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Minimally Invasive Treatment of Ankle Fractures in Patients at High Risk of Soft Tissue Wound Healing Complications

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ABSTRACT

The complex nature of ankle fractures is magnified when seen in patients at high risk of soft tissue wound healing complications. The major categories include associated soft tissue injury, diabetes, tobacco use, peripheral vascular disease, malnutrition, alcoholism, and corticosteroid use. Because of the potential for wound dehiscence and infection with open reduction and internal fixation of ankle fractures in these patients, minimally invasive procedures have been described. The aims of the present study were to assess the possibility for, and evaluate the results and complications of, minimally invasive techniques for different types of malleolar fractures in high-risk patients. We report the clinical results of 47 high-risk patients who presented with malleolar fractures from January 2007 to December 2012 and underwent minimally invasive reduction and fixation. One patient (0.5%) developed a superficial infection; however, none of the patients displayed wound dehiscence or deep infection. Five patients (10.6%) required open reduction because of intraoperative failure to achieve anatomic reduction. Using the American Orthopaedic Foot and Ankle Society ankle-hindfoot scale, 15 of the patients (36%) treated with minimally invasive techniques experienced an excellent outcome. In contrast, 23 patients (55%) had a good, 3 (7%) a fair, and 1 (2.5%) a poor outcome. The results of our study have shown that minimally invasive fixation appears to be a satisfactory method for the management of malleolar fractures in high-risk patients and could be helpful in the avoidance of the complications associated with conventional open reduction and internal fixation.

Despite the frequency with which ankle fractures are encountered, areas remain in which treatment can be optimized (1). Patients with complex fracture patterns, poor bone stock, or a compromised soft tissue envelope resulting from either the injury or other comorbidities are prone to high complication rates (2). Application of the principles developed by Arbeitsgemeinschaft für Osteosynthesefragen–Association for the Study of Internal Fixation (AO Foundation, Davos, Switzerland) is critical for successful treatment of ankle fractures. These principles include the following:

1. Accurate fracture reduction to restore the anatomic relationship
2. Fracture fixation according to the fracture type
3. Preservation of the blood supply to the soft tissues and bone using gentle reduction techniques and careful handling
4. Early and safe mobilization of the injured part and the patient as a whole (3)

Use of the Lauge-Hansen classification can help to obtain and maintain accurate reduction of ankle fractures (the first AO principle) by understanding and reversing the mechanism of injury. The Lauge-Hansen classification includes 4 categories and 13 subgroups of ankle fractures (Table 1) (4). Correlation of the Weber (Danis-Weber) classification with the Lauge-Hansen classification will help greatly in the understanding of the fracture type (4,5) (Fig. 1). However, the Lauge-Hansen and Weber classifications do not describe the level of the medial malleolar fracture. The level of the medial malleolus fracture will be either supracollicular or collicular which include fractures of anterior colliculus, posterior colliculus or through the intercollicular groove (6).

The choice of fixation tool is dependent on the fracture's morphology (second AO principle). A fibular transverse fracture should be fixed

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Table 1
Categories and stages of the Lauge-Hansen classification system (4)

Category	Stage
Supination external rotation	1. Injury of anterior inferior tibiofibular ligament 2. Oblique/spiral fracture of distal fibula 3. Injury of posterior inferior tibiofibular ligament or avulsion of posterior malleolus 4. Medial malleolus fracture or injury to deltoid ligament
Supination adduction	1. Transverse fracture of distal fibula 2. Vertical fracture of medial malleolus rotation
Pronation external rotation	1. Medial malleolus fracture or injury to deltoid ligament 2. Injury of anterior inferior tibiofibular ligament 3. Oblique/spiral fracture of fibula proximal to tibial plafond 4. Injury of posterior inferior tibiofibular ligament or avulsion of posterior malleolus
Pronation abduction	1. Medial malleolus fracture or injury to deltoid ligament 2. Injury of anterior inferior tibiofibular ligament 3. Transverse or comminuted fracture of fibula proximal to tibial plafond

with a tension band compression plate, an oblique or spiral fracture should be fixed using interfragmental screws and a neutralization plate, and a comminuted fracture will be best treated using bridging plate (7). In Weber C fractures, meticulous attention should be given to the dissection of the soft tissues to avoid injury to the superficial peroneal nerve, in particular, with a 6-hole or larger plate (8). The supracollicular medial malleolar fracture can be fixed using a lag screw or a tension band wire; however, for a vertical fracture, lag screws or an antiglide plate will be required (1,7,9). Transverse anterior collicular fractures can be fixed using a small fragment compression screw; for oblique fractures, a tension band is recommended. Posterior malleolar fractures of >30% of the articular surface should be fixed with 3.5- or 4.0-mm partially threaded cancellous screws from anteroposteriorly or posteroanteriorly (10–12).

The ankle ligaments must be considered as important as the bone in the assessment of the injury. A tibiofibular clear space >6 mm on the anteroposterior (AP) and mortise views and tibiofibular overlap <6 mm on the AP and >1 mm on the mortise views are indications of a syndesmotic injury. A distance of the medial clear space on both the AP and mortise films of ≥4 mm indicates a complete disruption of the deltoid and syndesmotic ligaments. No consensus has been reached regarding the optimal number of cortices, screw size, or foot position during screw insertion (9–13). The size of the medial malleolar fragment is the most important variable in predicting deltoid competence, mainly of the deep posterior ligament (DPL). When this fragment is >2.8 cm wide, the deltoid ligament will be intact. However, when it is <1.7 cm wide, the deltoid ligament will be incompetent (14). The DPL usually heals sufficiently without repair, provided that a good reduction of the medial joint space, syndesmosis, and lateral malleolus was obtained (15).

Adjuncts that can improve the fixation quality of fragility fractures associated poor bone quality include intramedullary fixation of the fibula; the use of a locking plate; augmentation using bone substitutes or bone cement; and insertion of a retrograde percutaneous calcaneotibial pin (16,17).

The complex nature of ankle fractures is magnified when seen in patients at high risk of soft tissue wound healing complications and a compromised thin soft tissue envelope. The major categories of high-risk foot and ankle patients include associated soft tissue injury, diabetes, tobacco use, peripheral vascular disease, malnutrition, alcoholism, and corticosteroid use (18). The effects of these factors on wound healing are summarized in Table 2 (19–26). Because of the potential for wound dehiscence and infection with open reduction and internal fixation (ORIF), especially in these high-risk patients, minimally invasive procedures for osseous stabilization have been developed (27). The decreased iatrogenic tissue damage in these techniques has enabled early mobilization and rapid rehabilitation, which, in turn, fulfill the third and fourth AO principles (28,29). Minimally invasive plate osteosynthesis has proved to be a viable option for lateral malleolar fractures with a low complication rate and high functional outcome, in particular, in high-risk patients. Early fixation of medial malleolus fractures with compromised skin through small incisions with minimal soft tissue stripping has been proved to be advantageous compared with delayed surgery, in terms of both wound healing and hospital costs (29–31). However, data regarding the treatment protocols for ankle fractures in high-risk patients are scarce (32).

The aim of the present study was to evaluate the possibility, results, and complications of minimally invasive reduction and fixation techniques for different types of malleolar fractures in patients with a high

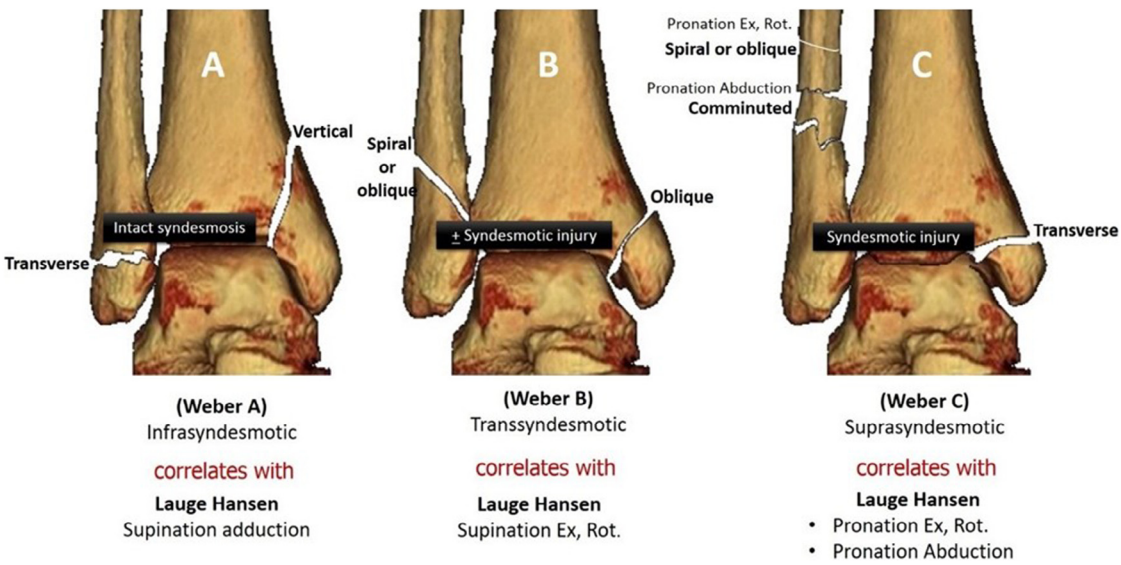

Fig. 1. Correlation between Weber and Lauge-Hansen classifications. *(A)* Weber A correlates with Lauge-Hansen supination adduction type. *(B)* Weber B correlates with Lauge-Hansen supination external rotation type. *(C)* Weber C correlates with Lauge-Hansen pronation abduction and external rotation types. (Figure created by S.M.D.)