European Journal of Molecular & Clinical Medicine

ISSN 2515-8260 Volume 11 Issue 5, 2024

DOI: 10.53555/ejmcm/2024.11.05.21

ANKLE FRACTURES: A REVIEW OF CLASSIFICATION, MANAGEMENT, AND PROGNOSIS

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Abstract
Ankle fracture-dislocations are complex injuries that pose significant challenges due to their association with severe functional impairments. Representing 9% of all fractures, these injuries predominantly affect young individuals experiencing high-energy trauma and elderly patients with conditions such as diabetes and osteoporosis. Younger patients are at risk of post-traumatic osteoarthritis and functional limitations, whereas older individuals often face complications such as wound infections, fixation failure, and, in severe cases, amputation. Classification systems provide a framework for categorizing fractures based on the mechanism of injury, guiding treatment decisions. Precise anatomical reduction of the talus within the ankle mortise and fibular length restoration are critical for maintaining joint congruity and preventing long-term complications.
Management strategies vary by fracture type. Posterior malleolus fractures typically benefit from surgical fixation, improving stability and reducing syndesmosis fixation requirements, while stable fractures are often managed conservatively. This review highlights the need for individualized treatment approaches to optimize recovery and minimize complications. Continued research is essential to refine fixation techniques and enhance the prognosis for patients with these challenging injuries.

Key words: Ankle dislocation, Fracture management

Introduction

Ankle fractures are among the most prevalent lower limb injuries, accounting for approximately 9% of all fractures and representing a substantial proportion of trauma cases globally. The annual incidence of these fractures is reported to range between 107 and 184 per 100,000 individuals, with open fractures constituting about 2% of cases. These injuries typically affect two demographic groups: young males under the age of 50 and older females, with a shift in prevalence to women post-menopause. Factors such as alcohol consumption and slippery surfaces contribute to a significant number of these fractures, as do underlying conditions like diabetes mellitus and obesity, particularly in middle-aged and older adults.
The primary causes of ankle fractures include twisting injuries, falls, and sports-related trauma. These fractures often coincide with ligamentous injuries, as the pattern and severity of the fracture are closely linked to the magnitude and direction of the force exerted on the ankle joint. The ankle itself is a biomechanically complex joint, accommodating a range of movements, including dorsiflexion, plantarflexion, inversion, and eversion, while bearing substantial loads—up to 5.5 times body weight during activities like walking and running.
Management of ankle fractures requires a comprehensive understanding of the anatomy, biomechanics, and mechanisms of injury to ensure accurate diagnosis and effective treatment. These injuries may involve multiple structures, including bones, articular surfaces, ligaments, tendons, nerves, blood vessels, and even the skin, which, if compromised, can lead to further complications. Additionally, systemic conditions such as diabetes significantly increase the risk of complications, including delayed healing and infection [1].
Ankle fractures are initially evaluated through clinical examination and imaging to assess the extent of damage. This thorough evaluation aims to identify both osseous and soft tissue involvement to guide treatment decisions. While conservative treatment with closed reduction and immobilization remains an option for stable fractures, operative management is increasingly preferred, especially for displaced or unstable fractures. Surgical intervention focuses on restoring the joint's anatomical congruity to prevent malalignment, which is crucial for preserving function and avoiding long-term complications such as post-traumatic arthritis.
Given the complexity of these injuries and the wide variability in their presentation, classification systems play a critical role in guiding both diagnosis and treatment. Prognosis varies significantly depending on factors such as fracture type, associated ligamentous injuries, patient age, and comorbidities, including systemic conditions like diabetes. This review aims to introduce the anatomy of the fracture comprehensively review the classification systems, management strategies, and prognostic factors associated with ankle fractures. By integrating existing literature and current practices, it seeks to

provide a detailed understanding of the best approaches for diagnosis, treatment, and optimizing outcomes for patients with ankle fractures [2]

Anatomy of ankle fracture

Successful treatment of the ankle joint requires a comprehensive understanding of its anatomy and mechanics. The physiology is well recognised and reported in the previous literature. The osseous components include the talus, fibula, and tibia. The talus is positioned between the tibial and fibular malleoli in a structural configuration called the malleolar fork, which forms the hinge- or mortise-type junction. Between the tibia and talus forms the ankle joint's main load-bearing region. The anterior and posterior parts of the tibial plafond protrude farther out, making it curved with respect to the talar dome [3], [4].

There is a measured difference of 2.4 ± 1.3 mm between the anterior and posterior aspects of the talus, which is almost 25% broader. The distal tibia and fibula form medial and lateral gutters on each side of this congruous surface between the talar dome and tibial plafond. The anterior and posterior colliculi, which are divided by a groove, make up the medial malleolus. The deep deltoid ligament, which is attached to the posterior colliculus and interfollicular groove, serves as the main medial stabiliser, whereas the superficial deltoid ligament is attached to the anterior colliculus. Research indicates that talar stability is dependent on the deep ligament's integrity, which directs stability restoration repair techniques [5].

For distal fibula articulation, the lateral tibia has a shallow groove that accommodates the anterior tubercle and a smaller posterior tubercle. A styloid protrusion marks the end of the lateral malleolus[5], [6] Several lateral collateral ligaments offer stability: the calcaneo-fibular ligament inhibits talar tilt, the posterior talo-fibular ligament prevents posterior talar relocation, and the anterior talo-fibular ligament, which is the weakest and most prone to damage, prevents anterior talar excursions. The tibia's posterior lip, the third malleolus in trimalleolar fractures, is susceptible to rotational damage, yet it stabilises against talar dislocation posteriorly. Surgical fixation is necessary for posterior malleolar fractures that affect 25–35% of the joint surface.

The deltoid ligament and syndesmosis, which connect the distal tibia and fibula, are essential for the ankle joint's rotational stability. Most frequently, ankle fractures result in the rupture of the anterior inferior tibiofibular ligament, which runs obliquely between Wagstaff's tubercle on the lateral malleolus to Chaput's tubercle on the tibia. The interosseous membrane crosses the tibia and fibula before changing into the interosseous a ligament, and the posterior inferior tibiofibular ligament joins the posterior malleolus to Volkmann's tubercle. The talus and fibula may laterally shift due to syndesmotic injuries, which are frequently brought on by external rotation and can throw off the tibial alignment. Talar stability is supported by an undamaged deltoid ligament, which lessens the requirement for syndesmotic fixation [7].

Classification

There are several categorisation methods for ankle fractures, but the most popular ones are the Danis-Weber and Lauge-Hansen categories. These tools seek to improve clinician-to-clinician interaction, direct the choice of medication, and forecast results. The placement of the fibular fracture in relation to the ankle joint serves as the basis for the Danis-Weber categorisation, commonly referred to as the Muller AO classification:

1. **Type A (Infrasyndesmotic):** Occurs when supination and adduction pressures are applied, resulting in lateral stress that can cause a transverse fibular fracture under the joint or a rupture of the lateral collateral ligament, which may then spread to a vertical medial malleolar fracture.
2. **Type B (Transsyndesmotic):** The most prevalent kind, which is brought on by the talus rotating externally, starts with an AITFL rupture and advances to an obliquely fibular fracture, PITFL failure, and either a deltoid ligament rupture or a medial malleolar fracture.
3. **Type C (Suprasyndesmotic):** Induced by external rotation and pronation, which begins inwardly with a fracture of the medial malleolar or a rupture of the deltoid ligament. The talus then rotates, rupturing syndesmotic ligaments and resulting in a fibular fracture beyond the joint.

ORIF is frequently necessary for higher fractures, such as Dupuytren or Maisonneuve injuries. This categorisation provides useful information for treating fractures of the fibular malleoli [8].

Introduced in 1940, the Lauge-Hansen classification highlights the causes of damage and classifies ankle fractures based on cadaveric research. It lists five different kinds of fractures. Based on the imposed deforming force (adduction, abduction, or external rotation) and foot position (pronation or supination), the categorisation finds damage patterns. Seventy to seventy-five percent of fractures are supination-external rotation fractures, which are commonly observed in middle-aged women after falls and in males during sports.

1. **Supination-Adduction**
2. **Pronation-Abduction**
3. **Supination-Eversion (External Rotation)**
4. **Pronation-Eversion (External Rotation)**
5. **Pronation-Dorsiflexion (Pilon)**

The Danis-Weber classification—Supination-Adduction with Weber A, Pronation-Abduction and Supination-External Rotation with Weber B, and Pronation-External Rotation with Weber C—is in line with the Lauge-Hansen method. Although it is useful for comprehending damage processes and mitigation, it provides little prognostic advice.

The posterior portion of the ankle is where the supination-adduction injury pattern begins because of the strain caused by the foot's posture. The inversion causes supination-abduction injuries, which develop in two phases. Stage I is characterised by a Danis-Weber type A fracture, which is a transverse avulsion fracture of the distal fibula or a rupture of the lateral collateral ligaments. Since the force is transverse to the connecting ligament or tendon, the fracture is usually transverse. The medial malleolus fractures almost vertically in Stage II because of the talus moving inwardly. Avulsion-induced vertical fractures of the medial malleolus are unpredictable and can happen apart from fibular fractures.
Most ankle fractures are caused by supination-external rotation injuries, which are typified by a spiral oblique fracture of the distal fibula that extends posteriorly superior to anteriorly inferior. As the tibia moves internally, a rotational shearing force causes this fracture. There are four phases to the injury's progression: The anterior-inferior tibiofibular ligament (AITFL) ruptures in Stage I, the fibular fracture occurs in Stage II, the posterior-inferior tibiofibular ligament (PITFL) ruptures or the posterior malleolar fracture occurs in Stage III, and the deltoid ligament rupture or medial malleolus avulsion occurs in Stage IV. The spiral fibular fracture is started by the AITFL failure, and more twisting is permitted by the PITFL's integrity.
Ankle joint dislocation is more likely in supination-external rotation injuries because the tibiofibular syndesmosis is under a lot of strain. Disruption to the medial frameworks, such as medial malleolar fractures or deltoid ligament rupture, occurs in the latter stage. A hybrid lesion can occasionally arise in which the deep deltoid ligament is unharmed, but the superficial deltoid fails. Since stage II injuries may entail stage III or IV damage, necessitating surgical treatment in order to prevent long-term consequences such talar displacement and ankle arthrosis, an accurate diagnosis of the deltoid is essential.
The first step in pronation-abduction injuries is forceful abduction of the pronated foot, which puts stress on the medial collateral ligaments by forcing the talus to adduct and plantarflex. Medial malleolus fractures (stage I) or deltoid ligament rupture result from this. AITFL and PITFL rupture (stage II) and an oblique fibular rupture (stage III) with a butterfly fragment are the outcomes of prolonged force.
Considering the fracture levels of pronation-abduction and supination-external rotation injuries are similar, it might be difficult to distinguish between them. Pronation-abduction fractures, which are brought on by bending pressures on the fibula, are usually transversal, oblique, or short with lateral comminution. Supination-external rotation patterns may be similar to some of them. Medial deltoid ligament rupture, AITFL rip, high fibular fracture, and PITFL rupture are the four phases of a spiral fibular fracture that begins above the syndesmosis in pronation-external rotation traumas. Pronation-external rotation fractures and extreme supination-external rotation injuries might be confused. Isolated malleolar fractures should raise the possibility of high fibular fractures, which need for syndesmotic repair [8], [9], [10], [11].

Diagnosis

Tenderness, swelling, deformity, and an inability to support one's own weight are common symptoms of ankle fractures, which are frequently caused by torsional pressures. On the other hand, non-displaced fractures could show up with no deformity and little oedema. The injury history helps with management decisions and offers important information into the fracture process. Before and after any reductions, a complete physical examination of the ankle should involve inspecting the foot, looking for open wounds, analysing the quality of the skin, and doing neurovascular examinations. Both soft and bone tissue should be palpated, encompassing ligaments such as the anterior tibiofibular syndesmosis, calcaneofibular, anterior talofibular, posterior talofibular, and deltoid ligament complex. Both sides must be used for the range-of-motion examinations, which include dorsiflexion, plantarflexion, inversion, and eversion. Special tests that evaluate syndesmosis include the Kleiger (external rotation stress) test and the squeezing test. The talar tilt test evaluates the lateral ankle ligaments, whereas the anterior drawer test aids in the evaluation of the anterior tibiofibular ligament. These tests become more accurate 4–7 days following the accident [12], [13].
Radiological assessment is integral to the diagnosis and management of ankle fractures, particularly for evaluating fracture patterns, joint alignment, and ligamentous stability. The Ottawa ankle rules are widely recognized for their efficacy in determining the necessity for radiographs. These rules, which apply primarily to patients with skeletal maturity, stipulate that X-rays are required if there is pain in the malleolar zone along with bone tenderness at specific locations or an inability to bear weight for four steps. The rules have demonstrated high sensitivity, with studies showing a significant reduction in unnecessary radiographs and a low incidence of missed fractures, especially in children and adults.
The standard radiographic protocol for evaluating suspected ankle fractures includes three views: anteroposterior (AP), mortise, and lateral. These views provide comprehensive insight into the ankle joint, allowing for the identification of fractures, talar subluxations or dislocations, and malalignment.
The AP view is obtained with the patient in a supine position, with the foot in a neutral position and the heel resting on the cassette. The X-ray beam is directed centrally to the midpoint of the malleoli. This view is essential for visualizing the medial and lateral malleoli, the anterolateral tibia, and the proximal fibula, as well as assessing the tibiofibular clear space. The tibiofibular overlap on the AP view is a critical indicator of correct syndesmotic alignment. Normal tibiofibular clear space should measure less than 5 mm, and the anterior tibial tubercle should overlap the fibula by at least 6 mm or 42% of the fibular width. Incongruency of the Shenton line, drawn from the Wagstaffe tubercle of the fibula to the medial malleolus, suggests fibular shortening, which is important for evaluating fracture severity.
The lateral view involves placing the lateral border of the foot against the cassette with the ankle in slight dorsiflexion. The lateral view is crucial for identifying fibular fractures, posterior tibial tuberosity fractures, and any anterior or posterior

displacement of the talus. The alignment of the talus under the tibial plafond is evaluated for articular congruity. Misalignment in this area can indicate significant disruption of the ankle joint mechanics.

The mortise view is obtained by internally rotating the leg 15-20 degrees, dorsiflexing the ankle, and centering the X-ray beam on the intermalleolar line. This view is valuable for evaluating talar shift, fibular length, talocrural angle, and the tibiofibular clear space. The medial clear space, which measures the distance between the medial malleolar articular surface and the medial edge of the talus, should normally be 4 mm. Any widening of this space suggests syndesmotic injury or fracture. The talocrural angle, which is the angle between a line parallel to the tibial plafond and a line connecting the tips of the malleoli, should normally be between 4 and 11 degrees. Any abnormality in the angle may indicate fibular shortening or misalignment.

Additional radiographic views, such as oblique and stress views, may be utilized when necessary. Oblique views provide supplemental information regarding the lateral and medial malleoli, the ankle mortise, and the talar dome. Internal oblique views give more detailed insights into the lateral malleolus, while external oblique views focus on the medial malleolus. These additional views can enhance the evaluation of fracture patterns and alignment.

Stress views are particularly useful for assessing ligamentous integrity and joint stability, especially in cases of suspected syndesmotic injuries. In a stress view, the ankle is stressed into supination and external rotation, and radiographs are taken. The external rotation stress view is especially useful for assessing the stability of the syndesmotic complex and deep deltoid ligament. A normal response is a minimal difference in the superior clear space between the medial and lateral sides of the joint, typically less than 2 mm. A larger difference indicates instability or injury to the syndesmosis.

While CT and MRI are not routinely used for all ankle fractures, they are valuable for specific indications. CT scans are employed to better define complex fracture patterns, such as pilon or triplanar fractures, which are challenging to assess through conventional radiography. MRI is particularly beneficial for evaluating soft tissue injuries, including ligament tears and occult injuries to the talar dome. MRI also plays a crucial role in assessing the extent of syndesmotic injuries, providing more accurate information than standard radiographs. In cases of Salter-Harris fractures in children, MRI can also detect additional soft tissue or growth plate injuries. Furthermore, ultrasound imaging can assist in detecting ligament injuries in cases of inversion sprains, although its accuracy is highly dependent on the operator's expertise. Bone scintigraphy may also be used to detect occult fractures, particularly in the talar dome, where radiographs may not reveal all injuries.

In cases of suspected syndesmotic injury, advanced imaging modalities like MRI are more precise than radiographs in assessing the degree of injury and the appropriate treatment. Syndesmotic injury often correlates with specific fracture types as outlined by the Lauge-Hansen classification, and MRI findings help determine the fracture stage and guide therapeutic interventions [14].

Management of Ankle Fractures

Effective management of ankle fractures begins with addressing pain, which is tailored to the severity of discomfort. Mild pain can be managed with oral paracetamol, while moderate pain may require a combination of oral paracetamol and codeine. Severe pain warrants the use of intravenous paracetamol and titrated intravenous morphine. In elderly patients, special caution is necessary when using opioids to avoid complications. Non-steroidal anti-inflammatory drugs are generally avoided to reduce the risk of gastrointestinal, renal, or cardiovascular complications, which are more prevalent in this population. Prompt reduction and stabilization are critical for fractures presenting with visible deformities. These steps are necessary not only to alleviate pain but also to minimize swelling and reduce the risk of skin complications, such as pressure necrosis. If performing radiographs would cause undue delay, immediate reduction should take precedence. Post-reduction, it is essential to reassess and document the neurovascular status to ensure that blood flow and nerve function remain intact. The fracture should then be immobilized using a well-fitted backslab cast or splint, and the limb should be elevated to control swelling. To confirm proper alignment, a post-reduction X-ray is mandatory and should be reviewed meticulously [15].

Open fractures demand urgent care as they carry a higher risk of infection and other complications. The initial step involves removing visible contaminants from the wound and documenting the injury with photography for medico-legal purposes. A sterile saline-soaked dressing should be applied to the wound and loosely wrapped with an occlusive film to protect it until surgical debridement can be performed. Intravenous antibiotics should be administered promptly, ideally within the first hour of injury, to minimize the risk of infection. The timing of surgical debridement depends on the level of contamination. Highly contaminated wounds require immediate debridement, while high-energy fractures should be debrided within 12 hours. For less severe cases, surgical intervention should occur within 24 hours. Definitive fixation and soft tissue coverage, if needed, should be carried out in the same surgical procedure when possible. In cases where a staged approach is necessary, definitive measures should be completed within 72 hours [16].

Once the initial treatment has been performed, the injured ankle should remain immobilized with a splint. Further management depends on the stability of the fracture and the patient's overall health status. Stable fractures, or cases where surgery is contraindicated due to significant comorbidities, are generally managed conservatively. This involves realigning the fractured bone segments to restore anatomical alignment, followed by immobilization in a short-leg cast, splint, or walker boot for at least six weeks.

Conservative management has particular relevance in older patients, especially those over the age of 60. For these individuals, close contact casting offers a practical alternative to surgery. This technique maintains fracture reduction while avoiding the risks associated with surgical intervention, which can be significant in patients with poor bone and soft tissue quality. However, the success of conservative management relies heavily on careful monitoring to ensure that the fracture alignment is maintained throughout the healing period [17]. Despite its advantages, conservative management is not without risks. Prolonged immobilization can lead to complications such as muscle atrophy, joint stiffness, and cartilage degeneration due to disuse. Additionally, there is a risk of secondary displacement, particularly in fractures that are inherently unstable. In such cases, conservative management may need to be abandoned in favor of surgical intervention. Surgical management is typically reserved for unstable or displaced fractures, where conservative measures are unlikely to succeed. The primary objective of surgery is to restore anatomical alignment and ensure the mechanical stability of the ankle joint. This is achieved through various fixation techniques, including internal fixation with plates, screws, tension band wiring, or external fixation systems. Surgical stabilization is particularly important for high-energy fractures, such as pilon fractures involving the distal tibial articular surface, where temporary external fixation may be employed initially to allow swelling to subside before definitive surgery is performed [18]. The benefits of surgical intervention include the potential for early stabilization and functional recovery. By securing the fractured components, surgery minimizes the risk of deformity, malalignment, malunion, or non-union, which are common complications in inadequately treated fractures. Early mobilization post-surgery can reduce the time required to return to normal activities and decrease the indirect healthcare costs associated with prolonged rehabilitation [19].

However, surgery is not without its drawbacks. Inherent risks include wound infection, pulmonary embolism, hardware failure, and complications necessitating reoperation. Long-term complications such as post-traumatic arthrosis, secondary displacement, and implant-related issues can also occur. In elderly patients, particularly those with osteoporosis, surgery may be less favourable due to diminished bone quality, which increases the risk of fixation failure. Additionally, the ability to safely initiate early weight-bearing is often compromised in this population, requiring a more cautious approach to postoperative rehabilitation. The decision to pursue surgical intervention must also consider the patient's overall health status. In cases where the risks of surgery outweigh the potential benefits, conservative management remains a viable alternative. For example, certain types of fractures, including bi- and trimalleolar fractures, can be successfully managed non-operatively if initial anatomical alignment is achieved and maintained. Evidence from studies, such as those conducted by Wei et al., supports the non-operative management of such fractures under strict follow-up protocols [20].

[21]. The management of ankle fractures is a multifaceted process that requires careful consideration of pain control, fracture stability, patient-specific factors, and potential complications associated with different treatment modalities. Whether managed conservatively or surgically, the primary goals are to achieve anatomical alignment, ensure stable fixation, and facilitate early mobilization to optimize functional outcomes. Rigorous follow-up and adherence to rehabilitation protocols are essential components of care to maximize the likelihood of successful recovery [22].

Surgical treatment

Maintaining fibula length and preserving anatomical reduction are the major goals of surgical therapy for ankle fractures. The main objectives for open ankle fracture-dislocations are to prevent infection, lessen complications, encourage bone repair, and restore functionality. Skin necrosis (18%) and deep infection (17%) are the most frequent side effects. Ankle architecture should be restored using strong internal fixation; if the soft tissue is unable to sufficiently cover the internal fixation, external fixation may be explored. If there is no tension, Grade I wounds can be closed; Grade II wounds must be treated either later or after the infection has been ruled out; and Grade III wounds require flap repair or skin grafting.

Ankle fracture-dislocations frequently result in syndesmotic complications, these must be treated since they can cause osteoarthritis and long-term disability. The main goal should be to restore syndesmotic stability, even if deltoid ligament restoration might enhance early healing and pain ratings. The gold standard for treating syndesmotic injuries is the insertion of syndesmosis screws, which are normally positioned 2-3 cm above the articular surface and at an angle of around 20° anteromedially. Since extended fixation may result in issues such screw fracture or loss of mobility, the best time to remove screws is still up for debate.

Bioresorbable screws and suture-button fixation have become viable substitutes for conventional syndesmotic screws. According to meta-analyses, screw and suture-button fixation had comparable functional results and postoperative problems. Bioresorbable screws are not advised, nonetheless, because to their increased risk of complications. An additional option that can enhance clinical results by lowering complications and the chance of reoperation is the use of dynamic fixation devices.

Deltoid ligament damage is frequent in ankle fracture-dislocations; research indicates that deltoid rupture accounts for 39.5 percent of acute fractures and medial triangular ligament damage for 58.1 percent. Ankle instability, chronic medial discomfort, and early arthritis can all be caused by non-anatomic repair of the deltoid ligament. Suture anchors are usually used in the medial ankle to fix the superficial and deep deltoid ligaments during surgical repair. However, some research indicates that if fibular architecture is appropriately restored, scar healing may lead to functional ligament regeneration, negating the need for deltoid restoration. Nevertheless, other research indicates that deltoid ligament restoration improves functional ratings and discomfort.

Despite the insertion of syndesmosis screws continues to be the norm for syndesmotic complications, several randomised trials have shown that inferior tibiofibular screws are not required in fractures of the supination-external rotation type [23].

Prognosis

Ankle fracture-dislocations, especially those caused by high-energy trauma, are associated with increased severity of complications. These injuries often lead to more significant damage to the bony and soft-tissue structures of the ankle joint, which can result in poor long-term functional outcomes. A significant factor influencing the prognosis of these fractures is the presence of dislocation, which complicates the healing process and increases the risk of chronic issues such as joint instability, arthritis, and persistent pain.

In ankle fractures, dislocations, particularly those involving SER IV (supination-external rotation) and PER IV (pronation-external rotation) injuries, have been shown to result in worse radiographic and functional outcomes. The dislocation often leads to higher energy damage to the ankle joint, causing malreduction of the articular surfaces and misalignment of the bones. This misalignment can contribute to long-term joint instability and chronic pain, which significantly hampers the recovery of normal function. Dislocations are particularly concerning because they often result in additional soft tissue damage, including ligament tears and cartilage injury, both of which contribute to the overall dysfunction of the joint.

Talar cartilage injury is one of the most common complications associated with ankle fracture-dislocations. The talus, which is an essential weight-bearing bone in the ankle joint, can suffer significant damage during the dislocation. This damage is often associated with the development of post-traumatic arthritis, which is more prevalent in older individuals. As the talar cartilage is critical for smooth joint movement, any injury to this structure can result in reduced joint mobility and increased wear over time. This can eventually lead to arthritis, a condition that severely limits joint function and can be debilitating for the patient.

The prognosis for patients with ankle fracture-dislocations is generally poor, particularly for those who experience dislocations. A study analyzing the functional outcomes of these fractures found that patients with dislocations were more likely to develop reflex sympathetic dystrophy (RSD), a painful condition caused by dysfunction in the sympathetic nervous system. RSD can result in chronic pain, swelling, and stiffness, further delaying recovery and complicating rehabilitation. Furthermore, patients with dislocations have a higher risk of developing other long-term complications, such as persistent joint instability. This instability is caused by the disruption of the ligaments and the joint capsule, which are responsible for stabilizing the ankle during movement. Once these structures are damaged, the ankle is more prone to further injury and dysfunction.

Despite the increased incidence of complications, some studies suggest that the functional outcomes for dislocated ankle fractures may not be worse in the mid-term. In a retrospective study examining the functional outcomes of dislocations according to the Lauge-Hansen classification, researchers found that although functional outcomes were worse for patients with dislocations, they did not continue to worsen in the mid-term. However, the likelihood of developing RSD remained higher in dislocated fractures, indicating that the early stages of recovery may be more complicated in these cases.

Furthermore, even in fractures without dislocations, ankle injuries that involve syndesmotic disruption or other ligamentous injuries can result in poor functional outcomes. The integrity of the syndesmosis, the fibrous joint that holds the tibia and fibula together, is essential for maintaining stability during weight-bearing activities. When the syndesmosis is damaged, it can lead to chronic instability, increased risk of further injury, and, eventually, osteoarthritis. This highlights the importance of proper reduction and fixation in preventing long-term joint dysfunction. In addition to these complications, patients with ankle fracture-dislocations are at a higher risk for malunion or non-union of the fractured bones, which can further complicate recovery. A study on the long-term outcomes of these fractures found that patients with severe dislocations particularly in the articular surface of the tibia or fibula. This misalignment can lead to abnormal stress on the joint, which in turn contributes to the development of arthritis and long-term functional impairment.

Overall, the presence of dislocation in ankle fractures, especially those caused by high-energy trauma, is a significant predictor of poor long-term outcomes. The damage to both the bone and soft tissue structures can lead to chronic pain, joint instability, arthritis, and impaired function, all of which complicate the recovery process. The severity of the injury and the associated complications require careful management to restore proper joint alignment, promote healing, and minimize the risk of long-term disability. Further research is needed to better understand the full spectrum of complications and to improve treatment protocols to optimize functional recovery for these patients [24].

Conclusion

Ankle fractures present significant treatment challenges requiring a thorough understanding of the injury mechanism, precise anatomical restoration, and appropriate fixation methods. Restoring fibular alignment and length is crucial for talar stability, with careful attention to the medial ankle and deltoid ligament integrity. Non-operative treatment, including immobilization, can be effective if anatomical reduction is maintained but carries risks such as muscle atrophy, joint stiffness, and cartilage degeneration. Surgical intervention, particularly open reduction and internal fixation, aims to restore normal anatomy and provide immediate stability to enable early mobilization, though it carries risks of complications like infection, implant failure, and peroneal tendon lesions, especially with posterior non-locking plates. Surgical fixation generally yields better outcomes than conservative treatment, especially in preventing post-traumatic arthritis. However, further research is needed to evaluate fixation techniques, long-term clinical outcomes, and complications to optimize treatment protocols and improve patient recovery.

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