CQ HAND + UPPER LIMB
SPECIALIST ORTHOPAEDIC SURGEON

EVIDENCE SUMMARY

Ankle fracture fixation

Anatomy & Pathophysiology

BONY ANATOMY

- The ankle joint is a three-bone joint where the body of the talus articulates with the tibial plafond superiorly and the medial malleolus medially [15].
- The posterior malleolus is a dorsal projection of the tibia that enlarges the confluent articular area and serves as a constraint to posterior translation of the talus [15, 17].
- The lateral articulation of the talus is with the distal fibula, which takes approximately 1/6th of the load during weight bearing [15].
- The medial malleolus is shorter and more anterior than the lateral malleolus, resulting in a joint axis positioned in 15 degrees of external rotation [15].
- The talus is shaped like a trapezoid that is wider in the anterior body than in the posterior body [17].
- Dorsiflexion of the ankle widens the mortise as the fibula migrates proximally and externally rotates through the syndesmosis [17].
- The fibula lies posterior to the central axis of the tibia in the sagittal plane within the concavity of the distal posterolateral tibia, known as the incisura [17].

LIGAMENTS AND SYNDESMOSIS

- The syndesmosis comprises the anterior-inferior tibiofibular ligament (AITFL), the posterior-inferior tibiofibular ligament (PITFL), and the interosseous ligament [15, 17].
- The AITFL arises from the tubercle of Chaput on the anterolateral tibia and inserts onto an equivalent prominence on the fibula [15].
- The PITFL attaches to the lateral aspect of the posterior malleolus [17].
- The interosseous ligament is central between the tibia and fibula and is confluent with the interosseous membrane above [15, 17].
- Medial ligamentous support of the tibiotalar joint is provided primarily by the deep deltoid ligament, which limits lateral translation and external rotation of the talus [17].

CQ HAND + UPPER LIMB
Dr Kieran Hirpara — Specialist Orthopaedic Surgeon
Suite 2, Level 1, Mater Private Hospital Rockhampton, 31 Ward Street, The Range, QLD 4700
Phone 07 4863 6556 · office@cqupperlimb.com.au · cqupperlimb.com.au

- Disruption of the deep deltoid ligament in association with a lateral injury may result in an unstable tibiotalar joint [17].

PATHOPHYSIOLOGY AND INJURY MECHANISMS

- Ankle fractures are typically low-energy injuries with the majority occurring due to simple falls or sport [15].
- High-energy mechanisms indicate the likelihood of additional soft tissue complications, compartment syndrome, pilon fractures, or other associated injuries [2].
- The Lauge-Hansen classification system is based on cadaver work identifying common fracture patterns based on the position of the foot and direction of force applied at the time of injury [8].
- Supination-adduction fractures are produced by tension failure of the fibula and axial loading of the medial plafond, resulting in a vertical medial malleolar fracture [8].
- Medial tibial plafond impaction occurs in up to 50% of supination-adduction injuries and must be addressed [10].
- The posterior pilon fracture variant is usually associated with a posterior tibiotalar dislocation and a characteristic posterior malleolar fracture extending from the PITFL origin laterally to the medial malleolus [8].
- The posterior pilon fracture variant produces a double contour of the medial malleolus on the AP radiograph [8].
- Ankle fractures represent 10% of all fractures with an incidence of around $137/10^5$ population per year [15].
- The mean age at injury for ankle fractures is 45 years [15].
- Ankle injuries have a bimodal distribution with peak incidences in younger men and older women, separated by a 50-year gap [15].
- Bimalleolar and trimalleolar ankle fractures do not have a bimodal distribution but instead show a type E distribution with a peak only in elderly women [15].
- The microarchitecture of the trabecular bone in the distal tibia of elderly patients with ankle fractures is abnormal and depleted, suggesting these injuries should be considered true osteoporotic fractures [15].
- Obesity is a risk factor for sustaining ankle fractures, with obese women over age 55 significantly more likely to sustain a fracture than nonobese women [15].
- Obesity predisposes to more severe injury, with patients with unstable ankle fractures far more likely to be obese (29%) than those with stable fractures (4%) [15].
- Alcohol use is a risk factor for ankle fractures, with 29% of patients in one series having consumed alcohol in the 4 hours preceding the fracture [15].
- Diabetes indicates an increased likelihood of wound complications owing to immunologic and vascular impairment [2].
- Poorly controlled diabetics are at risk of peripheral neuropathy, which may influence postoperative weight-bearing decisions [2].

- Diabetic patients with comorbidities such as vasculopathy, neuropathy, or Charcot arthropathy have a higher risk of complications compared with diabetics without comorbidities [1].
- Delayed fracture and wound healing, soft-tissue compromise, vasculopathy, and neuropathy are specific considerations in the treatment of diabetic ankle fractures [1].
- Nonoperative treatment of displaced ankle fractures is associated with up to 21-fold increased odds of complications compared with operative intervention [1].
- Concomitant intraarticular injuries such as syndesmosis disruption, ligament injury, and osteochondral lesions have been reported in up to 80% of patients with ankle fractures [6].
- Osteochondral lesions were present in 26% of Weber B fractures, 24% of Weber C fractures, and 20% of isolated medial malleolar fractures [6].
- Chondral lesions were identified in 78% of 116 patients with acute ankle fracture, with talar dome chondral lesions present in 43% [6].
- Patients with complete syndesmosis disruption and instability were more likely to have chondral injury [6].
- Patients younger than 30 were less likely to have a chondral injury [6].
- Minimal displacement of the talus can lead to increased joint contact pressures and increased risk of posttraumatic arthritis [14].
- Malreduction of the posterior malleolus is significantly more likely to lead to malreduction of the syndesmosis [22].
- Open reduction and internal fixation of the posterior malleolus significantly reduced the rate of persistent syndesmotic instability requiring fixation compared to no treatment [21].
- Syndesmosis malreduction was associated with a poorer clinical outcome in a study of 87 patients using comparison postoperative CT scans [7].
- Isolated assessment of the injured ankle using fluoroscopy is unreliable for determining syndesmosis reduction accuracy [7].
- A posteriorly placed clamp tine on the medial tibia was significantly more likely to lead to syndesmosis malreduction [7].
- Bioabsorbable screws have higher rates of complications than metal screws, particularly foreign body reactions [7].
- Planned screw removal has not been shown to be advantageous compared with retention and may lead to complications including infection, screw breakage, and recurrent diastasis [7].
- Suture button fixation has been demonstrated to reduce rates of syndesmosis malreduction compared to screw fixation [20].
- In one randomized study, the suture button group had a lower rate of malreduction and less pain at 2-year follow-up compared to the screw group [7].
- In another randomized study, the screw fixation group had more than twice as many malreductions (39% versus 15%) and a higher rate of implant removal compared to the suture button group [7].
- Osteoarthritis of the ankle is most commonly caused by trauma, with 39% of cases in a recent series found to be secondary to ankle fracture [19].

- AO/OTA type C fracture patterns, high BMI, dislocation, and increased age are risk factors for the development of posttraumatic osteoarthritis [19].
- Cartilage damage was a predictor of posttraumatic osteoarthritis at a mean of almost 13 years follow-up [19].
- Worse outcomes were found with deeper cartilage lesions and those located on the anterior or lateral talus or the medial malleolus [19].
- The mean time from ankle fracture to end-stage osteoarthritis was 21 years [19].
- Wound infection rates of up to 32% have been reported in diabetic patients with ankle fractures [19].
- Osteoarthritis may occur in up to 30% of unstable ankle fracture patterns [19].
- Loss of reduction is most common in conservatively treated, unstable fractures [19].
- Nonunion is most commonly encountered after nonoperative treatment of ankle fractures [19].
- Compartment syndrome is rare and associated with high-energy fractures [19].
- The superficial peroneal, sural, and saphenous nerves are at risk in the subcutaneous layer during ankle fracture surgery, potentially resulting in neuroma [19].
- In pediatric ankle fractures, inversion injuries typically result in distal fibular physeal fractures, almost exclusively Salter-Harris type I or II [5].
- Tillaux fractures are Salter-Harris type III fractures of the anterolateral tibial epiphysis that occur with supination–external rotation injuries [5].
- Triplane fractures are Salter-Harris type IV fractures that include an anterolateral fragment of the distal tibial epiphysis in conjunction with a metaphyseal fracture [5].
- Medial malleolar Salter-Harris type IV shear ankle fractures have the highest risk of growth arrest [5].
- Joint incongruity and late osteoarthritis are risks with distal tibial Salter-Harris type III and IV fractures [5].
- Complex regional pain syndrome is relatively common in children following ankle fractures [5].

Clinical Presentation

HISTORY AND MECHANISM

- Assessment of an ankle fracture requires a detailed history, a thorough physical examination, and radiographic imaging [2].
- High-energy mechanisms indicate the likelihood of additional soft tissue complications, compartment syndrome, the presence of the more complex pilon fracture, or other associated injuries [2].
- A history of smoking, alcohol abuse, and psychiatric illness increases the likelihood of complications [2].
- The increasing prevalence of diabetes results in surgeons treating more diabetic ankle fractures each year [1].
- Diabetic patients present a unique clinical challenge due to increased risk of complications, regardless of surgical or nonsurgical treatment [1].

PHYSICAL EXAMINATION

- Clinical examination begins with inspection for deformity, bruising, blistering, skin integrity, and color [2].
- Palpation of the limb starts at the fibular head and progresses sequentially down the lateral aspect of the leg to the lateral malleolus and the soft tissues anterior and posterior to it [2].
- Palpation then moves medially across the ankle joint to the medial malleolus and its adjacent soft tissue structures [2].
- Palpation of the skeleton of the foot excludes commonly associated or missed injuries such as fractures of the metatarsals or lateral talar process, or disruption of the midtarsal (Lisfranc) articulation [2].
- Palpation of the Achilles tendon and the Simmonds or Thompson's test exclude rupture of this structure [2].
- A distal neurovascular assessment includes assessment of temperature and capillary refill [2].
- Skin marking of palpable dorsalis pedis and posterior tibial arterial pulsations at presentation is helpful in later assessment if the condition of the limb deteriorates [2].
- A thorough neurologic and vascular history and examination is required when evaluating diabetic patients with ankle fractures [1].
- Monofilament examination should be performed on diabetic patients to assess for the presence of sensory neuropathy [1].
- Patients with diminished or absent pulses warrant additional workup and potential intervention with a vascular consultation to optimize outcomes [1].

DIAGNOSTIC CRITERIA

- The Ottawa ankle rules provide assistance in determining the need for x-ray [2].
- The Ottawa ankle rules offer a highly sensitive and cost-effective method of identifying patients presenting with ankle injuries that are most likely to have sustained a fracture [2].
- The applicability of the Ottawa ankle rules in certain patient groups such as diabetics has been questioned [2].
- Pain exists near one or both of the malleoli plus one or more of the following: age >55 years old, inability to bear weight, or bone tenderness over the posterior edge or the tip of either malleolus [2].

COMORBIDITY CONSIDERATIONS

- Diabetic patients with comorbidities (vasculopathy, neuropathy, Charcot arthropathy) have a higher risk of complications compared with diabetics without comorbidities [1].
- Delayed fracture and wound healing, soft-tissue compromise, vasculopathy, and neuropathy need to be considered when formulating a treatment plan for diabetic ankle fractures [1].

Investigations

CLINICAL ASSESSMENT

- High-energy mechanisms of injury indicate the likelihood of additional soft tissue complications, compartment syndrome, pilon fractures, or other associated injuries [2].
- Diabetes requires preoperative work-up and perioperative blood sugar management and indicates an increased likelihood of wound complications owing to immunologic and vascular impairment [2].
- The Ottawa ankle rules provide a highly sensitive and cost-effective method of identifying patients with ankle injuries most likely to have sustained a fracture [2].
- The initial assessment of a patient with an ankle fracture includes an evaluation of the soft-tissue envelope and neurovascular status [8].
- A carefully documented motor and sensory examination should be performed during initial assessment [8].

RADIOGRAPHY

- The three standard radiographs for ankle trauma are an anteroposterior (AP), a lateral, and a mortise projection [3].
- A mortise view of the ankle taken in 15 degrees of internal rotation is helpful in assessing the lateral aspect of the ankle, which is often poorly seen on the AP view due to the frustal shape of the talus and overlap of the tibia, fibula, and talus [3].
- Tenderness of the proximal fibula should be investigated with a full-length radiograph of the leg [3].
- Interpretation of ankle radiographs follows the sequence ABCS, including assessment of technical adequacy, alignment, cortical outline, trabecular morphology, articular margins, and soft tissue contour [3].
- The medial clear space should be less than 5 mm and no more than 2 mm greater than the tibiotalar clear space [3].
- The tibiofibular clear space (syndesmosis A) 10 mm above the joint line should be greater than 5 mm [3].
- The tibiofibular overlap (syndesmosis B) 10 mm above the joint line should be less than 5 mm on the AP view and less than 1 mm on the mortise view [3].
- The articular margins of the distal fibula and the lateral process of the talus on the mortise view should be parallel and equal to the tibiotalar joint space, a confirmatory visual cue known as the “ball sign” [3].
- The talocrural angle is approximately 83 degrees and should be symmetrical with the contralateral ankle [3].
- Medial malleolus displacement should be less than 2 mm [3].
- Lateral malleolus displacement should be less than 2 mm shortening, or displacement posteriorly or proximally [3].
- Posterior malleolus displacement is considered abnormal if the fragment is greater than 25% of the ankle joint seen on the lateral radiograph or greater than 2 mm displaced [3].

- The size of the medial clear space more than doubles depending upon the rotational position of the limb [3].
- There is a significant increase in medial clear space with ankle plantarflexion [3].
- The accuracy of plain radiographic measurements has been questioned in light of CT studies showing that assumptions based on two-dimensional radiographs are not always accurate [3].
- Comparison views of the contralateral side are occasionally helpful due to substantial variability in normal anatomy between individuals [3].
- AP, mortise, and lateral radiographs are often sufficient to identify the fracture pattern [10].
- External rotation stress or gravity stress radiographs assess for deltoid integrity [10].
- Medial clear space widening with stress indicates deep deltoid disruption and implies an unstable fracture pattern [10].
- The medial clear space is typically less than 4 mm [10].
- The talocrural angle is 83 (±4) degrees [10].
- Talar tilt should be less than 2 mm [10].
- Measurements for syndesmotic issues are made at 10 mm above the plafond [10].
- The tibiofibular clear space is less than 6 mm on AP and mortise views [10].
- Abnormality of the tibiofibular clear space is most predictive of syndesmotic disruption [10].
- Tibiofibular overlap should be less than 6 mm on the AP view and less than 1 mm on the mortise view [10].
- Tibiofibular overlap should be less than 10 mm or 42% the width of the fibula [10].
- A continuous curve along the lateral talus and tip of the distal fibula is known as the Shenton line or dime sign [10].
- The ankle fracture spur sign at the inferomedial tibial metaphysis is indicative of a hyperflexion variant injury [10].
- After reduction of an injury with an ankle fracture spur sign, a CT scan should be obtained to evaluate the articular surface more clearly [10].
- The medial clear space between the medial shoulder of the talar body and medial malleolus is typically less than 5 mm on AP and mortise radiographic views [9].
- The tibiofibular clear space between the medial border of the distal fibula and the medial incisura typically measures less than 6 mm on the AP and mortise views [9].
- Comparison radiographs of the contralateral limb are particularly useful to identify whether an accurate reduction of fibular length, rotation, and/or the syndesmosis has been obtained [9].
- Weight-bearing radiographs can simulate the gravity and external rotation stress tests to determine tibiotalar instability in the setting of an isolated fibula fracture [9].
- Ultrasonography may be effective and potentially less painful for the patient when evaluating deltoid integrity [9].

ADVANCED IMAGING

- A CT scan allows evaluation of the orientation of the fracture line, location of the fracture apex, size of the fragment, associated impaction, and presence of medial extension for posterior malleolar fragments [9].
- CT can identify impaction of the articular surface in injuries involving axial load, which is especially prevalent in supination-adduction type injuries [9].
- CT can evaluate the syndesmosis, including the shape and depth of the incisura, debris that may block a reduction, and small avulsion fractures of the anterior-inferior tibiofibular ligament or posterior-inferior tibiofibular ligament [9].
- Some authors have described obtaining a CT scan of both ankles in the presence of a syndesmosis injury to identify normal anatomy due to significant variability in the width and congruence of the incisura-fibula relationship [9].
- Fractures with a posterior malleolar component or fracture/dislocations are best evaluated with a CT scan to assess for the presence and displacement of articular fragments [10].
- The severity of posterior malleolar fractures on plain radiographs can be underestimated in comparison with appearance on CT scans [10].
- Review of CT scans for posterior malleolar fractures often alters the operative approach [10].
- A 2014 study concluded that MRI was unnecessary for supination-external rotation injuries, displaying a lower interobserver reliability compared with external rotation stress [9].
- Arthroscopy has been found to be more sensitive than MRI and stress radiographs of the syndesmosis in detecting instability [6].
- A cadaver study showed that stress radiographs were inadequate in distinguishing between an intact ligament and a single disrupted ligament, whereas arthroscopy better demonstrated an isolated ligament disruption [6].
- Arthroscopic evaluation of the joint before fixation can detect chondral injuries and latent syndesmosis injuries [6].
- Chondral lesions were identified in 78% of 116 patients with acute ankle fracture, and talar dome chondral lesions were present in 43% [6].
- All patients with dislocations had a chondral lesion [6].
- Concomitant intraarticular injuries have been reported in up to 80% of patients with ankle fractures [6].

SYNDESMOTIC ASSESSMENT

- The syndesmosis must be evaluated, and reduction and stabilization should be performed when instability exists [7].
- True instability at the distal tibiofibular joint should be distinguished from isolated medial clear space widening, which can occur with an untreated deltoid ligament injury [7].
- It is critical to assess for sagittal (anterior-to-posterior) instability and/or a sagittal plane malreduction of the syndesmosis [7].

- Preoperative AP and lateral images of the contralateral ankle are used to assess normal tibiofibular clear space and anterior-to-posterior position of the fibula [7].
- If the tibiofibular clear space widens compared with the normal ankle during stress testing, there is likely some degree of syndesmosis injury [7].
- If only the medial clear space widens during stress testing, the deltoid ligament is injured [7].
- In the setting of a medial malleolar fracture, an isolated deltoid ligament injury is rare [7].
- Radiographic comparison of the contralateral extremity, intraoperative or postoperative CT scan, or direct visualization of the confluence of the distal tibia, fibula, and talus are potentially more reliable options for assessing syndesmosis reduction [7].
- A larger study of 87 patients found that syndesmosis malreduction was associated with a poorer clinical outcome [7].
- One recent study of 48 patients was unable to detect a difference in functional outcomes based on reduction quality [7].
- A posteriorly placed clamp tine was significantly more likely to lead to syndesmosis malreduction [7].
- The axial view of the CT scan can be used to visualize the axis of reduction, plan tine placement, and identify the shape of the incisura [7].

PEDIATRIC CONSIDERATIONS

- Ankle fractures represent around 5% of all pediatric fractures and 15% to 20% of all physeal injuries [5].
- Ankle fractures are considered the most common physeal fractures of the lower extremity [5].
- Inversion ankle injuries in children typically result in distal fibular physeal fractures, almost exclusively Salter-Harris type I or II [5].
- MRI studies do not show physeal injuries of the distal fibula in children with inversion injuries, questioning the dogma that these fractures are more common than ankle sprains [5].
- Salter type I fractures are diagnosed clinically by tenderness at the level of the physis and radiographs that show no malalignment of the physis and soft-tissue swelling over the distal fibula [5].
- CT should be obtained after casting for triplane fractures to confirm that reduction is satisfactory, defined as less than 2 to 3 mm of fracture diastasis and articular step-off [5].
- Postreduction CT should show less than 2 to 3 mm of displacement (fracture diastasis or articular step-off) for Salter-Harris type III fractures [5].
- Growth arrest with angular deformity and/or leg length discrepancy is minimized by reduction within 2 mm of anatomic [5].
- Complex regional pain syndrome is relatively common in children following ankle fractures and should be suspected in children who do not show prompt resolution of pain following immobilization [5].

References

[1] Aaos Comprehensive Orthopaedic Review 3. The Diabetic Foot and Ankle > V. Diabetic Ankle Fractures.

[2] Rockwood And Green S Fractures In Adults. 59: Patellar Fractures and Dislocations and Extensor Mechanism Injuries > Clinical Assessment of Ankle Fractures.

[3] Rockwood And Green S Fractures In Adults. 59: Patellar Fractures and Dislocations and Extensor Mechanism Injuries > Imaging and Other Diagnostic Studies for Ankle Fractures > Radiography.

[5] Aaos Comprehensive Orthopaedic Review 3. Pediatric Pelvic and Lower Extremity Fractures > VIII. Ankle Fractures.

[6] Campbell S Operative Orthopaedics 4 Volume Set. ARTHROSCOPIC EXAMINATION AND DEBRIDEMENT OF THE ANKLE JOINT > ANKLE FRACTURES.

[7] Orthopaedic Knowledge Update Trauma. Ankle Fractures > Syndesmosis Injury.

[8] Orthopaedic Knowledge Update Trauma. Ankle Fractures > Initial Assessment and Classification.

[9] Orthopaedic Knowledge Update Trauma. Ankle Fractures > Imaging.

[10] Miller S Review Of Orthopaedics. ANKLE FRACTURES.

[14] Orthopaedic Knowledge Update Trauma. Ankle Fractures > Management.

[15] Rockwood And Green S Fractures In Adults. 59: Patellar Fractures and Dislocations and Extensor Mechanism Injuries > Introduction to Ankle Fractures.

[17] Orthopaedic Knowledge Update Trauma. Ankle Fractures > Ankle Anatomy.

[19] Rockwood And Green S Fractures In Adults. 59: Patellar Fractures and Dislocations and Extensor Mechanism Injuries > Management of Adverse Outcomes and Unexpected Complications in Ankle Fractures.

[20] Orthopaedic Knowledge Update Trauma. Ankle Fractures > Summary.

CQ HAND + UPPER LIMB
Dr Kieran Hirpara — Specialist Orthopaedic Surgeon
Suite 2, Level 1, Mater Private Hospital Rockhampton, 31 Ward Street, The Range, QLD 4700
Phone 07 4863 6556 · office@cqupperlimb.com.au · cqupperlimb.com.au