# SURGICAL AND APPLIED ANATOMY

Part of "47 - ANKLE FRACTURES"

The bony anatomy of the talocrural joint provides stability in dorsiflexion and relative mobility in plantarflexion. In the standing, dorsiflexed, close-packed position, the ankle joint behaves like a true mortise, with stability conferred principally by articular contact. In the non–weight-bearing, plantarflexed position, ankle joint stability is mostly conferred from ligamentous structures.

Ankle Joint

The ankle joint is a complex, three-bone joint (Fig. 47-2). It consists of the tibial plafond, including the posterior malleolus articulating with the body of the talus, the medial malleolus, and the lateral malleolus. The joint is considered saddle-shaped, with a larger circumference of the talar dome circumference laterally than medially. The dome itself is wider anteriorly than posteriorly, and as the ankle dorsiflexes, the fibula rotates externally through the tibiofibular syndesmosis, to accommodate this widened anterior surface of the talar dome.
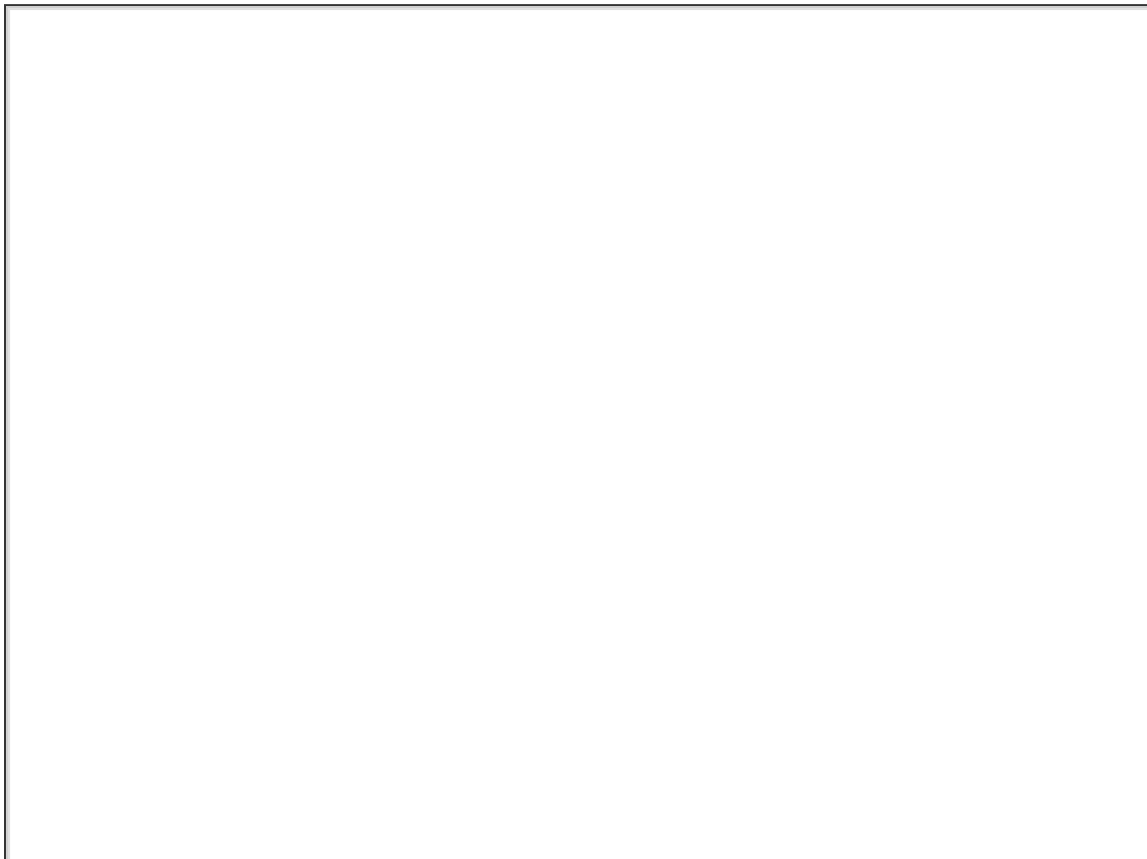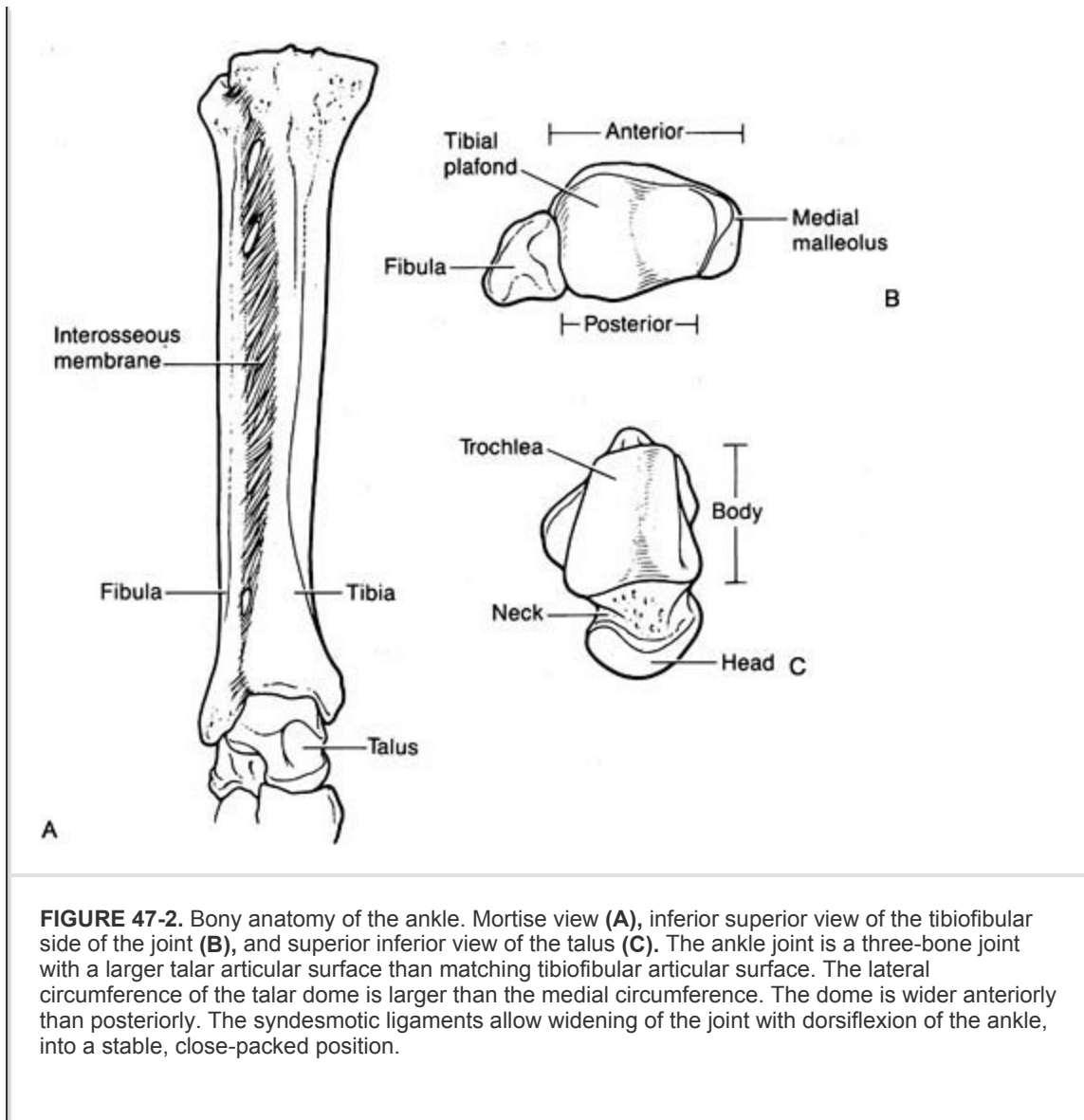
FIGURE 47-2. Bony anatomy of the ankle. Mortise view **(A),** inferior superior view of the tibiofibular side of the joint **(B),** and superior inferior view of the talus **(C).** The ankle joint is a three-bone joint with a larger talar articular surface than matching tibiofibular articular surface. The lateral circumference of the talar dome is larger than the medial circumference. The dome is wider anteriorly than posteriorly. The syndesmotic ligaments allow widening of the joint with dorsiflexion of the ankle, into a stable, close-packed position.

Tibia

The lower end of the tibia is formed by five surfaces: inferior, anterior, posterior, lateral, and medial. The inferior surface is articular, concave anteroposteriorly, and slightly convex transversely, dividing the surface into a wider lateral and narrower medial segment. The posterior border of the ankle joint is lower than the anterior border. The posterior border is in continuity with the posterior surface of the medial malleolus. This segment has an oblique groove medially, which is directed downward and inward, that corresponds to the tendon of the tibialis posterior muscle. Osteotomies of the medial malleolus regularly violate this groove, and the tendon should be identified and protected when one performs this procedure.

The distal lateral border of the tibia is concave, with anterior and posterior tubercles. The anterior tubercle is the site of origin of the anterior tibiofibular ligament, and the posterior

tubercle is the site of attachment of the deep component of the posterior tibiofibular ligament. The anterior tubercle overlaps the fibula. This relationship is the basis for the radiologic interpretation of tibiofibular syndesmosis alignment. The more superficial aspect of the posterior tubercle is the site of attachment of the posterior tibiofibular ligament, which extends around to the posterior surface of the distal tibia. This ligament usually remains intact in trimalleolar fractures; it tethers the posterior malleolus to the lateral malleolus, and it is the basis for the often observed indirect reduction of a posterior malleolar fragment after operative reduction of the fibular fracture.

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The medial surface of the distal tibial articulation is directed obliquely downward and inward. The medial surface is prolonged distally by the medial malleolus. The articular surface of the medial malleolus is comma shape, with a larger surface anteriorly. The posterior border of the medial malleolus includes the groove for the tibialis posterior tendon. The medial malleolus is composed of two colliculi separated by the intercollicular groove. The anterior colliculus is larger, extending approximately 0.5 cm distal to the more diminutive posterior colliculus. The deep talotibial component of the deltoid ligament inserts in the intercollicular groove and on the contiguous surfaces of the adjacent colliculi. The superficial deltoid ligament inserts on the medial surface and the anterior border of the anterior colliculus.

Fibula

The lower end of the fibula is a complex bony structure, giving rise to multiple ligaments and housing the lateral articular surface of the ankle. The distal fibula has two major surfaces, lateral and medial, which widen into the three-surfaced lateral malleolus at the level of the tibial plafond. The interosseous ligament attaches where the lateral surface twists and becomes the posterior border of the lateral malleolus. The lateral malleolus is encased in strong ligamentous attachments anteriorly, posteriorly, inferiorly, and superiorly. Anteriorly, these ligamentous attachments include the anterior tibiofibular ligament and the main and secondary bands of the anterior talofibular ligament. Inferiorly, the main attachment is through the stout calcaneofibular ligament. Posteriorly, the fibula is firmly connected to the talus and tibia through the posterior talofibular ligament, the superficial and deep components of the posterior tibiofibular ligament. Superiorly, the fibula is held in continuity to the tibia by the tibiofibular interosseous ligament.

Talus

The talus is almost entirely covered by articular cartilage, with no musculotendinous attachments. The superior surface is convex from front to back, and it is slightly concave from side to side. The dome of the talus is trapezoidal, with its anterior surface wider than its posterior surface (118). This shape confers increased ankle stability with dorsiflexion. The medial and lateral articular facets of the talus are contiguous with the superior articular surface. The talar dome bone is, on average, denser than tibial plafond bone, and generally it is not injured in ankle fractures. Because the lateral border is larger than the medial border, and the anterior border is longer than the posterior, this surface was described by Inman as a section of a frustrum of a cone, with a medial apex (143). This is partially

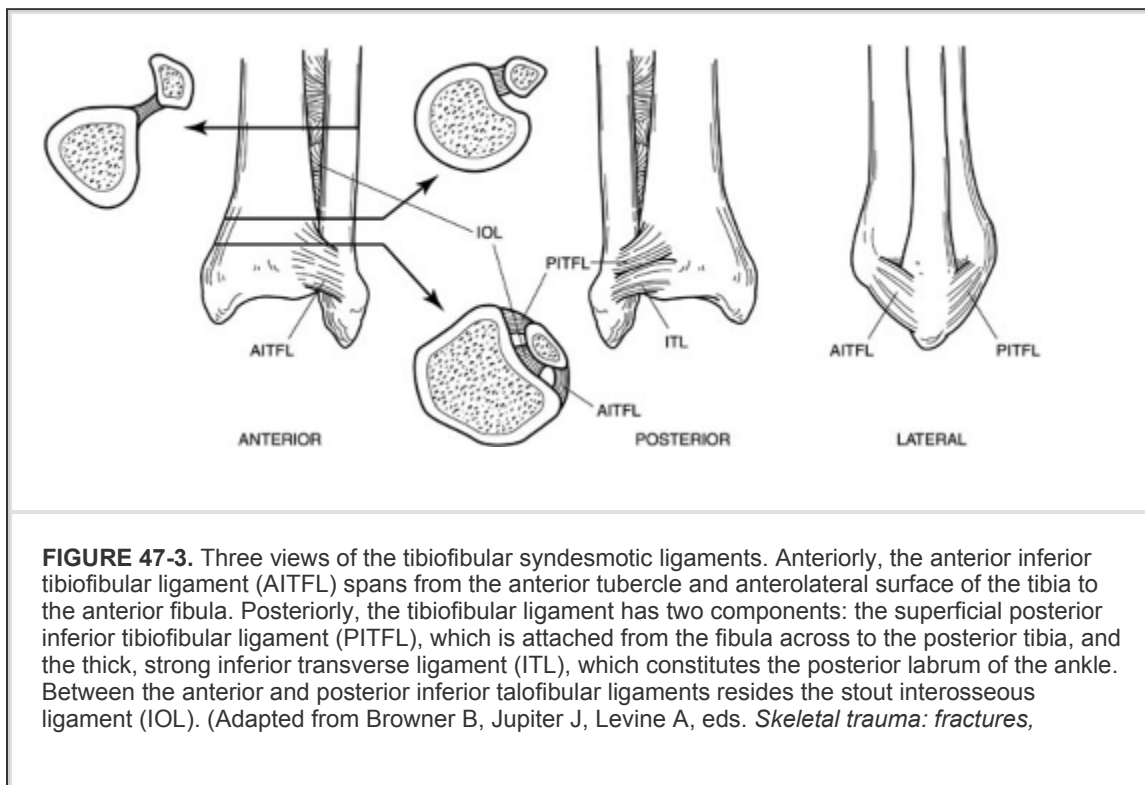responsible for the ankle joint's variable axis of rotation.

Ligaments

Ankle stability is conferred by bony architecture, and ligamentocapsular structures. There are three distinct groups of ligaments supporting the ankle joint: (a) the syndesmotic ligaments, (b) the lateral collateral ligaments, and (c) the medial collateral ligament.

The syndesmotic ligaments are composed of three distinct portions (Fig. 47-3). Anteriorly, the anterior inferior tibiofibular

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ligament originates on the anterior tubercle and the anterolateral surface of the tibia, and it runs obliquely to the anterior fibula. The posterior tibiofibular ligament is composed of superficial and deep components that originate from the posterior tubercle of the lateral malleolus and extend upward, medially and posteriorly to insert on the posterolateral tubercle of the tibia. The superficial component has broad attachment across the posterior tibia. The thick, strong, deep component inserts on the lower part of the posterior border of the tibial articular surface and constitutes a true posterior labrum of the ankle joint. The posterior tibiofibular ligament is far stronger than the anterior tibiofibular ligament, and because of this difference, torsional or translational forces cause avulsion fractures of the posterior tibial tubercle, often leaving the posterior ligament intact when the anterior tibiofibular ligament ruptures. The third component of the distal tibiofibular syndesmosis is the stout interosseous ligament, which extends upward and blends in continuity with the interosseous membrane. These structures are largely responsible for the integrity of the ankle mortise. If these structures fail, the mortise can widen, especially with a deltoid ligament injury, and can result in abnormal ankle joint loading.

FIGURE 47-3. Three views of the tibiofibular syndesmotic ligaments. Anteriorly, the anterior inferior tibiofibular ligament (AITFL) spans from the anterior tubercle and anterolateral surface of the tibia to the anterior fibula. Posteriorly, the tibiofibular ligament has two components: the superficial posterior inferior tibiofibular ligament (PITFL), which is attached from the fibula across to the posterior tibia, and the thick, strong inferior transverse ligament (ITL), which constitutes the posterior labrum of the ankle. Between the anterior and posterior inferior talofibular ligaments resides the stout interosseous ligament (IOL). (Adapted from Browner B, Jupiter J, Levine A, eds. *Skeletal trauma: fractures,*

dislocations, and ligamentous injuries, 2nd ed. Philadelphia: WB Saunders, 1997, with permission.)

The major lateral collateral ligaments are the anterior talofibular ligament, the calcaneofibular ligament, and the posterior talofibular ligaments (Fig. 47-4). The anterior talofibular ligament is the weakest of these three. It is formed within the anterolateral capsule of the ankle joint and originates from the inferior oblique segment of the anterior border of the lateral malleolus; it inserts onto the talar body, just anterior to the lateral malleolar articular surface. This ligament resists anterior subluxation of the talus when the ankle is plantarflexed, and it is susceptible to injury in inversion ankle sprains.
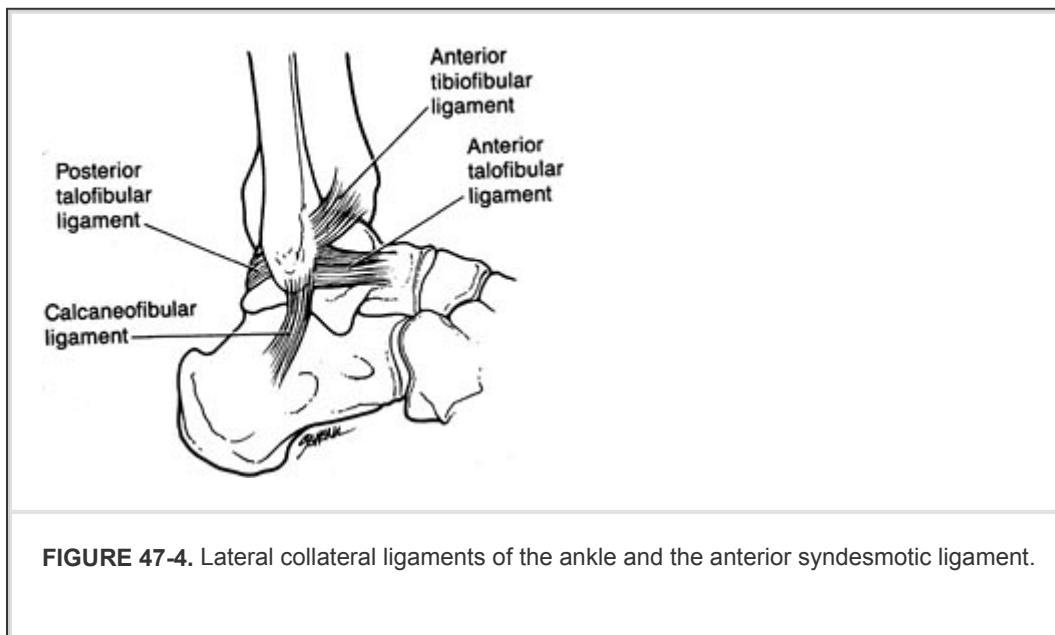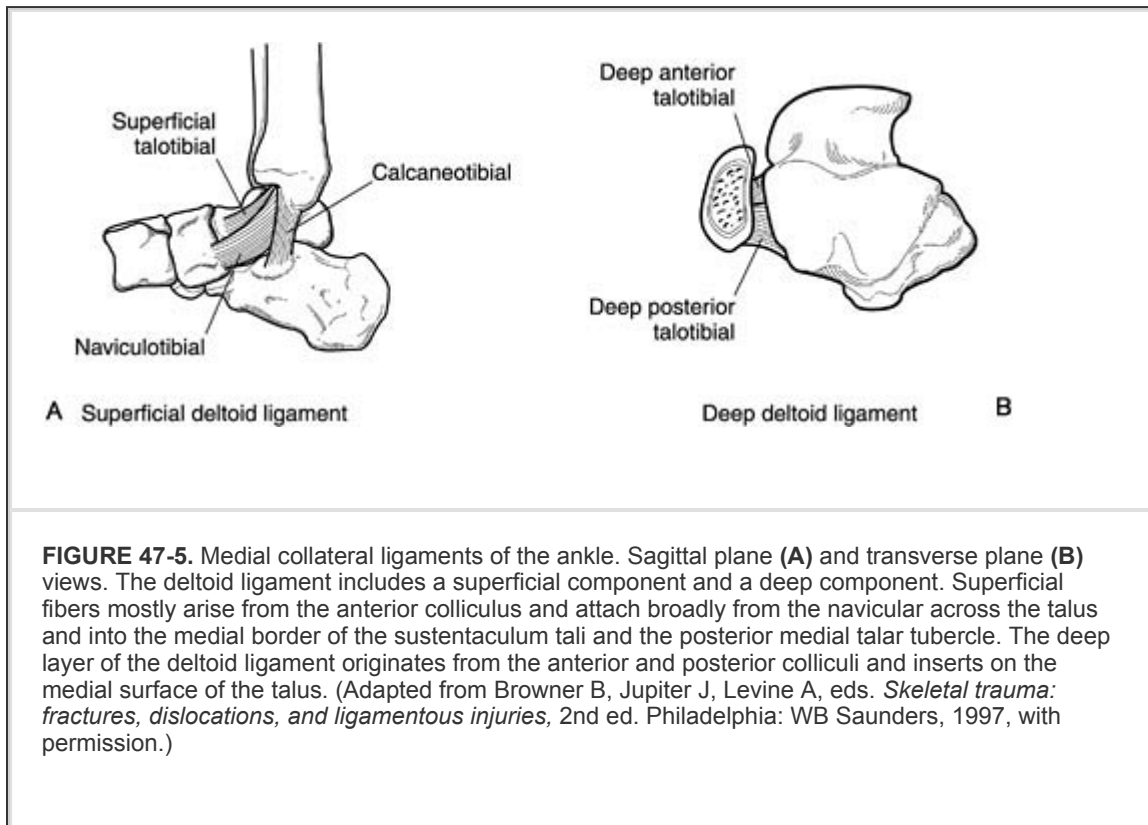

FIGURE 47-4. Lateral collateral ligaments of the ankle and the anterior syndesmotic ligament.

The calcaneofibular ligaments is a strong, flat, oval ligament originating from the lower segment of the anterior border of the lateral malleolus, running deep to the peroneal tendons, and inserting on the posterior aspect of the lateral calcaneus. This ligament resists inversion with the ankle in dorsiflexion and stabilizes both the ankle and subtalar joint. The posterior talofibular ligament is a very strong ligament that is nearly horizontal. It originates on the medial surface of the lateral malleolus and inserts on the posterior surface of the talus and is in continuity with fibers coursing from the superficial talotibial ligament, to form a posterior ligamentous sling. It is the strongest of the lateral ligaments and prevents posterior and rotatory subluxation of the talus.

The medial ligamentous support of the ankle is provided by the deltoid ligament (Fig. 47-5). The deltoid ligament has been characterized as having a superficial component and a deep component. The superficial fibers arise from the anterior colliculus and the anterior aspect of the posterior colliculus, and they attach into the navicular, the neck of the talus, the medial border of the sustentaculum tali, and the posteromedial talar tubercle. The tibiocalcaneal ligament is the strongest component of the superficial layer of the deltoid

ligament, and it is responsible for resisting eversion of the calcaneus.

FIGURE 47-5. Medial collateral ligaments of the ankle. Sagittal plane **(A)** and transverse plane **(B)** views. The deltoid ligament includes a superficial component and a deep component. Superficial fibers mostly arise from the anterior colliculus and attach broadly from the navicular across the talus and into the medial border of the sustentaculum tali and the posterior medial talar tubercle. The deep layer of the deltoid ligament originates from the anterior and posterior colliculi and inserts on the medial surface of the talus. (Adapted from Browner B, Jupiter J, Levine A, eds. *Skeletal trauma: fractures, dislocations, and ligamentous injuries,* 2nd ed. Philadelphia: WB Saunders, 1997, with permission.)

The deep layer of the deltoid ligament is the primary medial

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stabilizer of the ankle joint. It is a short, thick ligament that originates from a wide area between the anterior and posterior colliculi. The strongest fibers insert on the medial surface of the talus, under the tail of the comma-shaped articular surface. This ligament is virtually inaccessible from outside the joint, and it cannot be repaired unless the talus is displaced laterally or the medial malleolus is inverted distally through fracture or osteotomy.

Tendons and Neurovascular Structures

Five nerves, two major arteries and veins, and 13 tendons cross the ankle joint (Fig. 47-6). These tendons are divided into four groups: the posterior group, the medial group, the lateral group, and the anterior group. The posterior group includes the Achilles and plantaris tendons. The Achilles is the most power plantarflexor of the ankle, and the plantaris is a small, perhaps vestigial and inconstant tendon that can be used to supplement tendon or ligament repairs in the ankle or elsewhere. Immediately lateral to the Achilles tendon lies the sural nerve, which innervates the skin on the lateral heel and lateral border of the foot.
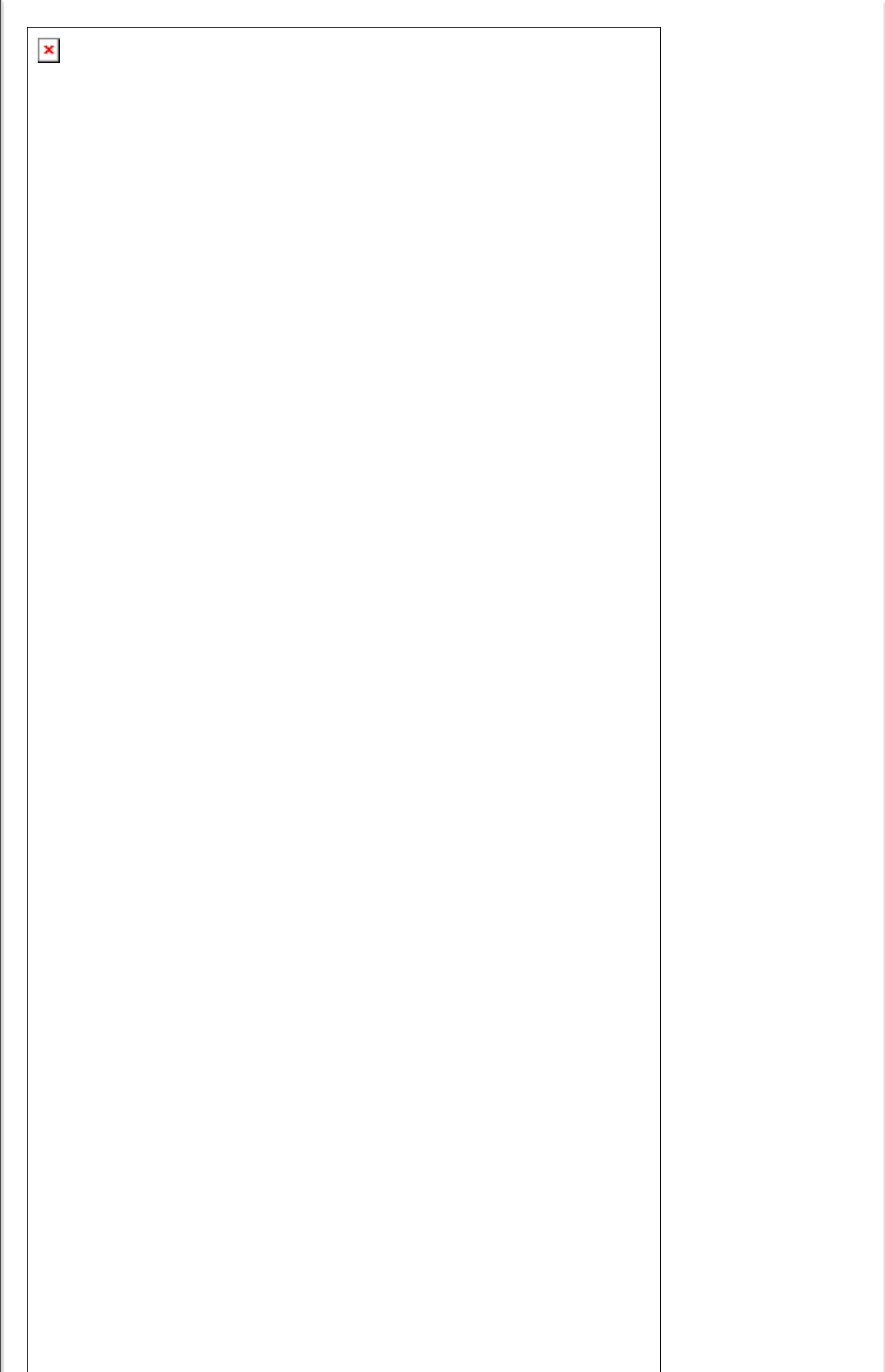
FIGURE 47-6. **A:** Structures crossing the medial ankle. **B:** Structures crossing the anterior ankle. **C:** Structures crossing the lateral ankle. Small sensory branches are easily injured during surgical approaches to the ankle. Dissection at the subcutaneous level must be done with care to reduce the incidence of these injuries. (Adapted from Browner B, Jupiter J, Levine A, eds. *Skeletal trauma: fractures, dislocations, and ligamentous injuries,* 2nd ed. Philadelphia: WB Saunders, 1997, with permission.)

On the medial side of the ankle, the flexor tendons are transmitted under cover of the laciniate ligament (Fig. 47-6A). This stout ligament courses from the calcaneus to the medial malleolus and has several septa separating its contents. Immediately posterior to the medial malleolus lies the posterior tibial tendon, which not infrequently is lacerated, incarcerated, or ruptured from medial malleolar fractures or osteotomies performed for visualization or reduction of talar fractures. Posterior and lateral to the tibialis posterior lie, in order, the flexor digitorum longus tendon, the posterior tibial artery and associated veins, the tibial nerve, and the flexor hallucis longus tendon.

Anterior to the medial malleolus courses the saphenous vein and accompanying nerves (Fig. 47-6B). Typically, these lie immediately medial to the tibialis anterior tendon. The saphenous vein is an excellent portal for re-establishment of intravenous access in cases of trauma with shock. However, the accompanying nerves can be inadvertently injured with incisions placed around the anterior aspect of the medial malleolus. Because the resultant neuromas can be painful and difficult to treat, meticulous care should be exercised when one dissects along the anterior aspect of the medial malleolus.

On the lateral side of the ankle, the peroneal tendons are transmitted under the superior peroneal retinaculum, posterior to the fibula (Fig. 47-6C). At the level of the ankle, the peroneus longus tendon is more external, and the peroneus brevis lies up against the lateral malleolus. In cases of severe sprains, and some fractures of the ankle and calcaneus, the peroneus longus and brevis tendons can become dislocated anterior to the fibula. Early recognition of these subluxations or dislocations is critical for restoring normal, painless function of these tendons. Lateral approaches to the fibula can injure the superficial peroneal nerve proximally and the sural nerve distally. These nerves and their terminal branches sometimes are best exposed and protected during fixation of fibular fractures.

On the anterior aspect of the ankle, the extensor retinaculum restrains the extensor tendons, anterior tibial vessels, and the deep peroneal nerve. The extensor retinaculum proximal to the ankle runs from the anterior medial subcutaneous surface of the tibia to the anterolateral surface of the fibula. Distal to the ankle, the inferior extensor retinaculum is Y-shaped, with its base lateral on the calcaneus. Under the extensor retinaculum are transmitted, from medial to lateral, the tibialis anterior tendon, the extensor hallucis longus tendon, the deep peroneal nerve and anterior tibial vessels, the extensor digitorum longus tendon, and the peroneus tertius tendon. In approaches to the anterior aspect of the ankle, a relatively safe interval is between the tibialis anterior tendon and the extensor hallucis longus tendon.

Superficial to the extensor retinaculum lie the terminal branches of the superficial peroneal

nerve. The superficial peroneal nerve fans into two or three major terminal branches that cross the ankle joint to innervate the dorsum of the foot. Because

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injuries to these branches can cause considerable pain and dysfunction and are not easily amenable to salvage surgical procedures, extreme care should be exercised when one approaches the anterior aspect of the ankle or the distal fibula.