Emergency Management of Ankle Fractures

Abhishek Ganta and Kenneth A. Egol

1 Introduction

Ankle fractures are some of the most common lower extremity injuries treated by orthopedic surgeons [1]. They typically occur in a bi-modal distribution with more severe fracture dislocations and open injuries occurring from high energy injuries in younger populations and lower energy injuries occurring in the geriatric population [2]. However, recent studies have demonstrated that the incidence of ankle fractures in the elderly population has had a significant rise since 2000 [3, 4]. Open fractures in this cohort are associated with increased complications and have a significant impact on health care costs [5].

While most patients with ankle fractures can be treated as an outpatient, there are circumstances which require urgent treatment, including admission and inpatient management [6]. These include displacement compromising skin viability, dislocation of the tibiotalar joint, neurovascular compromise, and severe soft tissue injury, including open fractures.

A. Ganta (✉) · K. A. Egol
Division of Orthopedic Trauma Surgery, Department of Orthopedic Surgery, NYU Langone Health, NYU Langone Orthopedic Hospital, New York, NY, USA

Department of Orthopedic Surgery, Jamaica Hospital Medical Center, Queens, NY, USA
e-mail: Abhishek.Ganta@nyulangone.org; Kenneth.egol@nyulangone.org

2 Emergency Room Work Up and Management

Initial assessment of an ankle injury requires history, physical examination and, often, radiographic imaging. Radiographs should be obtained if there is gross deformity, bony tenderness along the malleolar region or along the foot, and if the patient is unable to bear weight [7]. The mechanism of injury is important and includes both low energy twisting mechanisms and higher energy mechanisms such as falls from height, motor vehicle accidents, and pedestrian struck [2]. These higher energy mechanisms can indicate the likelihood of severe soft tissue compromise, compartment syndrome, pilon variations of ankle fractures, and associated injuries to the foot, as well as other musculoskeletal injuries (Fig. 1a, b) [8].

Obtaining a medical history can help direct post-operative management of the patient. Poorly controlled diabetics and patients with severe vascular disease are at risk of significant complications post-operatively even in simple ankle fracture patterns [9, 10]. Furthermore, a history of tobacco use, drug or alcohol abuse, and psychiatric illnesses can alert the physician to increased risk of post-operative complications [11].

Examination should begin with the knee at the fibular head and work distally. Careful inspection of the limb for scars, deformity, skin integrity,

D. Herscovici Jr. et al. (eds.), *Evaluation and Surgical Management of the Ankle*,
https://doi.org/10.1007/978-3-031-33537-2_10

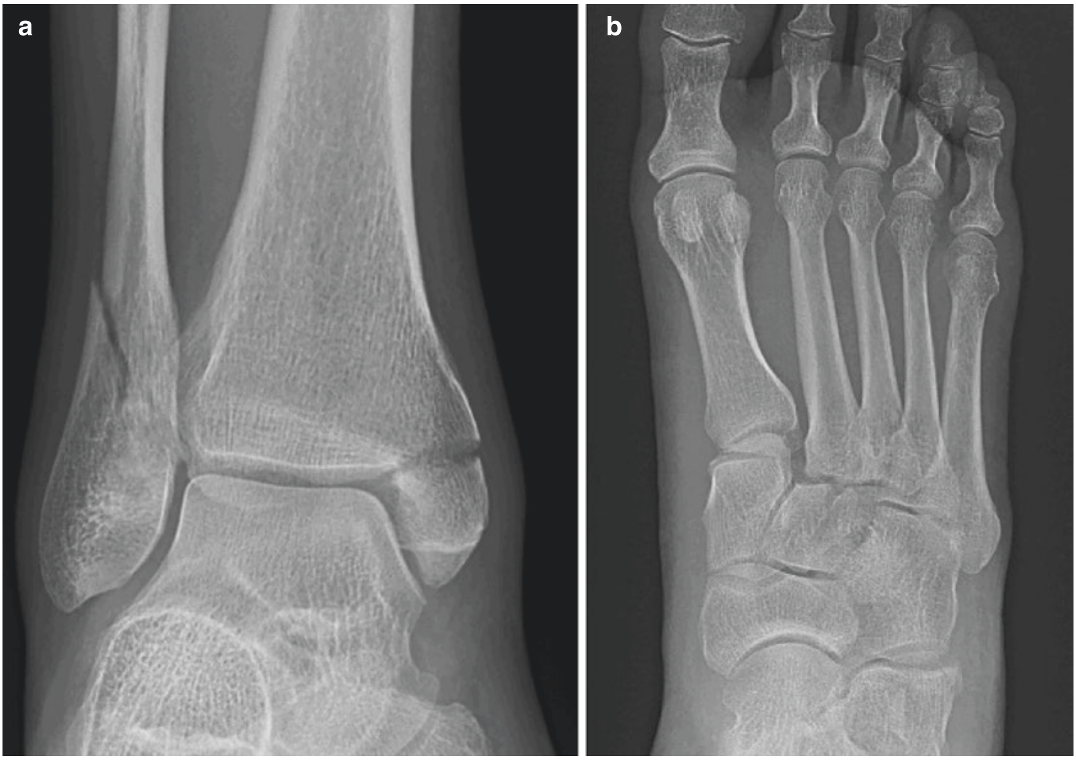

Fig. 1 (**a**, **b**) Patient is a 70-year-old male who had a forklift injury to the right ankle. He sustained a combined ankle and midfoot injury. (**a**) AP radiograph of the right ankle demonstrates a bi-malleolar ankle fracture. (**b**) AP of the right foot demonstrates incongruity of the first tarsometatarsal joint and widening of the Lisfranc Joint

open wounds, and any blisters should be noted and documented. Given the subcutaneous nature of the medial malleolus, skin blistering and compromise typically can be found in this area. Blanched, taut skin without capillary refill due to displacement of the ankle is an emergent condition requiring reduction to maintain viability of skin in this crucial area. Do not overlook the skin and soft tissues around the posterior aspect of the ankle. Palpation of the foot can help identify concomitant hindfoot, midfoot, and forefoot injuries such as calcaneus fractures and Lisfranc fractures. Palpation of the posterior tibial and dorsalis pedis pulses should be performed both before and after reduction and splinting. If the ankle is dislocated, the dorsalis pedis pulse may be diminished due to vessel kinking from the anterior displacement of the tibia relative to the talus. Expedient reduction will restore flow back to this vessel.

The ankle trauma series consist of three standard radiographs: the AP, lateral, and mortise (Fig. 2a–c). A full length tibia film should sometimes be obtained, if physical examination is suggestive or unclear, as proximal fibula fractures may not be fully visualized on the ankle radiographs [12].

Contra-lateral films can be obtained for a frame of reference as well in the emergency room or intra-operatively as there can be substantial variability in anatomy (Fig. 3) [13].

In isolated fibula fractures with medial signs and/or symptoms, a gravity stress or a stress external rotation examination should be performed to assess competency of the medial malleolar ligamentous complex (Fig. 4a–d) [14]. It is important to avoid a plantarflexed position as it can result in apparent but not true widening of the medial ligamentous complex due to narrowing of the talus posteriorly [15].

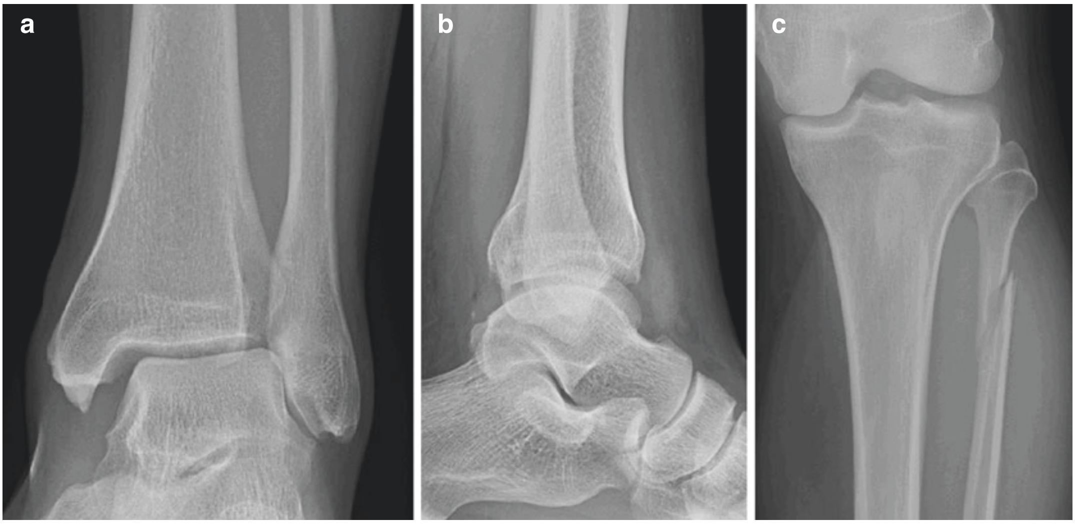

Fig. 2 (**a**–**c**) Patient is a 44-year-old male s/p fall on ice who sustained a left ankle injury with widening of the medial and tibia-fibula clear space on his injury films. (**a** and **b**) AP and Lateral imaging of the left ankle demonstrating widening of the medial clear space and lateral shifting of the talus. Of note there is a posterior malleolus fracture as well. (**c**) AP of the tibia demonstrates a proximal fibula fracture indicated a Maisonneuve ankle injury

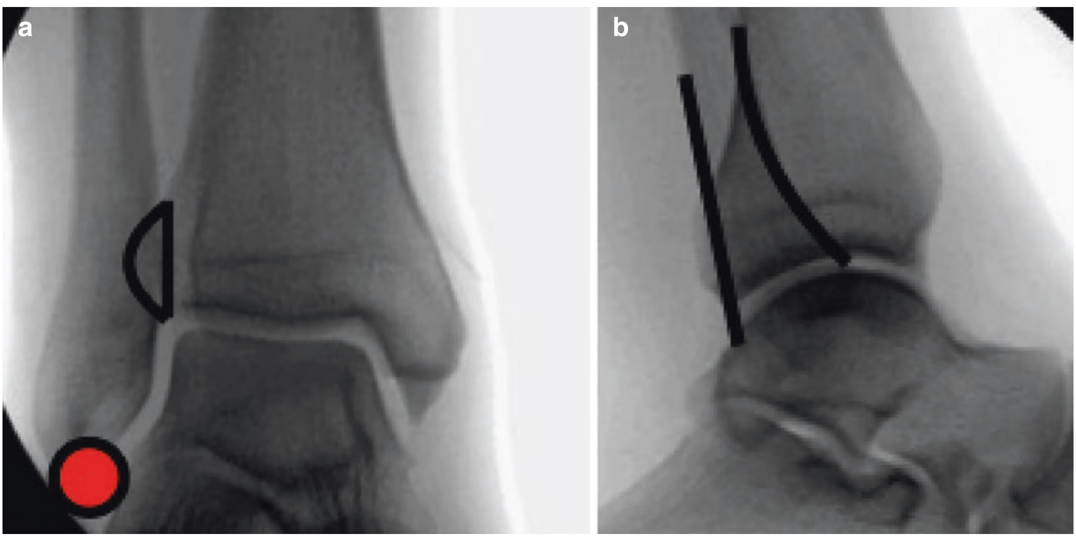

Fig. 3 (**a**, **b**) Intra-operative fluoroscopy of the contralateral ankle is used to assess fibular length and anatomic relationship of the fibula to the tibia. (**a**) Demonstrates the relationship of the distal tibia to the talus and the amount of overlap of the tibia and fibula on a mortise view. (**b**) Lateral fluoroscopy demonstrates how the fibula sits within the posterior aspect of the tibia

Fig. 4 (**a**, **b**) Patient is a 35-year-old man that slipped and fell on ice and sustained a right unstable lateral malleolus above the level of the syndesmosis. (**a**) Mortise view of the ankle demonstrate no lateral translation of the talus and no medial clear space widening. (**b**) External rotation stress view of the ankle demonstrates interval clear space widening and lateral translation of the talus. (**c**) This clinical picture demonstrates a gravity stress external rotation view where the foot is externally rotated due to its weight. The XR cassette is placed behind ankle. (**d**) This clinically demonstrates the technique of a manual stress external rotation stress where the foot is dorsiflexed and externally rotated

Fig. 5 Patient is a 31-year-old male that was bicyclist struck by a car and sustained a tri-malleolar ankle fracture dislocation. Note that the talus dislocates posteriorly following the posterior malleolus fracture displacement

Dislocated or subluxated tibiotalar joints should be reduced urgently to alleviate soft tissue tenting and pressure and splinted to maintain reduction. Typically, the talus will dislocate posteriorly while the tibia translates anteriorly especially in the presence of large posterior malleolus fractures (Fig. 5).

Reduction requires manual traction with anterior translation of the talus and supination of the foot. Closed reduction and splinting can be done with a single person; however, it requires coordination with the emergency room team. Closed reduction may require the following: (1) Sedation, (2) Analgesia, (3) Muscle relaxation, and (4) appropriate material to maintain reduction [12]. The ED team should be available to provide sedation and relaxation. A tibiotalar ankle block given within the tibiotalar joint can also provide additional analgesia [16]. A 10 cc syringe is used and 10 cc of 1% lidocaine is injected into the medial axilla of the ankle with a 22gauge needle. Given the capsular disruption, the lidocaine can spread along the fracture hematoma well. Multiple reductions should be avoided as they are painful and damaging to the joint, so splinting materials should be gathered and adequate assistance be present to allow immediate application of stabilizing immobilization to prevent re-dislocation. Prior to reduction, an "AO" short leg splint should be pre-measured and rolled out and ample webril padding should be available. The authors prefer 3–4 layers of webril padding on the splinted injury and 10 layers of plaster for both the posterior slab and sugar tong U mold. Plaster is preferable to fiberglass as a splinting material due to superior molding ability.

Once the set up for splinting is completed and the patient has adequate relaxation and analgesia, the knee should be bent to help relax the gastrocnemius/soleus complex. A Quigley maneuver can be used to not only assist with the reduction but also to suspend the extremity to allow independent splint placement [17]. The use of Quigley requires an IV pole and a cast stockinette. The IV pole is placed behind the contra-lateral shoulder while the patient is in a supine position. A long stockinette is placed around the ankle above the knee and tied to the IV pole. Alternatively a kerlix that can be attached to the great toe and second toe. This not only relaxes the gastrocnemius/soleus complex but also provides an anterior directed force on the talus. Placement of the IV pole posterior to the contra-lateral shoulder allows for supination of the foot as well (Fig. 6).

Once the ankle is reduced and the plaster splint is applied, a firm mold is applied to maintain reduction. While molding, care should be taken to avoid pressure points. Molding of a splint should be done with the flat surfaces of the palm and not fingers. The molds on the splint should be placed laterally along the base of the heel and medially above the medial malleolus to hold the mortise reduced (Fig. 7a–d).

After reduction is performed and the splint has dried appropriately, radiographs of the ankle should be obtained to ensure that the mortise is reduced. Axial imaging with a CT scan be obtained after reduction to look for marginal impaction in supination adduction type fractures and also to evaluate the morphology and size of posterior malleolus fractures as well (Fig. 8a–d) [18, 19]. MRI has been used in research studies to evaluate the competency of the deltoid ligament as well as osteochondral lesions; however, its use in clinical practice is unnecessary.

Fig. 6 This image demonstrates the use of a modified Quigley maneuver to help reduce and maintain reduction of an ankle fracture dislocation. Note that the IV pole along the contra-lateral should allow the foot to supinate. The knee remains flexed under sheets or pillows to relax the gastrocnemius/soleus complex. The reduction can be finetuned and a splint can be applied without the need for multiple assistants. A stockinette can also be used

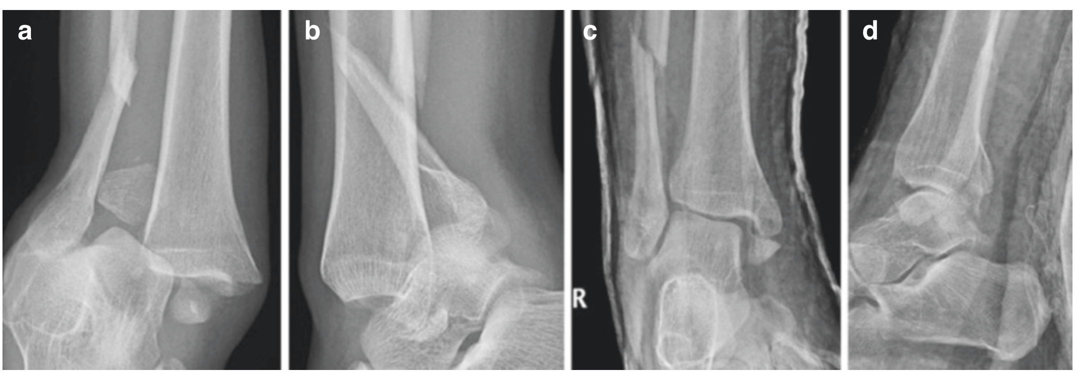

Fig. 7 (**a**–**d**) Patient is a 32 year old male who sustained a tri-malleolar ankle fracture dislocation after falling off an electric scooter. (**a**, **b**) AP and lateral of the ankle demonstrate a posterolateral dislocation of the talus with a large posterior malleolus fracture. (**c**, **d**) Demonstrates interval reduction and placement of an AO splint. Note the plaster mold along the medial aspect of the tibia and laterally along the calcaneus

Fig. 8 (**a**–**d**) Patient is an 18-year-old male s/p twisting injury to the right ankle while playing soccer sustaining a right tri-malleolar fracture dislocation. (**a**, **b**) AP and lateral of the right ankle demonstrate a tri-malleolar fracture dislocation with a large posterior malleolus fracture. (**c**, **d**) Post-reduction axial and sagittal CT scan of the ankle demonstrate medial extension of the posterior malleolus fracture as well as marginal impaction that is not fully appreciated on radiographs

3 Irreducible Ankle Fractures

While the majority of ankle fractures can be closed reduced and splinted, there are reports of ankle fractures that are irreducible. The patients that have these injuries usually present after a high energy mechanism such as a fall from height or a motor vehicle accident; however, there are cases of these that occur from a ground level fall or twisting mechanism. The fracture pattern typically involves a fibula fracture consistent with a pronation injury [20]. The continued appearance of a disproportionately wide medial clear space before and after an adequate reduction attempt should suggest the possibility of soft tissue interposition (Fig. 9a, b).

Most interposition occurs when the medial structures such as the posterior tibial tendon dislocates from its groove posteriorly and gets entrapped laterally at the level of the syndesmosis [20]. This results in an anterior and laterally subluxated talus. Other structures that can be entrapped in this region include the anterior tibialis tendon as well as the entire posteromedial tendons and neurovascular bundle [21, 22].

Concern and presence of entrapment can be confirmed with a CT scan; however, advanced imaging is often not needed. Repeated attempts at closed reduction may be damaging and should be limited; if concern about entrapped structures persist, the patient should be taken to the OR expeditiously for open reduction. While ankle procedures typically start with lateral sided fixation, if there is concern for entrapment, a medial approach can be utilized first [23]. This allows for interposed tissue to removed so that the ankle joint can be reduced.

4 Soft Tissue Injuries: Open Fractures

Open fractures comprise about 1.5–3% of all ankle fractures and typically occur in younger patients with high energy mechanisms [24]. However, there has been a substantial increase of these open

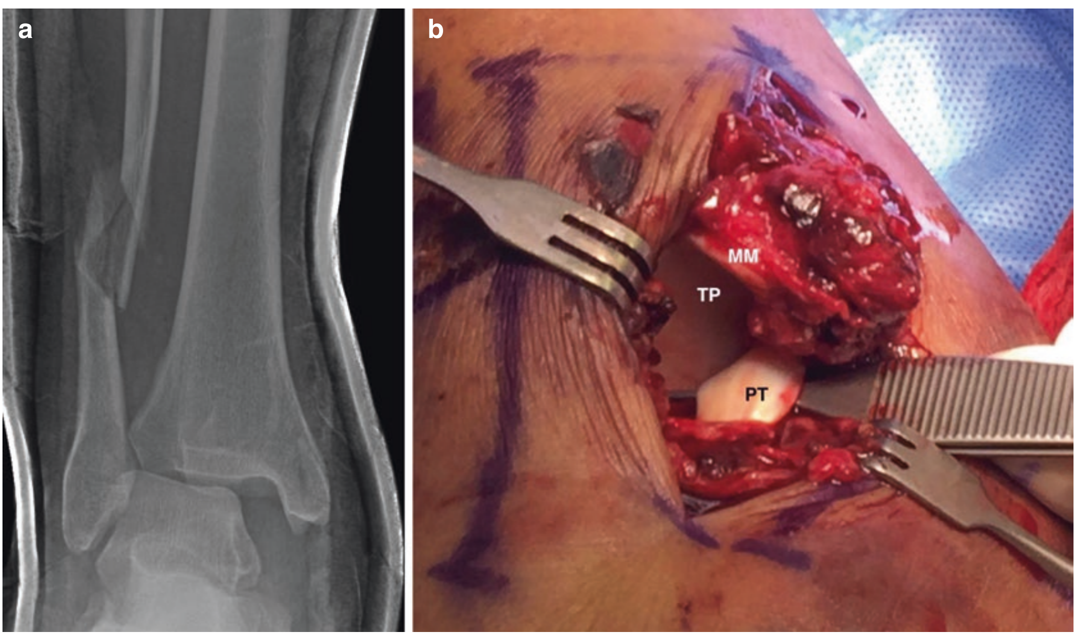

Fig. 9 (**a**, **b**) Patient is a 57-year-old male who had an irreducible ankle fracture following a fall and twist from a two-step height. (Courtesy of Dr. Sanjit R. Konda). (**a**) Mortise view of the ankle after multiple reduction attempts demonstrate persistent widening of the medial clear space and lateral subluxation of the talus. (**b**) Intra-operative image of the wound demonstrates displacement of the posterior tibial tendon within the axilla of the medial malleolus preventing reduction. *TP* tibial plafond, *PT* posterior tibial tendon, *MM* medial malleolus

injuries in geriatric patients from ground level falls or low energy mechanism. This can be attributed to the fact that this population has diminished skin tensile strength leading to open fractures even with low energy falls (Fig. 10a, b) [25].

Most open wounds result from a tensile failure along the medial aspect of the tibia. The wound is typically transverse or stellate in nature regardless of the presence of medial malleolus fracture . Rarely, does the open wound involve the lateral malleolus or the posterior aspect of the ankle. Emergency room management of these injuries includes removal of any gross contamination before reduction and protecting the medial skin from damage or entrapment during reduction. The wound should be covered with a sterile saline soaked gauze [26]. Intravenous antibiotics should be administered within 60 min of arrival with a first-generation cephalosporin for Gustilo Anderson type 1 and type 2 fractures. Gram negative coverage may be considered for type III fractures as well as for gross contamination [27, 28].

The authors prefer acute internal fixation after irrigation and debridement of these injuries [29, 30]. Lacerations may need to be extended longitudinally to allow adequate access, but careful placement of incisions is necessary with consideration of future needs. The ankle should be gently re-dislocated during irrigation and debridement to allow irrigation of the articular surface and into the incisura with several liters of low flow saline. Primary closure of the open wound is recommended if possible, as it has been associated with improved outcomes and lower rate of infection [31]. At times, immediate closure can have increased tension on the traumatic wound. The use of Allgöwer-Donati closure demonstrates superior incisional prefusion compared to vertical mattress; however, this may not correlate to any clinical difference [32]. While incisional wound vacs can be applied to areas at risk, its routine usage may not confer any clinical benefit even in open fractures [33, 34]. External fixation is reserved for fractures that require a second look due to contamination or as damage control for poly traumatized patient (Fig. 11). In the setting of severe bone loss/comminution or if the ankle remains unstable, an external fixator can be used to supplement internal fixation [25].

If the wound cannot be closed, a negative pressure dressing (wound VAC) can be placed and a delayed closure can be performed with either a local rotational flap or a free flap. The patient should remain on antibiotics until coverage, which ideally should be within 7 days [35].

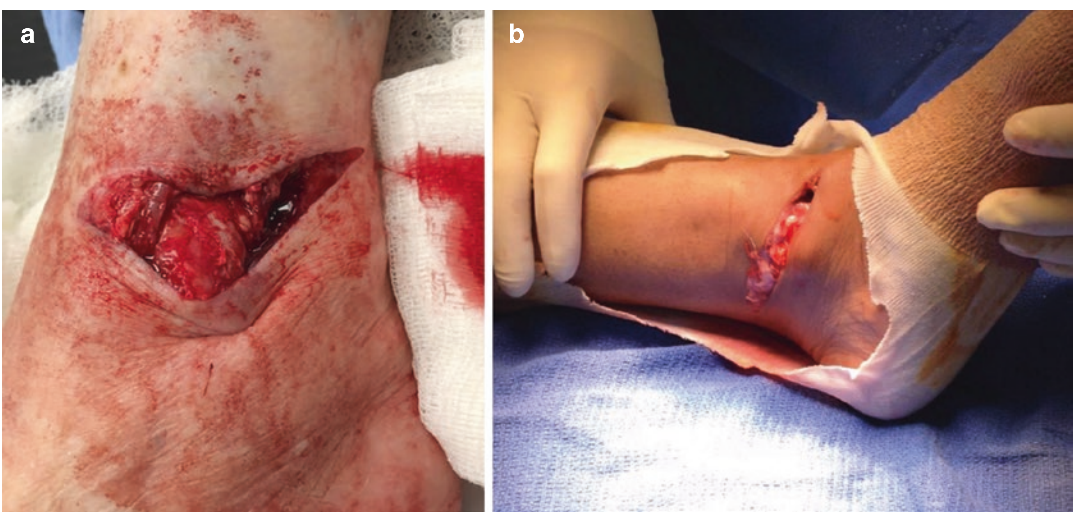

Fig. 10 (**a**) Patient is an 87-year-old woman who has a history of lung cancer that required chemotherapy, insulin dependent diabetes, and coronary artery disease who had a ground level fall sustaining a large transverse wound over the medial ankle. (**b**) Patient is a 40-year-old female with no past medical history who sustained a similar transverse wound over her medial malleolus from a motor vehicle accident.

Fig. 11 Clinical images demonstrate a severely contaminated open ankle fracture with soft tissue compromise. Due to this, the patient was treated with initial external fixation and serial debridement until they were amenable to internal fixation

Delaying wound closure or coverage longer than 7 days may increase risk of infection.

5 Soft Tissue Injury: Closed Fractures

Closed fractures can also have severe skin damage that precludes acute fixation for days or even weeks [35]. The presence of fracture blisters at the site of surgical incisions may require a staged approach with careful monitoring of soft tissues as immediate fixation is associated with increased wound complications. The injured limb should be strictly elevated in the hospital. Treatment of fractures with blisters with a defined protocol is generally recommended [36].

There are two main types of fracture blisters: serous (clear filled) and hemorrhagic (blood filled). These types differ in the depth of soft tissue injury. Blood-filled blisters have a greater degree of dermal-epidermal separation and injury (Fig. 12a, b).

Fracture blisters may develop 24–72 h post-injury and be first noticed upon removal of the splint [37]. They can be circumferential around the ankle. To adequately visualize and monitor the soft tissues, the authors prefer to place a delta frame external fixator for unstable patterns in the presence of fracture blisters around planned surgical incisions [38]. This allows for maintained reduction of the ankle mortise and allows inspection of the entire ankle. If the ankle is unstable or the mortise continues to subluxate with the external fixation in place, smooth Steinmann pins can be from the calcaneus into the tibia either transarticular or posteriorly out of the dome of the talus for additional stability (Fig. 13a–c) [39].

The blisters should be unroofed with sterile scissors and trimmed back to the point of healthy

Fig. 12 (**a**) Clinical image of a 43-year-old female who sustained a rotational ankle injury with several serous filled fracture blisters. (**b**) Clinical image of a 70-year-old female with history of severe lower extremity neuropathy who sustained a ground level fall and has developed hemorrhagic fracture blisters. Note the difference in appearance of the fracture blisters

Fig. 13 (**a**) Clinical image of a 30-year-old male with an open ankle fracture dislocation that was placed in a delta frame external fixator. This construct consists of two half pins in the tibia and two centrally threaded pins in the calcaneus. (**b**, **c**) Fluoroscopic images of an 86-year-old female with a tri-malleolar ankle fracture dislocation that was treated with stabilization with percutaneous Steinmann pins to allow for reduction and soft tissue stabilization prior to definitive treatment.


a
b
c

tissue. After this, Xeroform dressings can be applied to blistering area. The authors prefer to leave these on for a week. The dressings should then be changed regularly, ideally twice a day but at the minimum daily [36] . Patients with hemorrhagic blisters tend to take longer for the skin to re-epithelialize. Clinically, re-epithelialization occurs when the granulation type tissue that is present becomes replaced by a full epithelial layer and the blister is no longer evident. The patients should be counseled that definitive fixation should likely be delayed until full epithelization occurs.

6 Conclusion

While the majority of ankle fractures and fracture dislocations can be reduced and splinted in the emergency department and sent home with semi-elective outpatient surgical management, there are circumstances that require more emergent inpatient management. Clinicians should be aware of radiographic findings consistent with irreducible ankle fractures as these may require more urgent open reduction to mitigate soft tissue compromise. Furthermore, high energy injuries or severe fracture dislocations even in ground level falls may pre-dispose patients to soft tissue compromise. Open fractures should be urgently debrided in the operating room and temporized or definitively fixed in a timely fashion to mitigate complications. The lacerations should be closed, or the wounds covered as soon as possible. Fractures associated with blistering or deep abrasion of the skin need early care of the soft tissue envelope and may require delayed fixation.

References

1. Scheer RC, Newman JM, Zhou JJ, et al. Ankle fracture epidemiology in the United States: patient-related trends and mechanisms of injury. J Foot Ankle Surg. 2020;59:479–83.
2. Briet JP, Houwert RM, Smeeing DPJ, et al. Differences in classification between mono- and polytrauma and low- and high-energy trauma patients with an ankle fracture: a retrospective cohort study. J Foot Ankle Surg. 2017;56:793–6.
3. Kannus P, Palvanen M, Niemi S, et al. Increasing number and incidence of low-trauma ankle fractures in elderly people: Finnish statistics during 1970-2000 and projections for the future. Bone. 2002;31:430–3.
4. Strauss EJ, Egol KA. The management of ankle fractures in the elderly. Injury. 2007;38(Suppl 3):S2–9.
5. Toole WP, Elliott M, Hankins D, et al. Are low-energy open ankle fractures in the elderly the new geriatric hip fracture? J Foot Ankle Surg. 2015;54:203–6.
6. Qin C, Dekker RG, Helfrich MM, et al. Outpatient management of ankle fractures. Orthop Clin North Am. 2018;49:103–8.
7. Bachmann LM, Kolb E, Koller MT, et al. Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systematic review. BMJ. 2003;326:417.
8. Tarkin IS, Sop A, Pape H-C. High-energy foot and ankle trauma: principles for formulating an individualized care plan. Foot Ankle Clin. 2008;13:705–23.
9. Manway JM, Blazek CD, Burns PR. Special considerations in the management of diabetic ankle fractures. Curr Rev Musculoskelet Med. 2018;11:445–55.
10. Saleh H, Konda S, Driesman A, et al. Wound-healing issues following rotational ankle fracture surgery: predictors and local management options. Foot Ankle Spec. 2019;12:409–17.
11. Miller AG, Margules A, Raikin SM. Risk factors for wound complications after ankle fracture surgery. J Bone Joint Surg Am. 2012;94:2047–52.
12. Egol KA, Koval KJ. Handbook of fractures. 6th ed; 2020.
13. Panchbhavi VK, Gurbani BN, Mason CB, et al. Radiographic assessment of fibular length variance: the case for "Fibula Minus". J Foot Ankle Surg. 2018;57:91–4.
14. Schock HJ, Pinzur M, Manion L, et al. The use of gravity or manual-stress radiographs in the assessment of supination-external rotation fractures of the ankle. J Bone Joint Surg Br. 2007;89:1055–9.
15. Kragh JF, Ward JA. Radiographic indicators of ankle instability: changes with plantarflexion. Foot Ankle Int. 2006;27:23–8.
16. MacCormick LM, Baynard T, Williams BR, et al. Intra-articular hematoma block compared to procedural sedation for closed reduction of ankle fractures. Foot Ankle Int. 2018;39:1162–8.
17. Skelley NW, Ricci WM. A single-person reduction and splinting technique for ankle injuries. J Orthop Trauma. 2015;29:e172–7.
18. Mason LW, Marlow WJ, Widnall J, et al. Pathoanatomy and associated injuries of posterior malleolus fracture of the ankle. Foot Ankle Int. 2017;38:1229–35.
19. Alluri RK, Hill JR, Donohoe S, et al. Radiographic detection of marginal impaction in supination-adduction ankle fractures. Foot Ankle Int. 2017;38:1005–10.
20. Stevens NM, Wasterlain AS, Konda SR. Case report: irreducible ankle fracture with posterior tibialis ten-

don and retinaculum, deltoid ligament, and antero-medial joint capsule entrapment. J Foot Ankle Surg. 2017;56:889–93.
21. Pankovich AM. Fracture-dislocation of the ankle. Trapping of the postero-medical ankle tendons and neurovascular bundle in the tibiofibular interosseous space: a case report. J Trauma. 1976;16:927–9.
22. Natoli RM, Summers HD. Irreducible ankle fracture-dislocation due to tibialis anterior subluxation: a case report. J Foot Ankle Surg. 2015;54:268–72.
23. Karim A, So E, Taylor BC, et al. Ankle fracture fixation: medial or lateral first? J Foot Ankle Surg. 2019;58:75–9.
24. Bugler KE, Clement ND, Duckworth AD, et al. Open ankle fractures: who gets them and why? Arch Orthop Trauma Surg. 2015;135:297–303.
25. Rammelt S. Management of ankle fractures in the elderly. EFORT Open Rev. 2016;1:239–46.
26. Hulsker CCC, Kleinveld S, Zonnenberg CBL, et al. Evidence-based treatment of open ankle fractures. Arch Orthop Trauma Surg. 2011;131:1545–53.
27. Halawi MJ, Morwood MP. Acute management of open fractures: an evidence-based review. Orthopedics. 2015;38:e1025–33.
28. Garner MR, Sethuraman SA, Schade MA, et al. Antibiotic prophylaxis in open fractures: evidence, evolving issues, and recommendations. J Am Acad Orthop Surg. 2020;28:309–15.
29. Hong-Chuan W, Shi-Lian K, Heng-Sheng S, et al. Immediate internal fixation of open ankle fractures. Foot Ankle Int. 2010;31:959–64.
30. Peterson DL, Schuurman M, Geamanu A, et al. Early definitive care is as effective as staged treatment protocols for open ankle fractures caused by rotational mechanisms: a retrospective case-control study. J Orthop Trauma. 2020;34:376–81.
31. Jenkinson RJ, Kiss A, Johnson S, et al. Delayed wound closure increases deep-infection rate associated with lower-grade open fractures: a propensity-matched cohort study. J Bone Joint Surg Am. 2014;96:380–6.
32. Shannon SF, Houdek MT, Wyles CC, et al. Allgöwer-Donati versus vertical mattress suture technique impact on perfusion in ankle fracture surgery: a randomized clinical trial using intraoperative angiography. J Orthop Trauma. 2017;31:97–102.
33. Petrou S, Parker B, Masters J, et al. Cost-effectiveness of negative-pressure wound therapy in adults with severe open fractures of the lower limb: evidence from the WOLLF randomized controlled trial. Bone Jt J. 2019;101-B:1392–401.
34. Cook R, Thomas V, Martin R, et al. Negative pressure dressings are no better than standard dressings for open fractures. BMJ. 2019;364:k4411.
35. Pincus D, Byrne JP, Nathens AB, et al. Delay in flap coverage past 7 days increases complications for open tibia fractures: a cohort study of 140 north American trauma centers. J Orthop Trauma. 2019;33:161–8.
36. Strauss EJ, Petrucelli G, Bong M, et al. Blisters associated with lower-extremity fracture: results of a prospective treatment protocol. J Orthop Trauma. 2006;20:618–22.
37. Tosounidis TH, Daskalakis II, Giannoudis PV. Fracture blisters: pathophysiology and management. Injury. 2020;51:2786–92.
38. Wawrose RA, Grossman LS, Tagliaferro M, et al. Temporizing external fixation vs splinting following ankle fracture dislocation. Foot Ankle Int. 2020;41:177–82.
39. Meijer RPJ, Halm JA, Schepers T. Unstable fragility fractures of the ankle in the elderly: Transarticular Steinmann pin or external fixation. Foot (Edinb). 2017;32:35–8.