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Repair of syndesmosis injury in ankle fractures: Current state of the art

May Fong Mak[1]
Richard Stern[2]
Mathieu Assal[2]

- Conventional treatment of syndesmosis injuries in rotationally unstable ankle fractures is associated with an unacceptably high rate of malreduction, and this has led to a paradigm shift in the approach to a newer concept of anatomical repair.
- In the anatomical approach, the principle is to 'directly fix what is broken and repair what is torn'. The approach is effective in reducing the rate of syndesmosis malreduction, increasing the biomechanical strength of syndesmosis fixation and avoiding the need for trans-syndesmotic fixation and its secondary removal.
- The objective of this review article is to compare the conventional treatment of these injuries (accepted usage, general consent, traditional, generally accepted) with a newer anatomical approach to be considered as a shift in thinking.

Keywords: ankle fracture; anatomical approach; current conventional treatment; syndesmosis injury; syndesmosis repair; posterior malleolar fracture

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Introduction

The operative goal in the treatment of ankle fractures is well established: to restore anatomy and stability for early movement and full functional recovery, and prevent post-traumatic arthritis. However, the surgical approach specifically pertaining to the management of distal syndesmosis injuries in rotationally unstable ankle fractures continues to evolve. This is due to the realization that the rate of syndesmosis malreduction has been unacceptably high in the past. The conventional reduction technique in use for decades – utilizing a large pointed reduction forceps – most likely forces the fibula out of the incisura, leading to iatrogenic malreduction. Attempts to avoid this problem by open reduction of the syndesmosis have not been uniformly successful. This has led to a paradigm shift in approach to these injuries, from conventional to a newer concept of anatomical repair. The objective of this review article is to compare the conventional treatment of these injuries (accepted usage, general consent, traditional, generally believed) with a newer anatomical approach, to be considered as a shift in thinking.

Conventional approach

The rotationally unstable ankle fracture is common. It typically consists of osseous and ligamentous disruptions, namely, fracture of the lateral malleolus, fracture of the medial malleolus or deltoid ligament rupture and disruption of the distal tibiofibular syndesmosis. The latter occurs either through fractures of the posterior malleolus or Chaput tubercle or rupture of the syndesmotic ligaments (posterior inferior tibiofibular ligament [PITFL], anterior inferior tibiofibular ligament [AITFL], interosseous ligament and interosseous membrane). It is crucial to reduce anatomically and fix the syndesmosis ring to avoid the potential sequelae of instability, chronic pain, and arthritis seen following syndesmosis mismanagement.[1,2] Accurate syndesmosis fixation is a predictor of good functional outcomes in ankle fractures.[3-5]

In the conventional approach, open anatomical reduction and stable internal fixation of the lateral and medial malleoli are first performed. This is normally followed by an intraoperative Cotton test to evaluate the integrity of the syndesmosis.[6,7] An increase in medial tibiotalar clear space and/or an increase in tibiofibular clear space and decrease in tibiofibular overlap on fluoroscopy demonstrates syndesmosis instability. If the test is positive, the fibula is reduced into the incisura usually under fluoroscopic control without direct visualization, held with a large pointed reduction forceps, and fixed with a trans-syndesmotic position screw or suture-button device to restore stability for correct healing of the ruptured ligaments. Substantial variation exists amongst surgeons in the management of the posterior malleolar component of the injury; however, traditionally posterior malleolar fractures > 20% of the tibial plafond articular surface and displaced fragments with the potential for joint instability and incongruity are fixed.[8-13] Similarly, Chaput fragments of 'sufficient' size are fixed. Smaller fragments are not addressed due to the assumption that the small fragments are 'non-fixable' or 'inconsequential'. Moreover, the ruptured deltoid ligament is usually not repaired and its healing is assumed upon restoration of the ankle mortise.

It is therefore not surprising for the conventional approach to be increasingly viewed as an overly simplified 'one strategy fits all' method. Apart from anatomical malleolar fixation, there is no emphasis on direct restoration of the structures that form the syndesmosis ring. The trans-syndesmotic screw is merely a surrogate for direct fixation of what is fractured and repair of what is torn.

A significant flaw in the conventional approach to treating the syndesmosis is evidenced by the high rate of iatrogenic syndesmosis malreduction. Studies have shown postoperative syndesmosis malreduction rates of 16% detected on plain radiographs and up to 52% on CT scan.[3,14-16] The dismal results are thought to be largely attributable to the technique of indirect reduction without visualization of the tibiofibular articulation, and the notoriously difficult evaluation of reduction dependent on imprecise fluoroscopic images.[5,17] Reduction accuracy can be improved by direct open visualization of the syndesmosis joint, but there is still a 15% rate of malreduction reported on postoperative CT scans.[5,18] To improve the quality of reduction, some surgeons use intraoperative CT scanning in comparison with CT scans of the patient's uninjured ankle, which will allow for morphological variation of the syndesmosis.[5] While quite effective, this modality is not readily available in all hospitals, incurs additional financial costs and also increases radiation exposure. The problem of repetitive CT scan assessment for malreduction can be avoided through a novel technique utilizing 3D computer-assisted orthopaedic surgery (CAOS). This technique allows real-time intraoperative navigation of syndesmosis reduction and fixation, and has been demonstrated to provide accurate reduction of the syndesmosis in a cadaveric study.[19]

Another important area that has become increasingly questionable is the conventional treatment of the posterior malleolar fracture. A sufficiently large and displaced posterior malleolar fracture is normally fixed because it is viewed as an intra-articular fracture of the tibiotalar joint that will affect joint congruity, stability and biomechanics of movement and gait. Using the same logic, a small and non-displaced posterior malleolar fragment is often not fixed as it is generally believed to risk no significant adverse outcomes on the tibiotalar joint. This thought process is now increasingly challenged because it fails to recognize the posterior malleolar fracture with its intact attached PITFL as a crucial component of the syndesmosis injury, and overemphasizes it as purely an intra-articular fracture. There is no evidence that supports the fixation of only large fragments, such as those > 20% of the articular surface. Fixing the posterior malleolus not only restores tibiotalar congruity but also ankle rotational stability.[20] There is increasing awareness of this fact and more consideration is given to fixing posterior malleolar fractures regardless of size or displacement for direct posterior stabilization of the syndesmosis. An anatomically fixed posterior malleolar fracture may restore the posterior fibular incisura, which aids in the subsequent reduction of the fibula into its groove, correctly tensions the PITFL and improves syndesmotic stability.[21]

Anatomical approach

The anatomical approach to treatment of rotationally unstable ankle fractures emphasizes restoration of all injured components through fragment-specific fixation and repair of ruptured ligaments.[21-27] In other words, the surgeon 'directly fixes what is broken and directly repairs what is torn'. With this approach, the lateral and medial malleolar fractures are fixed as per convention to restore the ankle mortise. The focus of the anatomical approach is on direct stabilization of the syndesmosis achieved through anatomical fixation of medial malleolar, posterior malleolar and Chaput fractures, and repair of the deltoid ligament if it is ruptured. When syndesmosis ligament injuries are purely avulsions, direct repair of the AITFL and the PITFL with its avulsed periosteal sleeve using suture anchors and other soft-tissue techniques to stabilize the syndesmosis have been described.[24,28-29] The PITFL is usually avulsed at its tibial insertion in the form of a broad periosteal sleeve that is amenable to direct repair using a screw with a large washer. As the PITFL is the main ligamentous stabilizer of the syndesmosis, it is vital to address this injury. In comparison, the AITFL plays a lesser role in stabilizing the syndesmosis and frequently does not require anatomical repair, particularly since in a significant proportion of cases the stability of the syndesmosis would have been restored (Cotton test negative) after the PITFL avulsion has been addressed. Moreover, primary suture repair of the AITFL is technically difficult due to shredding of the fibres. If, however, there is residual syndesmosis diastasis at this stage (Cotton test positive), conventional trans-syndesmotic fixation is mandatory for establishing stability. It is important to note, however, that trans-syndesmotic fixation is no longer the first line or only method used. In most cases it may potentially be avoided altogether with this new approach.

A compelling benefit of the anatomical approach is the improvement in syndesmotic reduction. One study where the anatomical approach was used to fix supination external rotation type IV ankle fractures demonstrated a significant decrease in syndesmosis malreduction rate from 33.3% to 7.4% compared with trans-syndesmotic fixation.[22] Primary repair of the deltoid ligament, a key stabilizer of the talus within the ankle mortise, effectively restores congruity of the mortise comparable with syndesmosis screw fixation.[23,30] In the assessment of ankle and syndesmotic rotational stability, a biomechanical cadaveric study has shown that combined repair of the PITFL and deltoid ligament restores equivalent stability in resisting external rotation forces compared with syndesmosis screw fixation, with the repaired deltoid ligament functioning as a medial checkrein.[24] Compared with the trans-syndesmotic screw, fixation of the fractured posterior malleolus is thought to be biomechanically superior in increasing syndesmotic stability with stiffness restored to 70% of an intact ankle in posterior malleolar fracture fixation, compared with 40% in traditional screw fixation.[21] The greater stability conferred by posterior malleolar fracture fixation is supported in another study that reported syndesmosis fixation and alignment to be successfully maintained at a mean of 15 months follow-up.[25] In other data, no significant difference was observed in postoperative maintenance of reduction between anatomical and trans-syndesmotic fixation.[22] The findings highlight the ability of posterior malleolar fracture fixation to be as good, if not superior, at achieving a postoperatively stable syndesmosis while avoiding the risk of malreduction. The promising results seen in terms of reduction and stability make this new fixation strategy a feasible alternative to the traditional trans-syndesmotic fixation and may render the use of the syndesmosis screw or suture-button unnecessary. Data pertaining to functional outcome of patients treated with the anatomical approach is scarce and further research in this area is required. However, it is generally accepted that anatomical restoration of the syndesmosis, which may be effectively achieved through the anatomical approach, is vital for optimal postoperative function.[5]

Technical challenges that may be encountered with this approach include longer operative time, more extensive soft-tissue dissection and potential need for re-positioning of the patient. These factors pose a risk of soft-tissue morbidity and increased wound complication. However, this has not been our experience and to our knowledge there are no reports in the current literature of complications specifically resulting from the anatomical approach. In the preoperative planning stage, we usually obtain a CT scan to evaluate the posterior malleolar fracture anatomy so as to direct the best approach and fixation method. CT is a necessary step in our preoperative planning.[31]

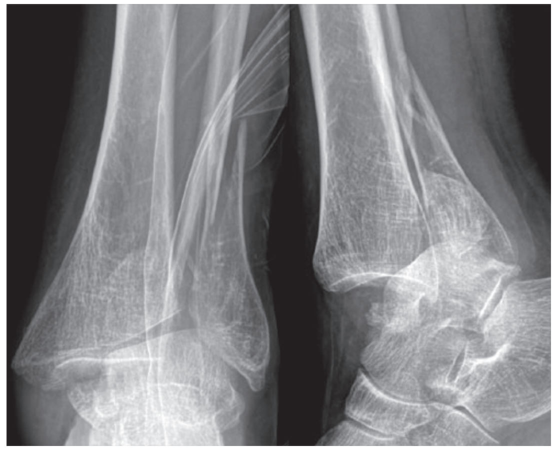

Fig. 1 Injury radiographs demonstrating a trimalleolar fracture-dislocation of the ankle.

Case study: the anatomical approach

A 61-year-old female patient with osteoporosis sustained a supination external rotation type IV ankle fracture-dislocation (Weber B). Radiographs demonstrated an oblique fracture of the fibula beginning at the level of the joint extending proximally, a small avulsion-type medial malleolar fracture, and a substantial posterior malleolar fracture (Fig. 1). The preoperative CT scan demonstrated a large, displaced posterior malleolar fragment without comminution or central impaction and the presence of a small Chaput cortical avulsion fracture. The axial CT image showed that the anterior and middle part of the syndesmosis was disrupted, whereas the PITFL remained intact as the fibular fragment follows the displaced posterior malleolar fragment (Fig. 2). Thus fixation of the posterior malleolar fragment would reduce the fibula to the incisura and allow the anterior and middle part of the syndesmosis to heal at the appropriate length. With the patient positioned prone, the posterior malleolar fracture was approached through a modified posteromedial approach to the tibia plafond.[32] The near midline approach permits clear visualization and allows for direct reduction and posterior plating of the posterior malleolar fracture. The anatomically reduced posterior malleolar fracture was temporarily fixed with a Kirschner-wire and definitively buttressed with a 2.7 mm locking plate (Fig. 3). Next, the patient was re-positioned supine with her leg internally rotated for access to the lateral malleolar fracture which was approached through a direct lateral approach, anatomically reduced and fixed with a conventional one-third tubular plate and 3.5 mm screws. The small medial malleolar fragment was anatomically reduced and fixed with a single 3.5 mm fully threaded screw in bicortical placement to optimize purchase in the osteoporotic bone. Following trimalleolar fixation, the Cotton stress test was performed, where the distal fibula was

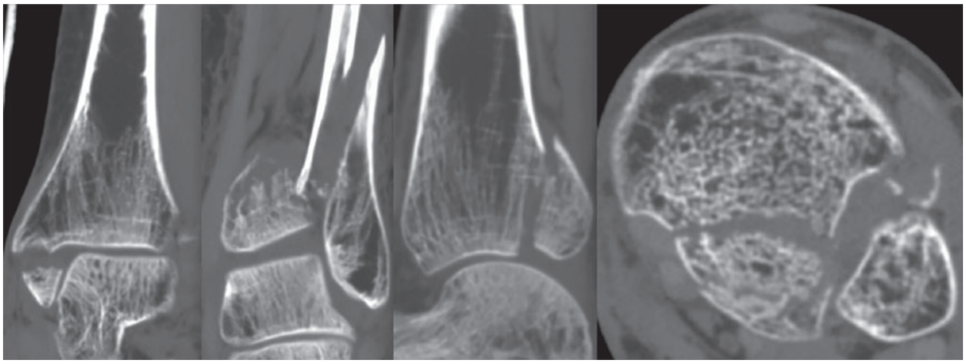

Fig. 2 CT scan images showing fractures of the lateral malleolus, medial malleolus, posterior malleolus, and Chaput tubercle.

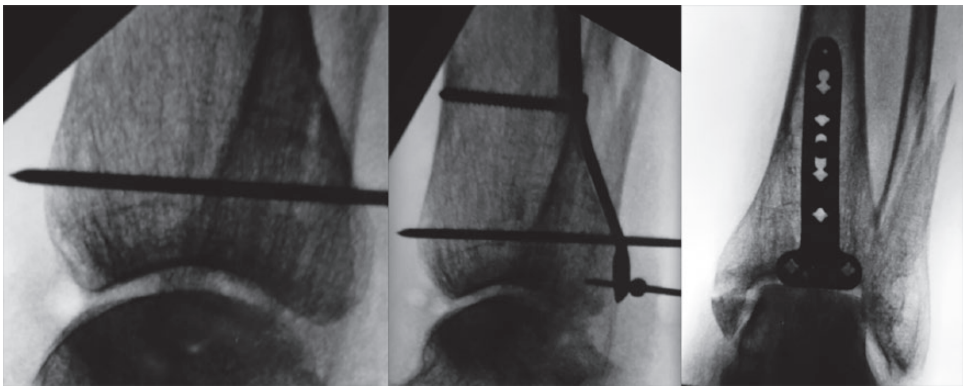

Fig. 3 Direct reduction and buttress plating of the posterior malleolar fracture as the first step in the operation.

Fig. 4 Intraoperative Cotton stress test assessing stability of the syndesmosis after trimalleolar fixation.

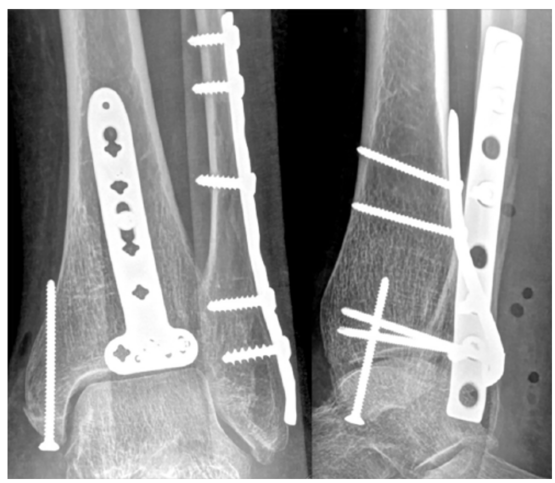

Fig. 5 Immediate postoperative radiographs showing anatomical restoration of the ankle mortise, without requiring a transsyndesmotic screw.

grasped with a bone clamp and pulled laterally to assess for tibiofibular diastasis. The negative test demonstrated that the anatomical osseous fixation leading to correct tensioning of the PITFL and deltoid ligament had successfully stabilized the syndesmosis (Fig. 4). As such, trans-syndesmotic fixation was avoided and fixation of the small avulsed Chaput fragment with its attached AITFL was not performed. Immediate postoperative radiographs showed anatomical restoration of the ankle mortise including the syndesmosis without using a syndesmotic screw (Fig. 5). Sequential radiographs at five months (Fig. 6) and two years postoperatively (Fig. 7) showed a healed fracture and

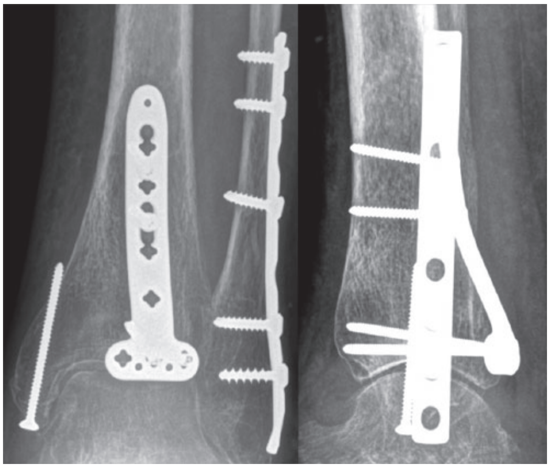

Fig. 6 Radiographs at five months showing healed fracture.

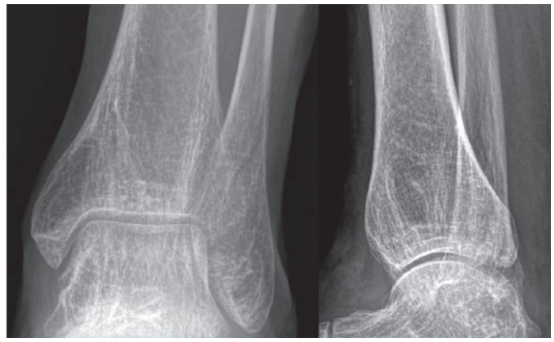

Fig. 7 Radiographs at two years. The implants have been removed, the ankle mortise is anatomical, and there are no findings of post-traumatic arthrosis.

anatomical preservation of the ankle mortise without post-traumatic tibiotalar or tibiofibular arthritis. The patient made a full functional recovery.

Conclusions

We have found the anatomical approach to be safe, effective and reproducible. The approach requires a good understanding of the mechanism of injury, fracture pattern and associated ligamentous injuries. The posterior malleolar and Chaput fracture patterns are not easily visualized on plain radiographs and the CT scan is mandatory for preoperative planning. Decision-making on which injury components must be addressed, surgical approaches, the sequence of fixation and choice of implants, is dependent on the fracture patterns and the soft-tissue condition of each specific case. The over-riding principle is fragment-specific fixation and repair of ruptured ligaments to directly stabilize the syndesmosis in lieu of trans-syndemotic surrogate fixation. Other advantages with the anatomical approach are improvement in syndesmosis reduction and biomechanically superior syndesmosis repair. In conclusion:

- Trans-syndesmotic screws are often associated with malreductions of ankle injuries and subsequent clinical problems.
- CT scanning is essential for the identification of all osseous components of the injury and for preoperative planning.
- Fixation of the posterior malleolus fracture is essential in order to restore ankle stability, as it usually leads to anatomical reduction of the syndesmosis.
- Chaput fractures are often overlooked and neglected, and this usually leads to poor reduction and poor clinical outcome.

AUTHOR INFORMATION

[1]Center for Surgery of the Foot & Ankle, Hirslanden Clinique La Colline, Switzerland; Department of Orthopaedics, Waikato Hospital, New Zealand
[2]Center for Surgery of the Foot & Ankle, Hirslanden Clinique La Colline, Switzerland

Correspondence should be sent to: M. F. Mak, Waikato District Health Board, Pembroke Street, Private Bag 3200, Hamilton 3240, New Zealand.
Email: makmayfong@gmail.com

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