CHAPTER **26**

ANATOMIC CONSIDERATIONS FOR ANKLE FRACTURES

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INTRODUCTION

The most common weight-bearing musculoskeletal injury encountered in orthopedic practice and emergency medicine occurs at the ankle joint. Ankle fractures are classically described as pathomechanic processes that involve both soft tissue disruption as well as osseous damage. The primary goal of treatment for ankle fractures is to restore normal function of the ankle joint. More specifically, establishing anatomic realignment of the talus with the tibio-fibular complex is crucial in preventing post-traumatic arthritis. A strong understanding of anatomic dissection and adequate exposure of injured structures involved in ankle fractures is paramount in successful open reduction internal fixation (ORIF). The purpose of this update is to provide insight in ankle joint anatomy and to provide a better understanding of anatomical dissection when surgically treating ankle fractures.

HISTORY

Ankle fractures have been studied since the late 18th century, beginning with investigators such as Pott, Dupuytren, and Cooper (1). The radiographic analyses of Lauge-Hansen in the 1940s helped tremendously in biomechanically understanding the mechanism of this injury (2). This later aided in the development of techniques for ORIF, which became widely accepted in the 1970s. The AO-Association for the Study of Internal Fixation progressed with the Danis-Weber classification of fibular fractures. This in turn led Willenegger, Allgower, and their understudies into the development of a new course of treatment for ankle fractures. Presently, ankle fractures are mostly discussed from a retrospective standpoint. Looking at the outcome of surgical management versus conservative care comprises most of the current research. There is seldom literature discussing the anatomical considerations and surgical technique involved in treating ankle fractures.

ANATOMY

The ankle joint is the connection between the foot and the lower leg that allows for dorsiflexion and plantarflexion. The tibia and fibula articulate to create a fork-like apparatus to allow for the talus to fit underneath each of the leg bones. This formation accommodates for the congruous motion of the load bearing surface of the tibia, the pilon, and the dome of the talus. Ligamentous attachments and the ankle capsule surround all of the osseous structures, and contribute to the stability of the ankle joint (3). Four main anatomic areas encompass the ankle joint: anterior, posterior, medial, and lateral structures. Abnormality or failure of any of these structures, whether it be osseous, ligamentous, or capsular, will cause anomalous motion or load on the joint, which has the potential to be symptomatic (4).

The anterior surface of the ankle joint is made up of the expanded tubercle of Tillaux-Chaput, which also serves as the origin of the anterior inferior tibiofibular ligament (AITF). The AITF ligament extends laterally to the anterior surface of the lateral malleolus. This area of the malleolus is also known as Wagstaff's tubercle (5). Behind the course of the AITF ligament, the tibial incisura notch articulates with the inner surface of the fibular malleolus. These two surfaces house the strongest component of the tibio-fibular syndesmosis, the interosseous tibiofibular ligament (3, 6).

The posterior malleolus of the distal tibia makes up a majority of the posterior component of the ankle joint. The posterior inferior tibio-fibular ligament (PITFL) runs from the posterior aspect of the lateral malleolus to the distal tip of the posterior malleolus or Volkman's Triangle. This ligament has a broad, stronger distribution across the back of the ankle adding to the stability of the ankle joint. The anterior and posterior components of the ankle joint control transverse plane motion of the talus and the integrity of the ankle mortise (2).

The medial malleolus is much larger than its counterpart on the lateral side of the ankle joint. The anterior colliculus protrudes more inferiorly than the posterior colliculus and has been classically described in the literature as comma shaped. The ligamentous attachment to the medial malleolus is bilayered. The superficial deltoid attaches from the anterior colliculus to the anterior talar neck, the spring ligament, and the sustentaculum tali. The deeper portion of the deltoid originates more posterior and inserts into the medial side of the talus just above the middle facet. Superficial and deep deltoid ligaments illustrate a fan-like appearance and cover the medial aspect of the ankle intracapsularly.

The distal fibula houses a multitude of ligamentous structures to form the lateral portion of the ankle mortise. This area is weaker than the tibial portion of the joint and has a higher incidence of injury (5).Three separate ligaments extend from the lateral malleolus in anterior, inferior, and posterior distribution along the lateral ankle. The anterior talo-fibular ligament extends from the anterior portion of the lateral malleolus and inserts into the neck and head of the talus. The calcaneo-fibular ligament extends inferior from the apex of the lateral malleolus to the lateral wall of the calcaneus. This ligament is extra-capsular and also contributes to the stability of the subtalar joint. The posterior talo-fibular ligament originates from the posterior surface of the lateral malleolus and inserts into the body of the talus along the lateral wall.

UNDERSTANDING OF INJURY

As mentioned above, Lauge-Hansen described radiographic fracture patterns that predict soft tissue damage associated with the injury. Complete ligament failure is just as detrimental to joint stability as bone fractures. Mueller and Allogower state that the diagnosis of a malleolar injury demands the identification of all fractures and ligamentous damage. Reconstruction of the lateral complex and restoration of the tight elastic connection as the tibio-fibular syndesmosis have biomechanical priority over the repair of the medial malleolus. However, the ultimate goal is restoration of the ankle mortise so all four components of the ankle joint, as described above, need to be considered during assessment of an ankle injury (2, 4, 7).

According to the Manual of Internal Fixation, Allogower and Mueller use the location of the fracture at the fibula to surgically classify the injury. The Danis-Weber classification of ankle fractures categorizes them into types A, B, and C. Each of these injuries helps a surgeon understand the associated ligament rupture and status of the tibio-fibular syndesmosis and inherently the overall stability of the ankle joint. Type A fractures demonstrate a transverse fracture of the fibula at or below the level of the ankle joint. Alternatively the collateral ligaments around the fibula could be ruptured. Notably the syndesmosis is always intact in this mechanism of injury. Continuation of this mechanism leads to a fracture of the medial malleolus in a vertical fashion and corresponds to a supination-adduction type fracture.

Fibular malleolar fractures that begin at the level of the ankle joint and extend proximally in an oblique manner often correspond to the supination external rotation pattern described by Lauge Hansen. These are a Danis-Weber Type B fracture and the anterior syndesmosis may or may not be intact. The fracture is associated with rupture of the AITF ligament. More advanced injuries lead to posterior malleolar (Volkman's fracture) and damage to the medial ankle. Fibular fractures observed proximally to the syndesmosis are termed Type C fractures. These are most often associated with torsional injuries and severe ankle instability. The syndesmosis and interosseus membrane are ruptured from the ankle joint to the level of the fibular fracture. This pattern corresponds to the Lauge-Hansen pronation-external rotation injury (8).

ANATOMIC DISSECTION

Lateral Approach

When gaining access to the lateral malleolus, incision planning varies depending on the fracture pattern and extent of the injury. The incision is usually made along the posterior margin of the fibula and carried distally curving anteriorly at the level of the lateral malleolus. This incision can be continued distally to the level of the sinus tarsi. This will allow for visualization of the AITF ligament and if inspection of the talar dome is necessary (9). The incision can be modified slightly to accommodate access to a fracture pattern in the fibula that has a posterior spike (Figure 1). Moving the incision posterior also aids in gaining access to the posterior malleolus if repair is warranted. The skin flaps are elevated carefully to protect the lesser saphenous vein and the sural nerve, which is posterior to the fibula in the subcutaneous layer. Anterior to the fibula, the superficial peroneal nerve comes through the interosseous membrane approximately mid-shaft between the tibia and fibula and runs over the AITF continuing into the foot (10). The hematoma surrounding the fibular fracture serves as a guide to create a dissection plane around the fracture. Keep in mind the peroneal tendons are directly behind the fibula and care should be taken when exposing a posterior spike of a fibular fracture.

Dissection is carried down to the level of the periosteum over the fibula (Figure 2). A sponge or the back end of a

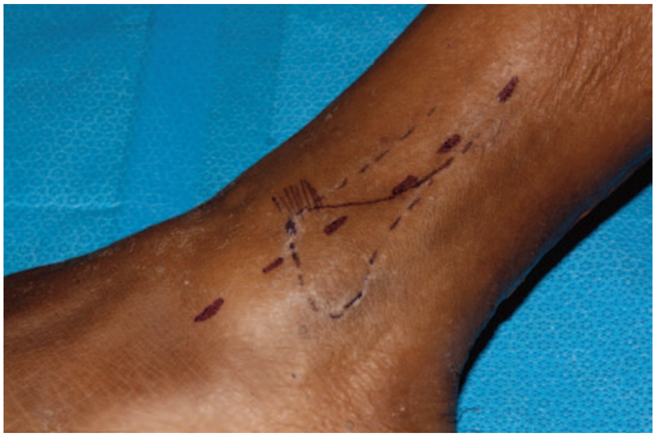

Figure 1. Incision placement extends from the proximal end of the fracture continuing distally to the level of the sinus tarsi.

Figure 2. The subcutaneous tissue separated from the periosteal layer overlying the fibula.

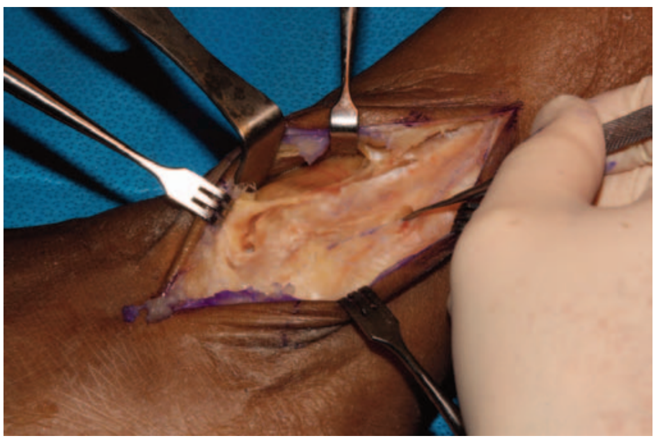

Figure 3. Entry to the anterior aspect of the ankle joint and the AITF ligament begins underneath the deep fascia surrounding the extensor tendon.

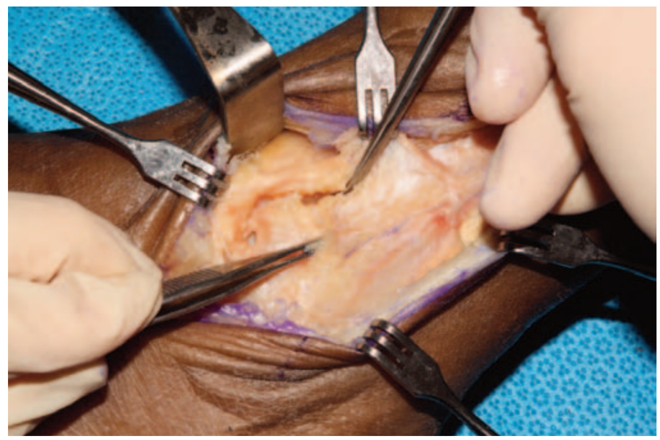

Figure 4. The syndesmotic ligament (cut) lies directly below the level of the peroneal artery.

blade handle can be very useful in separating the subcutaneous tissue from the deep fascia and periosteum. Reflecting the periosteum off the fibula with an elevator adequately enough to expose the fracture allows for open reduction and fixation. The next maneuver involves exposure of the syndesmosis. The subcutaneous tissue over the extensor retinaculum along the anterior aspect of the incision is reflected allowing visualization of the anterior compartment and the extensor digitorum longus tendon (Figure 3). The deep fascia and retinaculum are incised distally and carried up proximally to the fibula. This deep incision allows for anterior access to the ankle joint. The peroneal artery is often encountered during this exposure (11) and care must be taken to preserve this structure as well as the superficial peroneal nerve. Often, the peroneal artery can be torn or damaged due to nature of the injury. The syndesmotic ligament can also be seen just medial to the course of the peroneal artery underneath the deep fascia of the anterior compartment (Figure 4). Inferior to this ligament runs the course of the AITF ligament, which is often damaged in external rotation type injuries (9). Primary repair can be facilitated through this dissection technique. The anterior distal aspect of the lateral malleolus gives origin to the anterior talo-fibular which can be cut to reveal the lateral ankle gutter. An anterior drawer maneuver can be employed to inspect the lateral shoulder of the talus.

Medial Approach

The medial malleolar fracture can be visualized through an anterior curved incision running longitudinally with the midpoint at the tip of the malleolus. Similar principles of layered dissection are practiced when approaching the medial ankle. Skin flaps are mobilized and careful dissection must take place anteriorly in order to protect the great saphenous vein and saphenous nerve. Once down to the level of the deep fascia, a periosteal incision is made longitudinally, usually in line with the incision, to expose the fractured bone. Once the fracture is exposed, the deltoid ligaments are inspected and the fibers may be split to allow for internal fixation. An incision through the anterior capsule can also be made to inspect the medial ankle gutter and talar dome. This incision may also allow room for instrumentation to be used during indirect repair of a posterior malleolar fracture (1, 3). Alternatively, a retromalleolar incision can be made curving anterior to the apex of the malleolus and medial tibia. The saphenous nerve is protected in this region by only dissecting the deep fascia over the medial malleolus. If dissection is carried posterior medially, direct repair of a posterior malleolar fragment is possible. Careful observation along the posterior aspect of the medial malleolus is important so that the tibialis posterior and the neurovascular bundle are not injured. Olney suggests a release of the flexor retinaculum to retract the tibialis posterior tendon anteriorly when gaining access to the posterior malleolus from a medial approach (8, 12). Inspection of the deltoid ligaments should be performed and can be used as a hinge to turn down the medial malleolus and view the medial ankle gutter.

CONCLUSION

The primary goal of ORIF of an ankle fracture is to restore the length of the fibula, repair the inferior tibiofibular syndesmosis, and anatomically reconstruct the ankle mortise (1,8). The nature of an ankle fracture can be very complex and an understanding of the mechanism of injury and the anatomy involved is vital in the success of treatment. Advances in internal fixation have allowed for early mobilization and rehabilitation with immediate physiologic range of motion. This increases the significance of adequate repair of all osseous and soft tissue components of the ankle joint to create a stable ankle mortise. Consideration of anatomy is one key constituent of many critical factors that need to be understood and applied in order to surgically manage an ankle fracture.

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*Special Thanks to Dr. John Ruch for Cadaver Dissection Series on Lateral Approach to Ankle Fractures.