SYMPOSIUM: RECENT ADVANCES IN FOOT AND ANKLE SURGERY

Is Fibular Fracture Displacement Consistent with Tibiotalar Displacement?

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Abstract We believed open reduction with internal fixation is required for supination-external rotation ankle fractures located at the level of the distal tibiofibular syndesmosis (Lauge-Hanssen SER II and Weber B) with 2 mm or more fibular fracture displacement. The rationale for surgery for these ankle fractures is based on the notion of elevated intraarticular contact pressures with lateral displacement. To diagnose these injuries, we presumed that in patients with a fibular fracture with at least 2 mm fracture displacement, the lateral malleolus and talus have moved at least 2 mm in a lateral direction without medial displacement of the proximal fibula. We reviewed 55 adult patients treated operatively for a supination-external rotation II ankle fracture (2 mm or more fibular fracture displacement) between 1990 and 1998. On standard radiographs, distance from the tibia to the proximal fibula, distance from the tibia to the distal fibula, and displacement at the level of the fibular fracture were measured. These distances were compared preoperatively and postoperatively. We concluded tibiotalar displacement cannot be reliably assessed at the level of the fracture. Based on this and other studies, we believe there is little evidence to perform open reduction and internal fixation of supination-external rotation II ankle fractures.

Level of Evidence: Level IV, case series. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Although open reduction and internal fixation of fibular fractures is a relatively straightforward procedure, this operation is not without risks or complications [1, 9, 20]. Complications such as nonunion, malunion, posttraumatic osteoarthritis, reflex sympathetic dystrophy, infection, bleeding, and thromboembolic complications are reported in the literature [20]. These complication frequencies vary from 5% to 40% after operative treatment of closed ankle fractures [2, 4, 10, 20, 22]. Therefore, it is important to clearly identify the patients who will benefit from surgery [25]. The Arbeitsgemeinschaft für Osteosynthesefragen/ American Society for Internal Fixation (AO/ASIF) [40] based their guidelines for ankle fracture treatment on the Danis-Weber [39] classification. This classification as used by the AO/OTA [40] is based on the level of the fibular fracture in relation to the distal tibiofibular syndesmosis. The Weber B fracture is located on the level of the syndesmosis, the Weber A is located below, and the Weber C above this level. The AO/ASIF Weber B ankle fracture treatment protocols were mainly based on the Swiss and German literature of the 1960s and 1970s. Subtypes included an isolated fibular fracture (B1), associated with a medial lesion (either a fracture of the medial malleolus or deltoid ligament [B2]), or associated with a medial lesion and fracture of the posterolateral tibia (B3). Because a Weber B ankle fracture is an intra-articular fracture, they emphasized anatomic reduction of the lateral malleolus is

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the key to restoration of the ankle mortise [3, 18, 24, 34, 36, 39, 40, 42].

The Weber system is easy to remember because of its simplicity, but the Lauge-Hansen system [19] gives more insight into the trauma mechanism and associated ligamentous injuries. The supination-external rotation (SER) fracture in the Lauge-Hansen classification is the equivalent of the Weber B ankle fracture. Lauge-Hansen classification is based on two descriptors. The first word describes the position of the foot; the second word describes the motion of the foot (talus) with respect to the leg. The deltoid ligament is intact in a SER II ankle fracture and is injured in the SER IV ankle fracture. Approximately 85% of the lateral malleolar fractures occur without substantial injury to the medial side of the ankle [13, 26]. It is therefore important to identify the most reliable method to evaluate the integrity of the deltoid ligament to differentiate between SER II and SER IV fractures [38].

After the introduction of this classification, we supported the opinion that open reduction with internal fixation is required for patients with SER II ankle fractures with 2 mm or more fibular displacement [9, 14]. The rationale for operating on these ankle fractures was based on the studies of Ramsey and Hamilton in 1976 [32] and of Lloyd et al. in 2006 [21] suggesting high intraarticular contact pressures with displacement. In their study, 1 mm of talar shift or 3° external rotation of the distal fibula resulted in a 40% decrease in tibiotalar contact surface area [14, 21, 32]. Substantial lateral displacement of the talus can alter tibiotalar joint dynamics in isolated fibular fractures even with an intact deltoid ligament [14, 32]. Decrease in contact area gives an increase in force per unit area. Generation of high-stress concentrations can damage not only articular cartilage, but also osseous components of the distal tibia, diminish function through loss of congruence, and may be a decisive factor in the pathogenesis of posttraumatic osteoarthritis [14].

To diagnose these fractures, we presumed that in patients with a fibular fracture with at least 2 mm displacement at the fracture site, the lateral malleolus and talus have also moved at least 2 mm in a lateral direction without medial displacement of the proximal fibula; the direction and magnitude of displacement of the fibular fracture fragments can be determined by comparing the preoperative and postoperative radiographs.

Materials and Methods

We retrospectively reviewed 55 adult patients from a prospective database who were operated on for an SER II ankle fracture between 1990 and 1998. The indication for operative treatment was at least 2 mm displacement

between the two fibular fracture fragments measured on a standard mortise ankle radiograph. Based on the charts of the emergency room, there were no patients with tenderness, swelling, or ecchymosis over the deltoid ligament. All patients had a normal medial clear space on the mortise radiographic view. Patients were operated on either within 24 hours after trauma or delayed at least 5 days after initial trauma. The average interval between trauma and operation was 4.2 days (range, 0–12 days). The average age was 42 years (range, 17–89 years). The study group included 24 males and 31 females with 21 left ankle fractures and 34 right ankle fractures. Approval by the Institutional Review Board was not necessary because only radiographic measurements were performed.

Patients were treated by attending orthopaedic surgeons and residents experienced with the AO principles of anatomic reduction and internal fixation [40]. Thirty-one of the 55 fractures were fixed with two lag screws and 24 fractures were fixed and stabilized with one lag screw and a one-third tubular plate. To examine for syndesmotic instability under fluoroscopic control, we performed the hook test (Cotton test), first described by Frederic J. Cotton in 1910 [8]. With intraoperative anteroposterior stress radiography, by using a bone hook applied to the distal fibula and applying lateral force to the distal fibula in the coronal plane, the degree of syndesmosis diastases can be assessed by using an image intensifier. This test suggests if there is widening in the coronal plane in a mortise view, instability of the syndesmosis is present. There were no signs of syndesmotic instability in our series.

Postoperative treatment consisted of a short functional period followed by 6 weeks in a lower-leg cast without weightbearing. The average duration of hospital stay was 8 days (range, 2–13 days). No complications were observed during the hospital stay.

All patients were followed radiographically with a standardized mortise view and a lateral view until fracture healing. On the mortise views made on the first postoperative day, three distances were measured (CW): distance from tibia to proximal fibula (Fig. 1: line 1), distance from tibia to distal fibula (Fig. 1: line 2), and distance from the proximal fibular fracture fragment to the distal fibular fracture fragment (Fig. 1: line 3). These distances were compared preoperatively and postoperatively (after reduction and fixation of the fracture) (Fig. 1). Pre- and postoperative radiographs were measured using a loupe with x5 magnification and a calibration up to 0.1 mm.

Results

Preoperatively, the average distance between tibia and proximal fibula was 3.0 mm (standard deviation [SD],

Fig. 1A–B Three distances were measured on the (**A**) preoperative and (**B**) postoperative radiographs to compare fibular fracture displacement with lateral displacement of the distal fibula and talus (1) displacement between the proximal fibula and distal tibia; (2) displacement between the distal fibula and distal tibia; and (3) fibular fracture displacement.
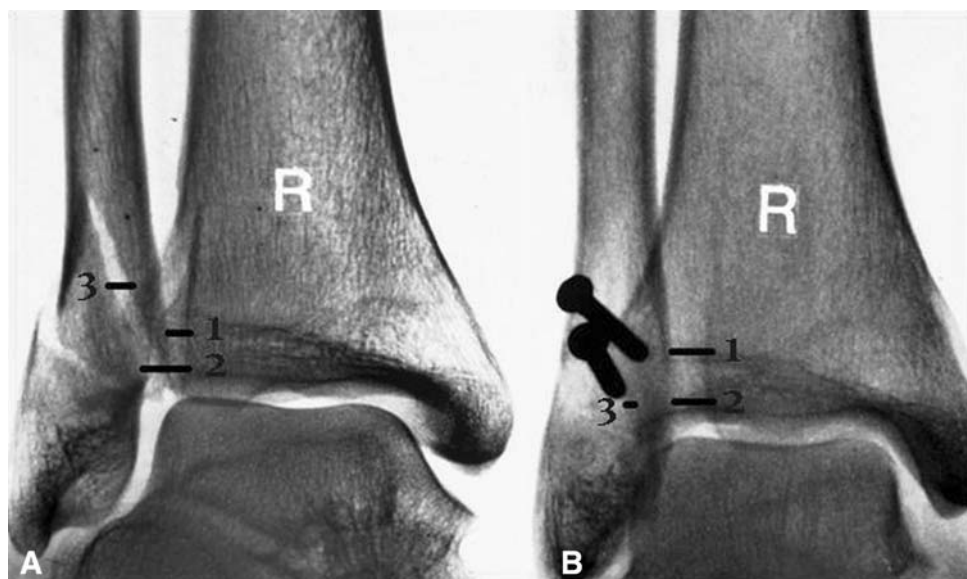

Table 1. Results of radiographic measurements

Measurement	Preoperative distance (mm)	Postoperative distance (mm)
Tibia–proximal fibula fragment	3 ± 0.91	4.8 ± 0.97
Tibia–distal fibula fragment	5 ± 0.96	4.4 ± 0.83
Fracture displacement	2.3 ± 0.45	0.1 ± 0.31

0.91), the average distance between tibia and distal fibula 5.0 mm (SD, 0.96), and the average distance at the fracture site was 2.3 mm (SD, 0.45) (Table 1). Immediately postoperatively, all 55 patients had a well-aligned mortise on the fractured side based on measurements of the medial, superior, and syndesmotic clear spaces and the position of the fibula on the lateral view. Postoperatively, the average distance between the tibia and proximal fibula was 4.8 mm (SD, 0.97), the average distance between the tibia and distal fibula 4.4 mm (SD, 0.83), and the average distance at the fracture site was 0.1 mm (SD, 0.31) (Table 1).

The average displacement at the fracture site was 2.3 mm. This displacement consists of a 1.8-mm (4.8 mm [postoperative distance] to 3.0 mm [preoperative distance]) medial displacement of the proximal fibula fragment and only a 0.6-mm (5.0 mm [preoperative distance] to 4.4 mm [postoperative distance]) lateral displacement of the distal fibula fragment (Table 1).

Discussion

Until this study was performed, we believed fracture displacement was a reliable method to assess tibiotalar displacement and therefore to determine which ankle fractures require operative treatment. This opinion was partly based on the studies of Ramsey and Hamilton in 1976 [32] and of Lloyd et al. in 2006 [21] showing high intraarticular contact pressures with shift of the talus. To diagnose fractures with tibiotalar displacement, we presumed that in patients with a fibular fracture with at least 2 mm displacement at the fracture site, the lateral malleolus and talus have also moved at least 2 mm in a lateral direction without medial displacement of the proximal fibula; that is, the displacement of the fibular fracture fragments at the level of the fracture would reflect the same as the displacement of the distal fibula and talus compared with the distal tibia in SER II ankle fractures.

Ours was a retrospective study based on a prospectively collected database. We did not confirm the radiographic measurements with computed tomography (CT) scanning because there was no indication to routinely perform a CT scan in these ankle fractures. We believed our radiographic measurements could reliably be assessed on standardized mortise ankle views. A recent systematic review suggests assessing deltoid ligament integrity with manual or gravity stress views instead of physical examination [28, 38]. None of our patients had a widened medial clear space and no patients had medial signs of deltoid ligament injury at physical examination. We believe the combination of these assessments allows one to reliably assess the integrity of the deltoid ligament.

As we noted earlier, the rationale for operating on these ankle fractures was based on the studies of Ramsey and Hamilton in 1976 [32] and of Lloyd et al. in 2006 [21] suggesting high intraarticular contact pressures with displacement. Several clinical studies suggest radiographic signs of ankle osteoarthritis in ankle malunions with greater than 1 or 2 mm of lateral talar shift [15, 16, 30, 41]. One millimeter of talar shift or 3° external rotation of the

distal fibula resulted in a 40% decrease in tibiotalar contact surface area [14, 21, 32]. Substantial lateral displacement of the talus can alter tibiotalar joint dynamics in isolated fibular fractures even with an intact deltoid ligament [14, 32]. Decrease in contact area gives an increase in force per unit area. Generation of high-stress concentrations can damage not only articular cartilage, but also osseous components of the distal tibia, diminish function through loss of congruence, and may be considered a decisive factor in the pathogenesis of osteoarthritis [14]. Changes in joint alignment may lead to degenerative changes and ankle pain [37]. Several clinical studies suggest radiographic signs of ankle osteoarthritis in ankle malunions with greater than 1 or 2 mm of lateral talar shift [15, 16, 30, 41]. However, one study suggested a surgically created fibular osteotomy with up to 6 mm displacement did not cause a substantial change in tibiotalar contact area [6]. Sectioning of the deltoid ligament, regardless of fibular displacement, created a decrease in contact area. Another study [27] reported the displacement at the fracture is caused by medialization and internal rotation of the proximal fragment and that the relation between the talus and the distal fibula remains intact. In this case, the ankle mortise remains unaffected and congruent. If this is indeed correct for all SER II fractures, this would mean the 2-mm cutoff point for fracture displacement does not lead to incongruence of the ankle mortise.

Contrary to what we believed, the fracture displacement mainly consisted of medial displacement of the proximal fibula with scant lateral displacement of the distal fibula. Because there is only 0.6 mm lateral displacement of the distal fibula and subsequently in the ankle with 2.3 mm displacement at the fibular fracture site, we conclude fibular fracture displacement is not a reliable measure to assess displacement at the ankle. We believe the indication for operative treatment of SER II ankle fractures cannot be assessed with displacement at the fibular fracture site. Current literature in fact suggests surgical correction is not required for fibular fractures with minimal displacement and an intact deltoid ligament (Lauge-Hansen Type SER Stage II) [5, 9, 16, 29–31].

What is the explanation for the medial displacement of the proximal fibula fragment in our study? The kinematics of the ankle complex during progressive stages of a Lauge-Hansen SER fracture provide a more detailed understanding of the incongruence between the tibiotalar dislocation and dislocation at the fibular fracture site. This fracture mechanism is already described [19] (Fig. 2). In a SER II ankle fracture, the external rotation force of the supinated foot stopped before a medial malleolar fracture occurred or before the deltoid ligament ruptured. The deltoid ligament becomes taut because the deep part of this ligament limits external rotation of the talus with the foot in supination [6, 12, 33]. At the end of this external rotating trauma mechanism, the distal fibular fragment internally rotates as a result of the movement of the foot from its supinated position to neutral position and because of the stretched deltoid ligament (Fig. 3). This internal rotation will happen without movement between the fracture fragments. The result will be that the distal fragment is in neutral position and the proximal fibular fragment is in an internally rotated position now. Because there is no lateral ligament injury in ankle fractures, the relationship between the distal fibula and the talus cannot be disturbed. The apparent external rotation of the lateral malleolus is only with regard to the proximal fibula and appears to be a result of increased internal proximal fibular rotation relative to the reference point on the tibia [27].

Fig. 2 The external rotation of the supinated foot stopped before medial injury occurred. The deltoid ligament becomes taut because the deep part of this ligament limits external rotation of the talus with the foot in supination.
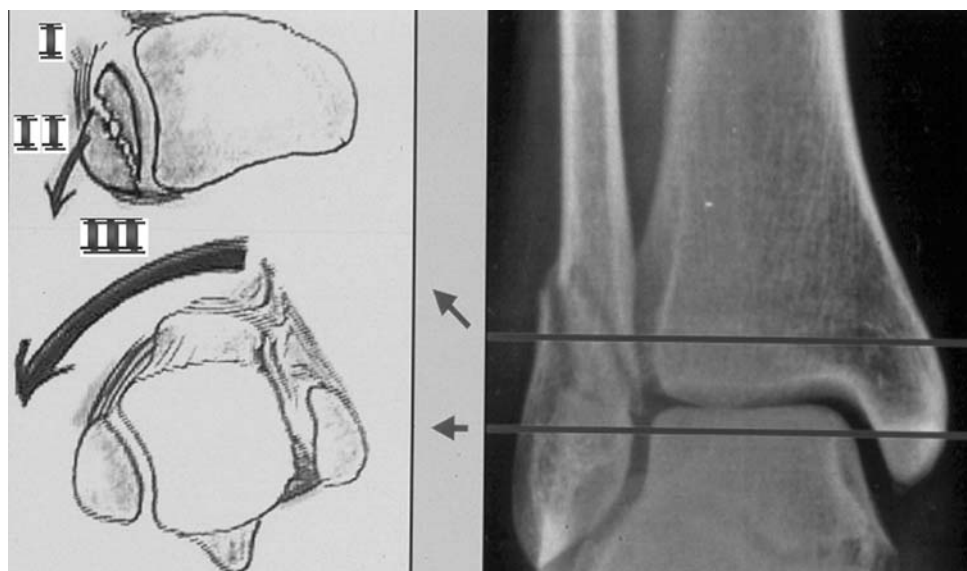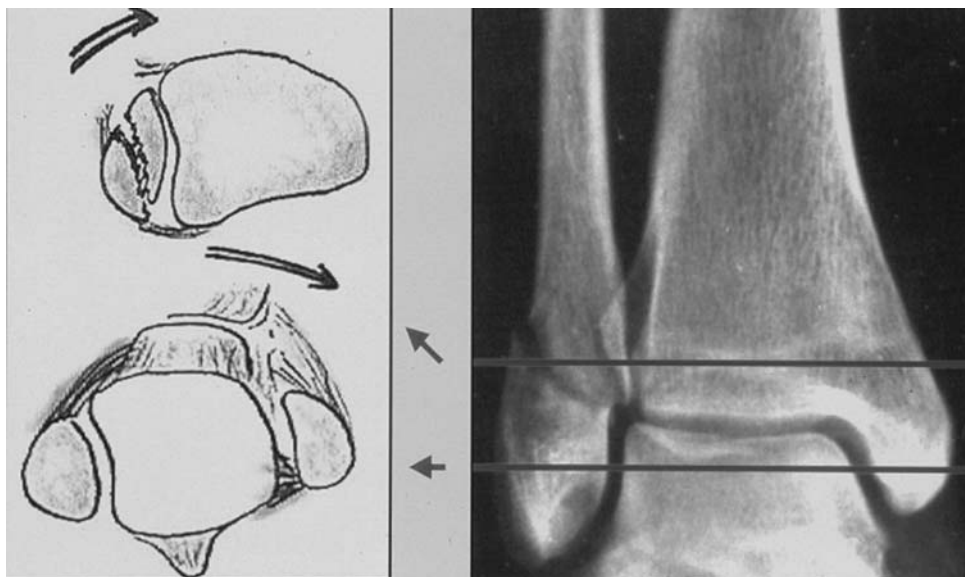
Fig. 3 At the end of this external rotating, the distal fibular fragment internally rotates and this will happen without movement between the fracture fragments. The result is the distal fragment is in neutral position and the proximal fibular fragment is in an internally rotated position.

This theory, based on the Lauge-Hansen mechanism, and our findings are in accordance with the findings of Michelson et al. [27] and Harper [13]. They observed a relative internal rotation of the fibula proximal to the SER II ankle fracture, whereas the distal fracture fragment maintained its normal relationship to the talus. Although they had no explanation for this phenomenon, they observed that attempts to internally rotate the distal fibula to achieve reduction tend to be blocked by the talus [13, 27]. However, the proximal fibula is easily externally rotated to anatomically reduce to the distal fragment.

Clarke et al. [6] stated that assessing fracture dislocation is not reliable in predicting which ankle fractures require surgical treatment. Because axial loading of the ankle will increase its stability [23, 35], the dynamic consequences of fibular displacement observed in unloaded ankles are not necessarily obvious [6, 32]. Indications for operative treatment of ankle fractures solely based on lateral malleolar displacement might not be reliable. These criteria for treatment do not adequately characterize the dynamic incongruities caused by the fracture.

Based on our radiographic findings and clinical studies [1, 17, 43, 45], we believe there is little evidence to perform open reduction and internal fixation of SER II ankle fractures with an intact deltoid ligament [1, 17, 43, 45]. These fractures managed nonoperatively had no increased physical and radiologic signs of osteoarthritis after long-term followup compared with operative treated SER II ankle fractures [1, 17, 43, 45]. Michelson et al. [27] and Harper [13] observed relative internal rotation of the fibula proximal to the fracture site, whereas the distal fracture fragment maintained its normal relationship to the talus.

We emphasize these recommendations are not applicable for bimalleolar ankle fractures or lateral malleolar fractures with deltoid ligament injury (SER IV). These fractures have a well-demonstrated instability pattern that is better addressed using open reduction and internal fixation [30, 44]. The primary function of the deltoid ligament is to firmly fix the tibia above the talus and to restrict the tendency of the talus to shift into a valgus position, to translate anterolaterally, and to externally rotate [7, 11, 19, 33].

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