The “Not So Simple” Ankle Fracture: Avoiding Problems and Pitfalls to Improve Patient Outcomes

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Abstract
Ankle fractures are among the most common injuries managed by orthopaedic surgeons. Many ankle fractures are simple, with straightforward management leading to successful outcomes. Some fractures, however, are challenging, and debate arises regarding the best treatment to achieve an optimal outcome. Some patients have medical comorbidities that increase the risk for complications or may require modifications to standard surgical techniques and fixation methods.

Several recent investigations have highlighted the pitfalls in accurately reducing syndesmotic injuries. Controversy remains regarding the number and diameter of screws, the duration of weight-bearing limitations, and the need or timing of screw removal. Open reduction may allow more accurate reduction than standard closed methods. Direct fixation of associated posterior malleolus fractures may provide improved syndesmotic stability. Posterior malleolus fractures vary in size and can be classified based on the orientation of the fracture line. As the size of the posterior malleolus fracture fragment increases, the load pattern in the ankle is altered. Direct or indirect reduction and surgical fixation may be required to prevent posterior or talus subluxation and restore articular congruency.

The supination-adduction fracture pattern is also important to recognize. Articular depression of the medial tibial plafond may require reduction and bone grafting. Optimal fixation requires directing screws parallel to the ankle joint or using a buttress plate.

Identifying ankle fractures that may present additional treatment challenges is essential to achieving a successful outcome. A careful review of radiographs and CT scans, a thorough patient assessment, and detailed preoperative planning are needed to improve patient outcomes.

Instr Course Lect 2011;60:73-88.

Although the nonsurgical or surgical treatment of many ankle fractures is considered to be simple and straightforward, certain ankle fracture patterns and fractures in patients with specific comorbidities can add significant challenges to achieving successful outcomes. It is important to understand potential problems to avoid complications and technical difficulties that may result in a poor outcome.

Ankle Fractures in Diabetic Patients
The public health burden of caring for diabetic patients with ankle fractures is substantial and increasing. Diabetic patients are more prone to complications and poor outcomes and have higher rates of in-hospital mortality and longer hospital stays compared with nondiabetic patients. Recognizing the higher risk involved, appropriately screening patients, collaborating on care, and tailoring management strategies will achieve the best possible outcomes in this challenging patient population.
Trauma

The chronic hyperglycemia of diabetes causes disruptions in cellular functions and alters extracellular tissue properties. Diabetes causes poor oxygen delivery to tissues, poor wound healing, susceptibility to infection, and delayed fracture healing. It can also lead to peripheral neuropathy and neuropathic arthropathy, a destructive, noninfectious, periarticular process that often has devastating consequences.

Risk Stratification

Risk stratification helps predict the chances of developing complications, guides preoperative risk reduction strategies, and may help focus the decision for surgery. Glycemic control should be addressed because reducing glycated hemoglobin levels by just 1% can reduce complications by 25% to 30%. Patients with diabetic comorbidities, such as retinopathy, nephropathy, and neuropathy, have a higher risk of surgical complications. In one study, the rate of complications in diabetic patients without comorbidities was identical to that of nondiabetic patients matched by age, sex, fracture type, and treatment. In contrast, the rate of complications in diabetic patients with comorbidities was significantly increased compared with matched nondiabetic patients (47% versus 14%, respectively; \( P = 0.034 \)). The lack of distal pulses, ankle-brachial indices less than 0.9, and transcutaneous oxygen pressure less than 30 mm Hg suggest the need for further vascular studies and possible revascularization before ankle surgery; however, ankle-brachial indices are often spuriously elevated in patients with diabetes. The risk of neuropathic arthropathy is associated with the loss of protective sensation, poor glucose control, the duration of diabetes, and a prior history of neuropathic arthropathy. Screening for neuropathy can include testing with a 5.07 (10 g) Semmes-Weinstein monofilament, testing for vibration sensation, or performing nerve conduction velocity studies. Other risk factors include the duration of diabetes, insulin use, smoking, hypertension, dyslipidemia, older age, delayed treatment, and an increased body mass index.

Patient Evaluation

The initial management of an ankle fracture begins with a thorough patient history, with particular attention to medical comorbidities such as peripheral neuropathy, neuropathic arthropathy, nephropathy, retinopathy, and the duration of diabetes. Appropriate consultation for managing comorbidities can help avoid complications. The physical examination should evaluate the skin, the vascular status, and the peripheral neurologic systems and inspect the midfoot or the contralateral foot for signs of neuropathic changes.

Treatment and Outcomes

Fractures and dislocations should be reduced and splinted; joint-spanning external fixation can be applied if soft tissues will not tolerate splinting. Stable ankle fractures can be treated with casting and a strict non–weight-bearing protocol. These fractures include isolated distal fibular fractures or nondisplaced medial malleolar fractures with no talar displacement or syndesmosis widening. The patient does not bear weight for 6 to 12 weeks, after which protected weight bearing is instituted for 4 to 8 weeks. Healing may take two to three times longer than expected in these patients. Follow-up radiographs should be obtained, with intervention in cases of fracture displacement. In a study by Schon and Marks, 15 nondisplaced ankle fractures in patients with diabetes and neuropathy healed with non–weight-bearing casting for 3 to 9 months.

Unstable ankle fractures in patients without diabetes-associated comorbidities can be treated in the same manner as ankle fractures in nondiabetic patients. When comorbidities are present, open reduction and internal fixation is indicated for unstable fractures if vascular status and soft tissues allow and there is no ongoing neuroarthropathic joint destruction. Unstable fractures include displaced medial malleolus fractures, fibula fractures with talar displacement, bimalleolar or trimalleolar fractures, posterior malleolus fractures, and fractures with syndesmosis widening. Surgery may be delayed for 1 to 3 weeks to optimize the patient’s medical management and allow soft-tissue swelling to subside, fracture blisters to resolve, and wrinkles to return to the skin.

The principles of reduction and fixation of ankle fractures in diabetic patients follow those used in nondiabetic patients; however, more rigid fixation should be used. A variety of techniques, including locked plating, fibula into tibia (syndesmosis) screws, supplementary intramedullary Kirschner wires, and posterolateral autoglide fibula plating allow more rigid fixation. Extraperiosteal contoured medial, lateral, and posterior plates help limit iatrogenic soft-tissue injury. Internal fixation can be augmented or replaced by joint-spanning external fixation if the condition of the soft tissues will not allow open surgery (Figure 1). Even a simple transcalcaneal pin can provide stability. Postoperative care should include longer immobilization and prolonged weight-bearing restrictions. A good rule in treating diabetic patients is to increase the degree of immobilization (cast rather than removable boot), increase the degree of protected weight bearing (not bearing weight rather than par-
tially or fully bearing weight), and at least double the duration of the limited weight-bearing period. Long-term bracing can be considered, especially when a fibrous union develops. Adjuvant treatments, including ultrasound, platelet-rich plasma, and internal electrical stimulation may speed bone healing.22-24

Unfortunately, there are no prospective or randomized trials to guide surgical decision making for unstable ankle fractures in diabetic patients. The surgical treatment of unstable ankle fractures in diabetic patients with comorbidities has a high complication rate, but closed treatment also results in frequent complications. In one small case series of neuropathic patients with unstable ankle fractures treated with casting, neuroarthropathy developed in 40% of the patients, and nonunion or malunion was reported in 100% of the patients.8,15 Closed treatment may avoid some complications of surgical treatment, including wound complications, infection, and amputation.25

The results of surgical fixation of unstable ankle fractures in diabetic patients are limited to case series and case-controlled studies of patients with diabetes of varying severities and mixed fracture types. Overall complication rates in diabetic patients ranged from 14% to 44%.15,26 Complications include poor wound healing, infection, malunion, loss of reduction, delayed union or nonunion, neuropathic arthropathy, noncompliance-related problems, and the need for further surgery or amputation (Figure 2). Risk factors for infection include peripheral vascular disease, neuropathy, and poor glucose control. In a study by Flynn et al,27 infections in patients with surgically treated ankle fractures were reported in 4 of 19 diabetic patients (21%) compared with 6 of 68 nondiabetic patients (9%). Open ankle fractures in diabetic patients are particularly devastating, with infection in 67% of patients, wound complications in 64%, and below-knee amputation in 36% reported in a 2003 study.28

If neuroarthropathic changes are present, internal fixation may not be beneficial, and salvage procedures may be required. Conservative care begins with serial total contact casts. This care is followed by long-term bracing for a well-aligned ankle and foot or fusion for an unbraceable deformity. Amputation is a reasonable treatment option for patients with nonreconstructible deformities, failed reconstructions, or deep infection.

Revision surgery should be considered for delayed fixation failure, syndesmosis widening, and instability or when additional fractures are discovered early and are not associated with neuroarthropathic joint destruction (Figure 3).

Understanding the additional risks of caring for diabetic patients with ankle fractures will reinforce the need for stratifying risks, treating medical co-morbidities, and appropriately selecting patients for surgical treatment. Careful technique and a more conservative postoperative course will help to maximize the probability for a successful outcome.

Ankle Fractures in Elderly Patients With Severe Osteoporosis
The demographic predictors of ankle fractures in elderly patients include fe-

Figure 1 A, AP radiograph of an open ankle fracture in a diabetic patient. The condition of the soft tissue would not safely allow open reduction and internal fixation. B, AP radiograph after débridement, fracture reduction, and stabilization with joint-spanning external fixation, which was used for definitive treatment along with a posterior splint.
male sex, obesity, and diabetes. The frequency of fractures observed in postmenopausal women has led several investigators to classify ankle fractures as osteoporotic fragility fractures. However, clinical studies suggest that the incidence of ankle fractures increases until age 65 years and then the occurrence either plateaus or declines; this finding contradicts the association between fracture risk and bone strength.

In a study comparing 103 women (age 50 to 80 years) with ankle fractures with 375 women of a similar age without ankle fractures, Greenfield and Eastell used dual-energy x-ray absorptiometry scanning and quantitative ultrasound to evaluate the presence of osteoporosis and its relationship to ankle fracture risk. The authors reported no significant difference in bone mineral density in the patient cohorts, except in the trochanteric region where the patients with ankle fractures had a higher bone density than the population-based group. Based on these findings, the authors concluded that an ankle fracture is not a typical osteoporotic fracture, and patients with an ankle fracture are not at an increased risk for fragility fractures. Because the patients with ankle fractures were significantly heavier with a higher body mass index than the population-based cohort, the authors believe that increased body weight increases the forces applied to the ankle during a fall and therefore contributes to the development of ankle fractures.

**Treatment Options and Techniques**

The goal of managing ankle fractures in elderly patients centers on providing a functionally stable ankle joint, which will allow patients to return to their preinjury functional levels. Currently, there is a lack of consensus within the orthopaedic community regarding the...
appropriate surgical indications for this patient population. Treatment goals have been reevaluated because of the growing number of older adults who are more physically active and have greater expectations for functional recovery.

In recent clinical investigations to evaluate the efficacy of surgical versus nonsurgical treatment of ankle fractures in elderly patients, results have varied. In general, the clinical results of the surgical treatment of ankle fractures in elderly patients have been favorable, with higher American Orthopaedic Foot and Ankle Society scores. The major problem with surgical treatment has been the need for reoperation. The results of nonsurgical treatment have been less favorable, with higher rates of nonunion. Davidoitch et al. reported a steady improvement in functional recovery during the first postoperative year in elderly patients surgically treated for an ankle fracture; however, the rate of improvement was slower than that seen in a younger patient cohort. Based on these findings, the authors concluded that surgical fixation of unstable ankle fractures in elderly patients provides a reasonable postoperative functional result.

Because it can be challenging to surgically manage ankle fractures in osteoporotic bone, modifications of the standard surgical treatments have been advocated. Koval et al. reported on the surgical treatment of 20 patients older than 50 years with comminuted or osteopenic ankle fractures. Two intramedullary Kirschner wires were used to augment fracture fixation with a contoured lateral plate (Figure 4). All the fractures healed without loss of reduction, with approximately 90% of the patients reporting either no pain or mild pain. Biomechanical evaluation of Kirschner wire augmented fibular fixation showed 81% greater resistance to bending and twice the resistance to torsional loading compared with lateral fibular plate fixation alone.

Intramedullary fibular fracture stabilization can be accomplished through a small incision without a significant amount of soft-tissue stripping. In a review of 11 Weber type B ankle fractures in elderly osteoporotic patients treated with fibular nailing, Ramasamy and Sherry reported no wound complications and good to excellent results in 88% of patients. Modifications of traditional plate and screw constructs have been advocated for these fractures as a method of addressing fixation concerns in osteoporotic bone. Using multiple syndesmotic screws or tricortical and quadricortical fixation of fibular fractures have been described to improve fixation in osteoporotic ankle fractures (Figure 5). Using multiple plates on the fibula is another strategy that may allow a more rapid return to weight bearing and improve the overall outcome after surgical repair.

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Figure 4  Lateral radiograph showing adjunctive intramedullary Kirschner wires placed anterior and posterior to the fibular plate screws to improve fixation stability in a severely osteoporotic patient with an ankle fracture. Kirschner wires also have been used for the tension band fixation of the medial malleolus. Heavy radiolucent suture has been used instead of cerclage wire.

Figure 5  Lateral radiograph showing quadricortical screw fixation into the tibia. Improved fixation can be achieved with tricortical or quadricortical screw fixation into the tibia, even in the absence of syndesmotic injury.
When formal open surgery is precluded (such as in patients with severe soft-tissue compromise, poor vascularity, or brittle diabetes), external fixation, with or without limited internal fixation, is an option for maintaining reduction in an unstable ankle mortise. The frame will hold the joint reduced until internal fixation is possible; in certain patients, the frame may be used definitively until healing is complete, with or without the addition of percutaneously placed screws.

Complications
Complications following the surgical treatment of ankle fractures in elderly patients can be devastating and significantly impact treatment outcomes. Common complications include painful prominent hardware, wound healing problems, infection, and malunion. Diabetes mellitus, discussed previously, is one of the most common comorbidities in elderly patients. Medical comorbidities play an important role in both the incidence and type of postoperative complications in elderly patients with ankle fractures.

Ankle Syndesmosis
Anatomy
The ankle syndesmosis is the ligamentous complex that stabilizes the distal articulation between the fibula and tibia. The medial aspect of the distal fibula normally resides within the concave posteromedial fibular notch of the distal tibia (incisura fibularis tibiae). Because of the minimal bony stability inherent in the tibial incisura, ligamentous integrity is necessary for syndesmotic stability. The four main ligaments that contribute to the syndesmotic complex are the anterior inferior tibiofibular ligament, the posterior inferior tibiofibular ligament, the transverse ligament, and the interosseous ligament (Figure 6). The anterior inferior tibiofibular ligament is situated obliquely between the anterolateral tibial (Chaput) tubercle and the anteromedial distal fibula. The posterior inferior tibiofibular ligament joins the posterolateral tibial (Volkmann) tubercle and the posteromedial distal fibula. The transverse ligament represents a deep, thickened zone of the most distal portion of the posterior inferior tibiofibular ligament and functions like a labrum, deepening and stabilizing the tibiotalar joint. The posterior inferior tibiofibular ligament and associated transverse ligament provide nearly 50% of the overall syndesmotic strength. The interosseous ligament is the distal aspect of the tibiofibular interosseous membrane and joins the tibia to the fibula several centimeters above the articular surface. The syndesmosis is normally a mobile articulation, allowing slight motion in the coronal, sagittal, and rotational axes. Injury to the syndesmosis alters the normal relationship and motion between the fibula and the tibia and between the tibia and the talus.
Avoiding Pitfalls

Diagnosis

Ankle fractures are frequently accompanied by injury to one or more of the syndesmotic ligaments. The severity of syndesmotic injury can result in varying degrees of instability. The ultimate goal of ankle injury treatment is to maintain the normal relationships between the ankle mortise and the syndesmosis until healing. This requires accurate diagnosis of syndesmotic injuries and appropriate treatment.

The main potential pitfall in treating syndesmotic injuries involves the diagnosis. The Lauge-Hansen classification system was devised to provide mechanistic insight of ligamentous injuries based on the fracture patterns; however, this classification does not accurately correlate the mechanism of injury with the soft-tissue injury pattern. In 1989, Boden et al recommended that syndesmotic fixation was required only when rigid medial fixation was not possible and the fibular fracture was greater than 3 to 4.5 mm proximal to its tip. Since that report, it has become clear that rigid medial and lateral malleoli fixation is not sufficient to stabilize the syndesmosis in an unstable injury. The first flawed assumption is that rigid medial malleolar fixation obviates medial instability. In fact, up to 25% of medial malleolus fractures, particularly of the anterior colliculus, may have a concomitant deep deltoid injury. MRI data have demonstrated that the level of the fibular fracture is not an accurate indicator of the level of the syndesmotic injury. Clinical evidence has corroborated the high incidence of syndesmotic injuries in Weber type B injuries, which would not be predicted by the Boden criteria or the Lauge-Hansen or Weber fracture classification systems. Traditional radiographic measurement criteria for syndesmotic injuries include the tibiofibular clear space and tibiofibular overlap, with specific thresholds for both the AP and mortise views. Unfortunately, these static radiographic measurements have a poor correlation with syndesmotic injury. Dynamic stress testing is necessary for the diagnosis of a syndesmotic injury; however, because the syndesmosis cannot be adequately stressed until the fibula is stabilized, dynamic stress testing cannot be performed preoperatively. Given the high incidence of ankle fractures with concomitant syndesmotic injuries and the difficulty in making a preoperative diagnosis, every surgically treated ankle fracture should undergo intraoperative dynamic stress testing after malleolar fixation. This testing can be done with the Cotton test (lateral fibular translation), the external rotation stress test, and the sagittal plane stress test or by placing a Hohmann retractor directly in the syndesmotic space (Figure 7).

Malreduction

Once the appropriate diagnosis has been made, it is necessary to avoid syndesmotic malreduction. Based on CT data, the rate of malreduction with the use of standard techniques is higher than previously recognized. Achieving anatomic syndesmotic reduction is critical for optimizing a patient’s outcome. Syndesmotic malreduction is a significant predictor of a poor functional outcome. Many factors can lead to syndesmotic malreduction. Fibular malreduction may be the main source of malreduction. Substantial anatomic variability of the tibial incisura predisposes some patients to malreduction, particularly those with flatter articulations compared with those with more concave articulations (Fig-
In these patients, the vector of the clamp or other reduction instrument is critical for appropriately positioning the fibula within the incisura. The posterolateral Volkmann tibial tubercle, which is involved in fractures of the posterior malleolus, is critical for incisura competence. A large or displaced posterior malleolar fragment that remains malreduced may also lead to syndesmotic malreduction. Because the posterior inferior fibulofibular ligament is universally intact when the posterior malleolus is avulsed, anatomic reduction and stable fixation of the posterior malleolus may achieve reduction and stabilization of the syndesmosis\(^5\) (Figure 9).

Following reduction, it is critical to use a reliable method to assess the accuracy of the reduction. Assessing reduction on a mortise fluoroscopic view is necessary, but it is insufficient when used alone. A true talar dome lateral view is vital to assess the sagittal position of the fibula; however, because of the high regional anatomic variability, comparison with the contralateral limb is necessary. Open reduction with direct anterior visualization of the syndesmotic articulation may also have a role in assessing reduction, but whether this is necessary when using a true lateral fluoroscopic view and contralateral comparison remains controversial.

**Fixation**

Several implants and configurations are available for syndesmotic fixation. Larger screw diameters (4.5 mm) do not appear to provide a clinically significant mechanical advantage over
small fragment screws, and their heads are often prominent. A prospective, randomized study reported no difference in functional outcomes at 1 year when comparing tricortical with quadr-cortical fixation. This finding was confirmed by a subsequent randomized study. Early clinical data on su-
ture fixation of syndesmotic injuries are promising, although biomechani-
cal data have implied poor fixation strength compared with screws.

Postoperative management of syn-
desmotic injuries also remains contro-
versial, specifically regarding the time to weight bearing and screw removal. Moore et al reported the outcomes of 120 syndesmotic injuries in which weight bearing was initiated between 6 and 10 weeks and screw removal was not routinely performed. Although screw breakage was common, very few patients were symptomatic. The authors recommended against routine screw removal. A study by Hamid et al analyzed 1 year outcomes of pa-
tients with syndesmotic injuries and found no benefit to screw removal.

**Posterior Malleolus Fractures**

**Incidence**

Posterior malleolus fractures have been reported in 14% to 44% of all ankle fractures. These fractures are differented from tibial plafond fractures by their recognizable fracture patterns and sparing of the anterior distal tibial articular surface. Most are associated with other fractures or liga-
ment injuries around the ankle, with less than 1% of posterior malleolar fractures occurring as isolated inju-
ries.

**Classification**

Posterior malleolus fractures can be classified into three patterns. The most common pattern involves an oblique fracture of the posterolateral corner of the distal tibia (Figure 10). The fracture is an avulsion of the tibial insertion of the posterior inferior tibiofibular ligament and typically occurs with a rotational injury. An exter-
nal rotation lateral radiograph will show the true fracture size and may aid in assessing fracture reduction.

The second common fracture pattern is a large transverse fracture of the posterior distal tibia, often with a separate posteromedial frag-
ment or impaction injury to the articular surface (Figure 12). This pattern occurs with rotation, an axial load with posterior shear, or hyper-
plantar flexion. Standard radiographs show the large posterior fragment and often the presence of a double contour or flake fragment above the medial malleolus. Posterior lip fractures are the least common type, appearing as one or multiple shell-like avulsion fragments of the far posterior distal tibial surface. A CT scan may better define the size and orientation of the fracture fragments.

**Treatment**

Surgical indications for open reduc-
tion and internal fixation remain con-
troversial. Criteria based on the frac-
ture characteristics include fragments greater than 25% to 33% of the joint surface area or with greater than 2 mm articular incongruity. Cadaver studies
have shown increasing alterations in the joint-loading pattern with an increase in the fragment size and degree of articular step-off. Clinical studies have reported mixed recommendations regarding the fragment size that requires fixation. These studies do not address the fracture pattern or the adequacy of syndesmosis fixation. Fibular or syndesmosis reduction and fixation often reduces and stabilizes the posterior malleolus in posterolateral oblique fractures but not transverse fractures. Conversely, reduction and fixation of a posterolateral fracture restores syndesmosis stability more rigidly than does syndesmosis fixation. Residual posterior subluxation of the talus after reduction of the medial and lateral malleoli is an absolute indication for posterior malleolus fixation. A displaced posterior malleolus with posterior talar subluxation should be repaired with corrective osteotomy even after fracture healing.

A variety of surgical approaches, reduction techniques, and fixation methods are available for treating the posterior malleolus. The lateral approach between the fibula and peroneal tendons allows access to the posterolateral fracture fragment but is limiting for larger transverse fractures or when posterior plating is planned. Attention must be given to the superficial peroneal nerve if this approach is extended proximally. A posterolateral approach between the peroneal and Achilles tendons allows better access to the medial aspect of the posterior malleolus and allows more direct access for plating. The sural nerve is at risk with this approach. A medial approach may be made between the posterior tibial and flexor digitorum longus tendons. This approach is well suited for posteromedial fractures or split posterolateral and posteromedial fragments that are not easily accessed with the lateral approaches or when there is posteromedial marginal impaction. Experience with medial ankle approaches is helpful because the posterior tibial neurovascular bundle is adjacent to the incision.

Posterior malleolar fragment reduction may be evaluated with palpation, direct visualization, fluoroscopy, or arthroscopy. A periosteal elevator assists with elevating the flexor hallucis longus muscle off the posterior tibia and can help disimpact a fragment that is reluctant to move. A large tenaculum clamp helps reduce and hold the fragment (Figure 13). The choice of fixation depends on the size of the fragments, the comminution present, and the stability required. Anterior to posterior or posterior to anterior interfragmentary screw fixation is useful for noncomminuted fragments. Posterior plating may provide additional stability for comminuted or transverse-type fractures. The addition of syndesmosis fixation can help augment stability in posterolateral fractures.

Postoperative Care and Outcomes
Postoperative care depends on fixation stability. Early motion is acceptable for seniors patients with rigid fixation. Although avoiding weight bearing for 4 to 6 weeks is the prudent approach, no loss of reduction was reported in 15 patients with fixation of small posterior malleolus fractures who were allowed to bear weight in a cast within 7 days of surgery.

Reported clinical results of posterior malleolar fractures are limited to case-controlled and case studies; outcomes have been mixed. Large posterior malleolar fractures did better with internal fixation but still had worse 5-year outcomes in a study of 62 fractures matched to similar fractures without posterior malleolar involvement. Large posterior malleolar fractures or those with talar subluxation had fair to poor outcomes in a series of 51 trimalleolar ankle fractures followed for 42 months; however, 44 of the fractures were not internally fixed. In a series of 612 fractures with 1-year follow-up, posterior malleolar fractures of more than one third of the cross-sectional area had worse outcomes than those with small unfixed fragments. In a series of 57 trimalleolar fractures with more than a 4-year follow-up, posterior malleolar fractures with joint incongruity of more than 10% had worse outcomes. Failure to reduce posterior fragments smaller than 25% of the cross-sectional area did not affect results. Other large studies have failed to find a...
The relationship between fragment size or fixation of posterior malleolar fractures and outcomes.\textsuperscript{81,82}

Posterior malleolus fractures should be treated as part of the overall ankle fracture management to ensure optimal outcomes. Small posterolateral fractures typically reduce and are stable after fibular reduction and fixation. Larger posterolateral fragments, transverse-type fractures, or fragments that do not reduce with fibular reduction should be reduced and fixed. Fixation of the syndesmosis may provide indirect stability to the posterolateral fragment; however, anatomic reduction and internal fixation of the fragment itself is more stable and will typically aid in syndesmosis reduction and stability.

The Supination-Adduction Fracture Pattern

The supination-adduction fracture pattern occurs in 5% to 20% of ankle fractures.\textsuperscript{83,84} This type of fracture occurs when a foot in supination undergoes a forceful adduction moment without a rotational component. The first structure injured is either the lateral collateral ligament or the fibula. A fibular fracture created by this mechanism appears on radiographs or intraoperatively as a low transverse fracture line at a level below the syndesmosis. As the severity of the adduction moment increases, the talus displaces toward the medial malleolus, and a vertical fracture line is created extending...
from the medial axilla of the joint and proximally into the metaphyseal cortex of the tibia (Figure 14). This fracture mechanism tends to result in a large vertical shear fragment and is rarely associated with comminution at the medial malleolus. Usually the medial tibial plafond will sustain an impaction injury, which is not always easily recognized on plain radiographs, although a CT scan will clearly show this injury (Figure 14, B).

It is important to note that the presence of a vertical shear fracture pattern of the medial malleolus is the essential component of this injury pattern and may be the only osseous injury, with the lateral-sided injury being purely ligamentous. It is important for the treating surgeon to have a high index of suspicion for this injury when assessing this fracture pattern. A failure to adequately assess articular impaction will lead to inadequate reduction of the articular surface and may potentially lead to poor results.

Most of these injuries require surgical fixation. The procedure usually begins on the medial side of the ankle. Following exposure, the medial malleolus should be “booked open” to allow visualization of the medial aspect of the talar dome and tibial plafond. Cephalic irrigation is used to remove fracture hematoma and any loose fragments of bone and cartilage. The periosteum is elevated 1 to 2 mm from the fracture edges to aid in anatomic reduction. The area of articular impaction is disimpacted and may be provisionally stabilized with Kirschner wires placed in an anterior to posterior direction. The void left following disimpaction may require grafting with some type of osteoconductive material. The malleolar fragment is then anatomically reduced. Vertically oriented fractures of the medial malleolus benefit from the use of either a buttress plate or screws inserted parallel to the ankle joint (perpendicular to the fracture line).

The transverse fracture pattern of the fibula is amenable to intramedullary fixation, which can be achieved with several different implants. The benefit of this technique is the relative sparing of the soft-tissue envelope associated with percutaneous placement. Under fluoroscopic control, the tip of the lateral malleolus is identified on the AP and lateral views. This chapter’s authors prefer using an intramedullary screw. A small incision is made, and either a guidewire or drill bit is used to enter the distal fibular metaphysis. Once entry is confirmed, the wire is either advanced up the canal across the fracture site, or a partially threaded screw of appropriate length is inserted retrograde to gain purchase on the proximal intramedullary cortex. Formal open reduction with plate and screw fixation is an alternative method (Figure 15).

Complications specifically related to this fracture pattern include pain from the hardware and the development of posttraumatic arthrosis. Prominent hardware is common around the medial ankle. When hardware is removed for pain relief about the ankle, the results are somewhat better than for hardware removal at other locations in the body. Jacobsen et al85 reported on 66 patients who had hardware removal as part of their standard treatment protocol following a malleolar fracture. The authors reported improvement in pain symptoms following hardware removal.

Summary

An increasing percentage of patients presenting with ankle fractures have significant comorbidities that increase the risk of complications and provide technical challenges in achieving stable fixation. Diabetic patients, with the associated comorbidities of retinopathy, nephropathy, and neuropathy, are at especially high risk for complications. The duration of weight-bearing limitations and immobilization should be increased in patients with diabetes, but care must be exercised to monitor insensitive patients for potential skin breakdown. If surgical treatment is re-
required, more fixation should be used than in nondiabetic patients. Elderly patients with severe osteoporosis also present challenges in achieving stable fixation. Bone clamps should be used judiciously and with caution. Locked plate fixation offers a mechanical advantage in osteoporotic bone. Other techniques include the use of transfibular tricortical or quadricortical screw fixation (even in the absence of syndesmotic injury) and supplementary Kirschner wire fixation.

There are numerous pitfalls in accurately reducing and fixing syndesmotic injuries, especially in patients with a shallow incisura. Direct fixation of an associated posterior malleolus fracture may provide improved syndesmotic stability because the posterior inferior tibiofibular ligament is very strong and usually intact. Open reduction of the syndesmosis may allow more accurate reduction than standard closed methods. Careful intraoperative radiographic assessment is required but still may not identify subtle malreduction, which can be best assessed with CT.

Posterior malleolus fractures vary in size and fracture orientation. Oblique radiographs can be used to estimate the fragment size, but a CT scan can more accurately evaluate the fragment size. Fixation is recommended when the fragment involves more than 25% to 33% of the joint surface and when there is any posterior subluxation of the talus. Although the supination-adduction injury pattern occurs in a minority of ankle fractures, it is important to recognize because of the associated medial tibial articular impaction and the need to alter the standard orientation of the medially placed malleolar screws.

Identifying ankle fractures that may present additional treatment challenges is essential for achieving a successful outcome. A careful review of radiographs, the addition of CT, a thorough patient assessment, and detailed preoperative planning are needed to improve patient outcomes.

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