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REVIEW ARTICLE

Addressing Controversies in the Management of Ankle Fractures

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ABSTRACT

Ankle fractures account for approximately 10% of all fractures and are among the most common orthopedic injuries treated surgically. The incidence of these injuries has increased significantly in the last decade, particularly in the elderly population. Regardless of the method of intervention, the primary goal is restoration of normal anatomy to achieve normal biomechanics, painless function, and prevent long-term posttraumatic degeneration. Surgical treatment carries a potential risk of complications, such as nonunion, implant failure, and soft tissue-related complications. Despite the invention of novel devices, surgical techniques and biomechanical studies for restoration and maintenance of the congruent ankle joint following ankle fractures, several aspects of management of these injuries still remain controversial. The aim of this article is to address these controversies based on the available evidence base.

Keywords: Ankle fracture, Posterior malleolus, Stress views of ankle, Syndesmotic injury, Tightrope.

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INTRODUCTION

Ankle fractures account for approximately 10% of all fractures and are among the most common orthopedic injuries treated surgically.[1] They have bimodal age distribution with peaks in young males and elderly females.[2] The incidence of these injuries has increased significantly in the last decade, particularly in the elderly population.[3] Ankle fractures should be considered as joint fractures even in the absence of fracture cleft in any of the articular surfaces. The usual mechanism of injury is a rotational force to the ankle. The mechanism of injury is highlighted in different classification systems, including that of Weber[4] and Lauge–Hansen,[5] the two most common systems in use. It is, however, not entirely clear whether the severity of ankle fractures, based on these classification systems, predicts the outcome of these injuries.[6-8] Regardless of the method of intervention, the primary goal is restoration of normal anatomy to achieve normal biomechanics, painless function, and prevent long-term posttraumatic degeneration. Surgical treatment carries a potential risk of complications, such as nonunion, implant failure, and soft tissue-related complications.[9] These may be caused by surgical factors, fracture pattern, severity of injury, and patient characteristics.[10] The surgical factors include patient selection, timing of surgery, surgical approaches, type of implant, and appropriate rehabilitation program.

Despite the invention of novel devices, surgical techniques and biomechanical studies for restoration and maintenance of the congruent ankle joint following ankle fractures, several aspects of management of these injuries still remain controversial. The aim of this article is to address these controversies based on the available evidence base.

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When is the Best Time to Operate?

Swelling of the skin (Fig. 1) and surrounding soft tissue after ankle fracture can pose a significant challenge to the timing of definitive surgical treatment.[9,10] Avoiding wound complications is of paramount importance and must be considered a high priority.[9] A significant risk

Fig. 1: Severely swollen ankle fracture with ecchymosis of the medial side

Table 1: Studies demonstrating the influence of delayed surgery on wound-related complications

Study	*Early fixation wound complications*	*Late fixation wound complications*	*Recommendation for fixation (time to surgery)*
Schepers et al[9]	<24 hrs–4%	>24 hrs–13%	Early
Carragee et al[12]	<24 hrs–5%	>1 week–44%	Early
Hoiness et al[11]	<24 hrs–3%	>24 hrs–18%	Early
Breederveld et al[15]	<24 hrs	5-8 days	Early or late
Konrath et al[16]	<5 days	>5 days	Early or late
Miller et al[17]	<5 days	>5 days–4%	Early or late

of wound-related complications, such as surgical site infection was noted when surgery was delayed 1 week or more.[11] More importantly, this can lead to poor functional outcome.[10] When treated early, an improved quality of anatomical reduction can be achieved.[12] Immediate, definitive surgery is possible only if the soft tissues are not critically injured or extremely vulnerable, usually within first 24 hours after initial trauma.[9,10]

If a delay is contemplated in the definitive management due to excessive swelling, the fracture position should be closely monitored both clinically and radiologically.[13] In cases of trimalleolar or unstable bimalleolar fractures, where a stable reduction cannot be maintained by the plaster, an external fixator should be applied, as loss of reduction will lead to further soft tissue complications.[14] A recent systematic review demonstrated a significant difference in infectious wound complications for patients who underwent surgery after a delay for a closed ankle fracture.[9,11,12,15-17] Published data regarding the influence of delayed surgery on the outcome or soft tissue-related complication are limited (Table 1).

Fracture Blisters

The incidence of fracture blisters in ankle fractures has been reported to be as high as 7%.[18,19] Blisters have significant impact on decision-making in both nonoperative and operative management. Fracture blisters are thought to be the result of a cleavage injury at the junction of dermis and epidermis. Such superficial shearing injuries are called fracture blisters.[20] Anatomical areas, such as the ankle, with poor muscle and adipose tissue cover are especially prone.[18] These blisters can appear as clear or hemorrhagic (sanguineous) blisters (Fig. 2). Clear blisters lie completely within the epidermis, whereas the hemorrhagic type often extends deeper into the dermis, compromising the crossing microcirculation.[21] While some studies support the view that allowing the blisters to resolve before any surgical intervention is desirable,[18,19] others have validated a treatment protocol for unroofing the blister surface and application of sliver sulfadiazine antibiotic cream until the swelling of skin permits surgery

Fig. 2: Hemorrhagic fracture blisters in a patient with a high-energy injury closed ankle fracture

and the blister appeared re-epithelialized, on average after 7 days.[22] There is no clear consensus on how best to manage ankle fractures with associated blisters. The presence of blisters, particularly the hemorrhagic ones, indicates significant injury to the soft tissues and alternative strategies, such as different surgical approaches, use of minimally invasive techniques, or staged fixation to achieve as near anatomic reduction of the ankle mortise should be adopted to allow adequate resuscitation of traumatized soft tissue envelope.

Stability in Isolated Lateral Malleolar Fractures

Almost 70% of ankle fractures are stable.[3] Stable ankle fractures will not displace on physiological axial loading when deep deltoid ligament is functionally intact, by providing checkrein and maintaining further stability.[23] A 1-mm lateral talar shift is known to decrease the contact area between talus and tibia by 42%. Incongruity of joint surfaces predisposes to an irreversible condition, such as posttraumatic osteoarthritis.[24] Historically, any fibular displacement was thought to cause talar displacement or shift.[25] Two studies have shown that in isolated lateral malleolar fractures, a functionally intact deep deltoid ligament acts as checkrein and prevents lateral talar or mortise displacement, providing further stability and normal ankle anatomy even during weight-bearing.[26,27] They also stated that apparent fibular displacement is often misleading.

Current practice relies upon different clinical and radiological methods to identify stable isolated lateral malleolar fractures and help dictate an appropriate treatment strategy. These are categorized based on clinical or radiological findings. Medial tenderness, ecchymosis, or swelling has been used clinically to delineate a potential injury of the deltoid ligament, suggesting an unstable morphology.[28,29] A systematic review of the literature

Fig. 3: Gravity stress test; positioning of a patient and C-arm "X-ray" machine

Fig. 4: Manual external rotation test

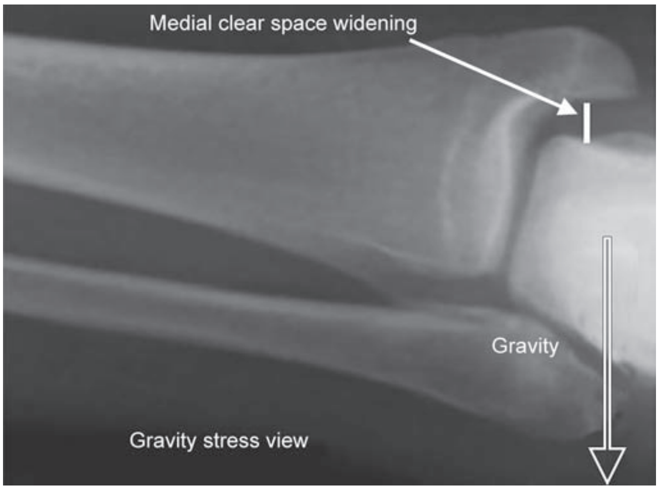


Fig. 5: Anteroposterior X-rays demonstrating Weber B fracture of the ankle and widening of medial clear space of > 5 mm indicating deltoid ligament injury (positive gravity stress test)

looking at diagnostic modalities to assess the integrity of the deltoid ligament in adult ankle fractures (supination external rotation injuries) concluded that clinical signs, such as swelling and ecchymosis on medial side with associated tenderness, initial radiographic findings, and the Lauge–Hansen classification systems are poor predictors of deltoid ligament injury and ankle stability.[30]

Stress X-ray is considered the gold standard to identify stable or unstable ankle fractures (Figs 3 to 5). Manual and the gravity external rotation tests are two most common ways to perform stress X-rays.[66] Medial clear space widening of more than 5 mm is regarded as a reliable indicator of unstable ankle fracture. Both tests have proven to be effective.[31] However, the amount of force applied when performing an external rotation stress radiograph (dynamic test) is not well defined and purely determined by the patient's pain level and assessor's familiarity with the procedure. Manual stress test requires more time and radiation exposure, whereas gravity stress test necessitates X-ray education.

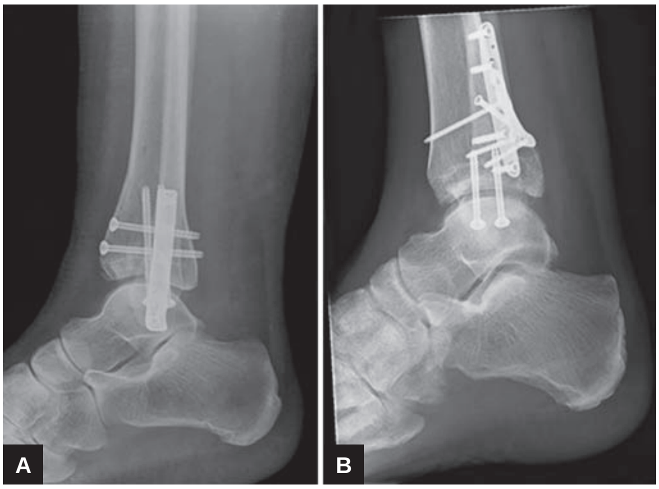
Does an Abnormal Stress Test equate to Surgery?

Based on magnetic resonance imaging (MRI) studies, 90% of patients with positive stress radiographs have partial tear of deep deltoid ligament. These fractures can heal without surgical intervention as long as they are reduced adequately and immobilized.[31,32] Stress radiographs can overestimate the need for surgery.[33,34] If in doubt, clinician is suggested to obtain standing radiographs to differentiate between stable and unstable ankle.[35] About 89 to 100% of patients with abnormal stress X-rays were eventually stable on standing radiographs.[33,35]

The indication for surgery should not be based on the absolute value of one parameter, but on the combination of several measures. Close monitoring/follow-up is essential if nonoperative treatment is chosen despite a positive stress test, because subluxation or displacement of the ankle joint is still possible. The MRI can be useful in individual cases.[33]

Posterior Malleolus Fractures: Need for Preoperative Computed Tomography and Which Approach to fix?

The prevalence of posterior malleolar injury in ankle fractures has been reported to be as high as 44%. The functional outcome following ankle fractures with posterior malleolar fragment is often not satisfactory,[36] particularly when associated with syndesmotic injury. Operative management continues to be controversial. Morphology of fracture has received far less consideration in common fracture classification systems and treatment algorithms. The fracture lines associated with posterior malleolar fractures are variable.[36] The common fracture patterns are categorized into three types: (1) The posterolateral-oblique type (67%), (2) the medial-extension type (19%), and (3) the



Figs 6A and B: Postoperative lateral X-rays demonstrating fixation of posterior malleolus fracture using (a) anteroposterior cannulated screw, and (b) plate and screws through posterior approach

Fig. 7: Mortise view radiograph of an ankle fracture with syndesmotic disruption

small-shell type (14%).[36] Knowledge of this pathoanatomy and careful scrutiny of the preoperative imaging are essential for approaching these fractures. Preoperative computed tomography (CT) is useful to delineate anatomy of the fracture, presence of comminution, impaction of the fragment, and to plan the approach.[36,37]

Traditionally, the decision to fix posterior malleolus has been based upon the amount of articular surface involved. Other factors to consider are a posterior subluxation of the talus, an articular step-off of more than 2 mm, instability after fibular fixation, or residual syndesmotic widening or malreduced mortise. A prospective study with long-term follow-up period has demonstrated fair-to-good outcomes when fracture fragment is involved less than 25% of articular surfaces and managed nonoperatively.[38]

Two most common ways to fix posterior malleolus fixation are anteroposterior (AP) or posteroanterior. There is controversy with regard to screw fixation *vs* plating (Fig. 6) via posterior approach.[38,39]

It has been shown that when posterior malleolus is fractured, posterior syndesmotic ligaments are intact and attached to the fragment.[39] In a cadaveric study assessing the biomechanics of syndesmosis after internal fixation of the posterior malleolus, 70% of syndesmotic stability could be established in contrast to restoration of 40% by fixing the syndesmosis alone.[39] It is important to ensure that posterior fragment is well reduced and there is no subluxation of the ankle joint once medial and/or lateral malleoli are stabilized.[40] A prospective study has shown a significant difference in outcomes comparing patients with unstable ankle fractures associated with or without posterior malleolus fracture (fixed or not fixed). The presence of posterior malleolus fracture indicates high-energy trauma and seems to result in worse outcomes at 1 year after intervention.[41]

Syndesmotic Injuries: To fix or Not to fix?

Over 90% of the total resistance to lateral displacement of the fibula is provided by the three syndesmotic ligaments, and injury to one or more of them results in weakening, abnormal movement of the joint, and instability (Fig. 7). Although many mechanisms for syndesmotic injury have been reported, the most common is external rotation of the foot and, to a lesser extent, forced dorsiflexion of the ankle with axial loading. In most complete syndesmotic disruptions, external rotation causes a Weber C or Weber B fracture with widening of the mortise and, occasionally, a Maisonneuve fracture.[42]

In up to 13% of all ankle fractures, and in 20% of patients requiring internal fixation, there will be an associated injury to the syndesmosis. These injuries can create a diagnostic challenge and there is a lack of consensus on optimal method of treatment. There are controversies with regard to the type of fixation device (screw *vs* TightRope®), characteristics and position of the screw, the type of cortical fixation, number of screws, and whether the screw should be retained or removed prior to weight-bearing. It remains unclear whether these technical aspects of surgery affect the clinical outcome.[43]

How to assess Syndesmotic Injuries?

Tibiofibular clear space and overlap (Fig. 8) are used as a common radiological assessment when suspecting syndesmosis disruption. A normal tibiofibular clear space is defined as a distance between the lateral border of the posterior tubercle and the medial border of the fibula.[42] The tibiofibular overlap is the distance between the medial border of the fibula and the lateral border of the anterior distal tibial tubercle.[42] These are measured at 1 cm proximal to the ankle joint.[44] A normal tibiofibular clear space should be less than 6 mm on both AP or

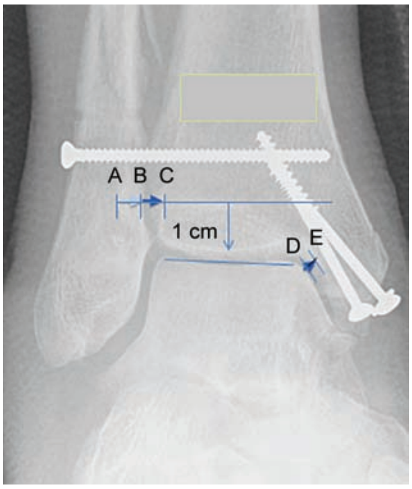


Fig. 8: Mortise view X-ray of ankle illustrating radiological parameters for assessment of syndesmosis: (A and B) tibiofibular overlap (N > 6 mm); (B and C) tibiofibular clear space (N < 6 mm); and (D and E) medial clear space (N < 5 mm)

Fig. 9: Anteroposterior X-ray of ankle demonstrating assessment of syndesmosis intra operatively using "Hook test"

mortise views, whereas tibiofibular overlap of >6 mm on the AP view or >1 mm on the mortise view suggest an intact syndesmosis.[42,44] However, these indices for confirmation of syndesmosis disruption could not detect externally rotated malreduction of syndesmosis of up to 30°.[45] The position of the ankle greatly influenced these measurements, and some authors believe there are no optimal radiological parameters to assess the integrity of the syndesmosis.[46-48] Although CT scan has been considered more sensitive than plain radiographs to detect syndesmotic injuries, MRI has become the modality of choice to delineate the syndesmotic integrity.[49] However, MRI has not been considered as a routine modality of investigation due to its cost-implications.[50]

How to assess Syndesmotic Stability during Operation?

Many orthopedic surgeons evaluate the need for syndesmotic fixation intraoperatively by pulling laterally on the fibula with a bone hook (Fig. 9). Widening of the syndesmosis by more than 2 mm on the mortise view suggests the need for fixation. Despite being a popular diagnostic tool, the "hook test" is poorly described in the literature and can be difficult to interpret.[51] Candal-Couto et al[52] assessed the reliability of this test in a cadaver model by sequentially dividing the ligaments of the syndesmosis and finally the deltoid ligament. They showed that the AP and mortise views correlated poorly with the observed clinical syndesmotic injury.[52] However, performing the hook test in the sagittal plane (the sagittal-shift test) appeared to be a more sensitive assessment of inferior tibiofibular instability.[52] Similarly, fluoroscopic examination following the application of an external rotation stress has been shown to demonstrate syndesmotic instability.[53] However, there is no consensus on how much force is needed to accurately identify the potential pathology.[42] Some authors suggest that arthroscopy is required for the accurate diagnosis of syndesmotic disruption.[49] Damage to the tibiofibular syndesmosis can be diagnosed accurately in 100% of cases by arthroscopy of the ankle, compared with only 48% by AP radiography, 64% by mortise views, and 96% with MRI.[43,50]

Which Device to use to fix Syndesmotic Injuries?

Most surgeons advocate the use of metal screws for stabilization of the syndesmosis, but opinions vary with regard to the characteristics of the procedure or type of the device.[42]

Randomized studies comparing metal and bioabsorbable screws have demonstrated that both techniques are equally effective in fixation of a syndesmotic disruption, with patients more likely to return to their previous level of activity when treated with a bioabsorbable rather than a metal screw.[54] However, concerns about the use of bioabsorbable materials include osteolysis, foreign body reaction, late inflammatory reaction, and osteoarthritis due to polymer debris entering the joint.[55,56] TightRopes® may be used with placement of a heavy suture, which is looped and tightened through cortical button anchors on either side of the ankle.[57] TightRope® has shown similar outcome, but quicker time to recovery or return to work based on a systematic review of the literature.[58] A recent randomized controlled trial (RCT) has concluded that dynamic fixation with TightRope® appears to result in better functional and radiological outcomes in acute ankle syndesmotic rupture. They also demonstrated that TightRope® offers good stabilization without failure or loss of reduction and subsequently the reoperation rate was significantly lower than the conventional metallic screw fixation.[59]

Regardless of the method of fixation, patients who required syndesmotic fixation in addition to their malleolar fracture stabilization showed poorer outcome at 12 months. This information is important for patient counseling and managing their expectation regarding recovery and regaining function after injury.[40]

Retain or remove the Syndesmotic Screw?

There is no consensus whether syndesmotic screw should be removed prior to weight-bearing or left in place indefinitely. Fixation with a screw provides rigid fixation of the distal tibiofibular joint where physiological micromovement has been shown to occur.[47,60] Therefore, leaving it in place may contribute to abnormal ankle movement, which, in turn, may result in loosening or fatigue fracture of the screw.[61,62]

In a literature review conducted by Schepers et al,[43] limited level I studies were available on the absolute requirement for removal of the syndesmotic screw. Most included studies found no difference in functional outcome between retained and removed metalwork. Removal of syndesmotic screws is usually not performed before 4 to 6 months.

A comparative study by Stuart and Panchbhavi,[63] evaluating 137 syndesmotic fixation using 3.5 *vs* 4.5 mm screws, demonstrated no difference in loss of reduction, but 3.5-mm screws were more likely to break.

Postoperative Rehabilitation: Early Mobilization *vs* Plaster Cast

In a literature review of 31 RCTs concerning rehabilitation of ankle fractures, common complications elucidated included pain, stiffness, weakness, and swelling.[64] All these are recognized as barriers to overcome for successful rehabilitation. Evidence is lacking regarding intervention following conservative management, with more evidence available on interventions following surgery.[13] A prospective RCT recruiting 100 patients after ankle surgery (open reduction and internal fixation) compared an immobilizing cast with a functional ankle brace. Results showed that functional outcome was similar at 2 years follow-up although brace carried higher risk of wound complications.[65]

A combination of early mobilization, early commencement of weight-bearing, and the use of a removable immobilzation device, in conjunction with exercise showed a positive effect on ankle range of motion.[64] A systematic review identified an increased risk of wound complications when ankle was mobilized early, but patients returned to activity or work quicker. It was observed that patients' compliance is a predisposing factor along with skin condition or other comorbidities (e.g., peripheral vascular disease, diabetes). It is important to consider patient factors, particularly their ability to correctly apply and use a temporary immobilization device and their compliance with directed exercise regimes, as these variables can influence overall effectiveness of the intervention.[13,64,65]

CONCLUSION

Although ankle fracture is a common injury, there are still controversies with regard to its optimum management. It is imperative to understand basic biomechanics, pattern, and mechanism of injury. Early intervention to achieve anatomical reduction and stabilize the fracture is recommended. If possible, the fractures should preferably be fixed definitively within the first 24 hours. A delay of more than 1 week gives a significant rise in surgical-related complication, particularly wound infections, which lowers functional outcome and patient satisfaction. Diagnostic tests and management of syndesmotic injuries are still controversial, but sagittal plane instability should be recognized in addition to coronal plane. Associated syndesmostic injury and posterior malleolus fracture lead to poor functional outcome and patients should be counseled appropriately. Early mobilization after primary surgery leads to quicker recovery and early return to work, but may carry higher risk of wound-related complications.

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