strong ligamentous attachments. Movements of the talus in relation to the leg and foot are exceedingly complex and never consist solely of one-plane movements. Plantarflexion and dorsiflexion are the main
functions of the ankle joint. However, in internal rotation of the leg the talocrural joint is one of the major regions in which motion takes place [11,12]. Movements in the subtalar joint, are mainly inversion and eversion, occurring by moving of the ovoid surfaces of the talus over the ovoid surfaces of the calcaneus [13].

2.4. Instability
The etiology of chronic functional ankle instability is fairly well understood [14]. Pathophysiological factors such as mechanical instability, proprioceptive deficit and peroneal muscle weakness have been demonstrated [14]. The major source of instability is thought to be located at the talocrural level [14]. Often a tear or sprain of the anterior talofibular ligament (ATFL) alone can lead to widening of the mortise, greatly reducing articular stability of the ankle [15].
The role of the subtalar joint in instability of ankle and hindfoot is less well understood. Both the articular surface and bony configuration of the talus and calcaneus and the stabilizing role of the ligamentous anatomy are believed to play an important role in subtalar stability. Subtalar instability must be considered after a sprain, if other causes have been excluded [16,17].

Acute injury to the subtalar joint rarely warrants invasive intervention. Chronic instability symptoms can require surgical stabilization [18].

2.5. Ligaments and sinus tarsi
Each of the ligaments has a role in stabilizing the ankle and subtalar joint, depending on the position of the foot and ankle. There are three main ligamentous structures in the ankle:

- the medial collateral ligament complex (deltoidus), rarely involved in ankle sprains,
- the distal tibiofibular syndesmotic complex, and
- the lateral ligamentous complex, most frequently involved in ankle sprains.

The lateral ligamentous complex consist of three ligaments: the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL) and the posterior talofibular ligament (PTFL) (Fig. 7).

Figure 7.
The collateral ligaments of the ankle joint.
B, The medial aspect of the ankle is supported by the deltoid ligament, composed of four bands. Adapted from ref [36].
The ATFL is a thickening in the anterolateral joint capsule and limits internal rotation and inversion of the talus [19,20]. This ligament plays a crucial role in external rotation of the talus, which results into inversion of the foot [21].

The CFL primarily inhibits inversion of the calcaneus [19]. When torn, it is often associated with ATFL tears in more severe injuries [22].

The PTFL is the strongest ligament of the lateral ligament complex and rarely injured. The PTFL primarily inhibits external rotation and dorsiflexion [19].

The clinical diagnosis of rupture of these ligaments has been based on instability of the joint. Inversion and anterior stress radiography of the ankle have been commonly used to show instability of the joint due to rupture of these lateral ligaments [23]. Values for a normal range of talar tilt and anterior displacement of the talus in relation to the tibia have been difficult to determine [24].

Sinus tarsi
The tarsal canal and sinus tarsi form the space between talus and calcaneus. It contains the ligamentous complex of the sinus tarsi, composed of the interosseous talocalcaneal ligament and the cervical ligament. The main function of these ligaments is stabilization of the hindfoot. The inferior extensor retinaculum is composed of three groups of very lax fibers only indirectly contributing to talocalcaneal stability [25,26]. The subtalar ligaments may be injured during inversion. The major complaints of such patients are a feeling of instability and weakness [20]. Acute ankle sprain is associated with acute abnormalities of the sinus tarsi in 43% of the patients and correlates with the extent of lateral ligament tears [27].

2.6. Osteochondral plate and articular cartilage
The articular surfaces of the bones are covered with hyaline cartilage. Articular cartilage is a highly ordered structure. Four distinct layers have been described within it: the superficial, the transitional, the deep zones, and the calcified zone.

The deep and calcified zone are divided by a line called the tidemark (Fig. 8) [28]. In traumatic separation of cartilage and bone the separation takes place at the junction between the calcified and noncalcified cartilage [29]. Hyaline cartilage deforms under pressure but recovers its original shape when pressure is removed, when damaged it has virtually no intrinsic repair capacity [28].

Acute injuries can produce damage to the cartilage (pure chondral component), damage to the subchondral bone with preservation of the overlying cartilage, or a combined damage: cartilage together with underlying subchondral bone forming an osteochondral fragment [29].
The dome of the talus is part of the weightbearing bone. Direct weightbearing forces through the ankle are transmitted to the subchondral plate which is supported by the trabecular meshwork in the metaphysis and epiphysis [30]. When impactional forces occur during injury, a bone contusion or bone bruise can arise. This bone bruise is formed by trabecular microfractures associated with hemorrhage, edema and hyperemia [31]. MR imaging findings in ankle injury do not depend on direct visualization of this fractured trabeculae (either at the time of injury or during repair), but depend on imaging the marrow and its behaviour in response to acute injury. In osteochondral fractures, rotational high energy forces, extending to the underlying bone are responsible for the classic osteochondral fracture (see classification of osteochondral talar injury, chapter three). Comminution of the articular surface may occur with variable degrees of surface depression [28].

An intact subchondral plate is of critical importance in avoiding posttraumatic sequelae. Without the smooth support of the intact subchondral bone, the articular cartilage can break down, leading to degenerative joint disease [30]. Current treatment of osteochondritis dissecans (OD) lesions is aimed at preservation of the integrity of the joint. If MR imaging identifies a bony injury, there are clinical implications: injuries to bone require reduced weightbearing during an extended period for proper healing [32]. Cancellous bone is the
weightbearing structure that suffers most in acute traumatic injuries of the ankle [32]. A period of non-weightbearing may be sufficient to induce healing [32,33]. When there is no healing response, a surgical option is percutaneous drilling of the subchondral bone in an attempt to facilitate revascularization of the compromised subchondral tissues. Therefore MR investigation is recommended to all patients after ankle sprain if a painful condition is maintained after conservative treatment [34,35].

References