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Unstable Ankle Fracture Fixation Using Locked Fibular Intramedullary Nail in High-Risk Patients



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ABSTRACT

Open reduction internal fixation is the gold standard for unstable ankle fracture fixation; however, complications in patients with multiple medical comorbidities are common. Intramedullary nail fixation of the fibula can help to mitigate these difficulties. A retrospective chart review was performed on all patients who underwent fixation for unstable ankle fracture between January 2015 and March 2016 at our level I trauma center. Comorbidities in the patient sample included were one or several of diabetes, renal disease, hypertension, advanced age with osteoporosis, hemorrhagic blisters, and alcoholism. The primary outcomes studied were wound complications, infections, and hardware failure or failure of fixation. Eighteen patients with a mean age of 61 years underwent fibular intramedullary nail fixation, all of whom were considered at high risk for postoperative complications. Patients presented with Weber B or C fracture patterns. All patients had syndesmotic fixation through the nail by one or two 3.5-mm tricortical screws. A medial malleolus was added if needed for stability. The average follow-up time was 291.1 (range 9 to 14 months) days. The prescribed range of time to weightbearing was 2 to 6 weeks. All patients maintained reduction of the fracture and had no wound complications. No syndesmotic screws broke postoperatively, although most patients failed to comply with the postoperative non-weightbearing restrictions. Intramedullary nailing of the fibula with syndesmotic intranail fixation is minimally invasive, quick, and provides adequate fixation strength. It offers a viable treatment option for patients at high risk for complications or who are suspected to have difficulty with follow-up or compliance.

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Ankle fractures are among the most common orthopedic injuries necessitating operative management (1,2). There is an increasing incidence among elderly individuals and those with poor bone quality (3,4). Open reduction and internal fixation (ORIF) is the gold standard for ankle fracture fixation; the vast majority of these fractures require plating of the distal fibula. A significant number of patients experience complications after open reduction and plating (5–7). Patients with medical comorbidities (e.g., neuropathy, renal failure, uncontrolled diabetes) have a higher incidence of complication after open reduction of the fibula (8). Also, patients with

certain conditions (e.g., contamination by open fracture or chronic edema by heart failure) will have an increased possibility of skin complications (Fig. 1). Minimally invasive strategies for fracture fixation have been attempted to avoid potentially severe wound complications, especially in the older individual with multiple medical comorbidities (9–11).

Intramedullary nail fixation of the fibula offers the advantages of decreased surgical dissection, gentle soft tissue handling, less hardware prominence, less surgical time, improved biomechanical strength in osteoporotic bone, and possible shorter duration of hospitalization (12,13). This technique has been shown to provide reliable union rates, excellent functional outcomes, and a low complication profile, comparable with that of ORIF of fibular fractures in high-risk patients (10,13,14).

We hypothesized that using the fibular intramedullary nail in high-risk patients with multiple medical comorbidities is a viable alternative for fracture fixation.

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Fig. 1. Poor soft tissue envelope owing to brawny induration and woody skin secondary to vascular disease and neuropathy.

Patients and Methods

An internal review board approved retrospective review of 18 consecutive patients treated with locked intramedullary nail fixation of unstable distal fibular fractures at a level I trauma center was performed. Patients who underwent internal fixation of distal fibular fractures using locked intramedullary nailing (Fibula Rod System Acumed®, Hillsboro, OR) by the senior author (A.A.) between January 2015 and March 2016 were identified in the electronic medical record using *International Classification of Diseases*, 10th edition, codes and were included in the study. Only high-risk patients were treated with fibular intramedullary nails based on the presence of medical comorbidities that made ORIF a relatively risky procedure with a higher than average incidence of complications. Inclusion criteria were uncontrolled diabetes mellitus with neuropathy, advanced renal disease, poor skin condition, advanced age with severe osteoporosis, dementia, and expected noncompliance with the weightbearing restriction (Table 1). There were no exclusion criteria.

A resident (E.E.) and fellow (S.D.) were responsible for collecting the data retrospectively. The Weber classification system and the Lauge-Hansen classification system were used to identify and stage fracture patterns (15,16). Postoperative clinic follow-up visits were reviewed for fracture union, mortise or hardware displacement, time to weight-bearing, and the presence of infection or implant-related symptoms. The outcomes of interest were wound complications, infections, hardware failure, or failure of fixation.

Table 1
Patient demographics (N = 18)

Age	Gender	BMI	Side	Fracture Weber Classification	Lauge- Hansen Classification	Medial Malleolus Fixation	Syndesmotic fixation 3.5mm	Open/ Closed fracture	Comorbidity
65	M	24	Left	B	SER stage 2	No	1	Closed	DM, HTN, CAD, MI, alcoholism
22	M	20	Left	C	PER stage 3	No	1	Closed	Empyema, thoracentesis
61	F	18	Left	B	SER stage 4	No	2	Closed	Cirrhosis, alcoholism, hepatitis C, HTN
72	F	20	Left	B	SER stage 4	No	1	Closed	DM, ARF, stroke
89	F	17	Left	C	Fracture dislocation PER stage 4	Yes	2	Open	HTN, advanced age with osteoporosis
53	F	25	Right	B	SER stage 4	No	1	Closed	DM, neuropathy, HTN, depression
70	M	20	Right	B	SER stage 2	No	1	Open	HTN, CAD, MI, hyperlipidemia
56	F	24	Right	B	SER stage 4	Yes	2	Open	HTN, hemorrhagic blisters
64	M	28	Right	B	SER stage 4	No	1	Closed	Charcot, COPD, DM, depression
68	M	22	Right	B	SER stage 2	No	2	Closed	DM, ESRD, HTN, osteoporosis
50	F	30	Left	B	Fracture dislocation PER stage 4	No	2	Open	Schizophrenia, hemorrhagic blisters, dyskinesia
60	M	24	Right	B	SER stage 2	No	2	Closed	DM, HTN, neuropathy, AFIB, osteoporosis
69	M	18	Left	B	SER stage 4	No	2	Closed	HTN, alcoholism
56	F	28	Left	B	SER stage 2	No	2	Closed	DM, neuropathy, Charcot, CRD (dialysis), HTN
75	F	20	Right	C	PER stage 3	No	2	Open	HTN, hypercholesterolemia, advanced age with osteoporosis
68	M	19	Left	B	SER stage 2	No	2	Closed	HTN, CAD, COPD, DM
33	F	26	Right	B	SER stage 4	Yes	2	Closed	DM, neuropathy, HTN, ARF
55	F	28	Right	B	SER stage 4	Yes	2	Open	DM, HTN

Abbreviations: AFIB, atrial fibrillation; ARF, acute renal failure; BMI, body mass index; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; ESRD, end-stage renal disease; HTN, hypertension; MI, myocardial infarction; PER, pronation external rotation; SER, supination external rotation.

Microsoft Excel® (Microsoft, Inc, Redmond, WA) was used to run the stats for the different outcomes, means, and variables.

Surgical Technique

The patient is positioned supine, and surgery is performed under general or spinal anesthesia. No tourniquet is required. After prepping and draping, a 1.6-mm guidewire is inserted percutaneously and is used to identify the entry point for the fibular nail (the tip of the fibula) using intraoperative fluoroscopy in 2 perpendicular planes (anteroposterior and lateral). We try to lean 1 to 2 mm medial to the tip of fibula if possible to avoid blowing the lateral wall of the fibula.

The wire is first drilled into the fibula and then advanced using the mallet to allow the wire to find its path in the fibular medulla rather than pushing it using the power drill (this strategy avoids the piercing of the medial wall of the fibula). Reduction is achieved by manipulation of the guidewire into the proximal fibula and internal rotation of the extremity to align the fracture. In more proximal fractures, the wire may not be able to pass across the fracture. It may instead escape from the medial side of the fracture to become extramedullary. In these cases, a hand reamer may be used to pass across the fracture.

A small nick incision is made around the guidewire, just large enough to allow passage of the drill and hand reamer. The medullary canal is prepared by drilling the distal 4 cm of the fibula using a 6.1-mm cannulated drill over the guidewire. The guidewire and the drill are removed. The diaphyseal canal is subsequently reamed a few centimeters past the planned length of the nail using the appropriately sized hand reamer. The fibular rod is then assembled on a back-table and inserted into the reamed fibula. Appropriate placement of the nail and reduction of the fracture are confirmed using fluoroscopy. Patients with proximal fibular fractures (Weber C) receive the 180.0 × 3.0-mm nail, whereas all distal fibular fractures (Weber B) receive the 145 × 3.0-mm nail.

Attention is then directed toward placing the 2 anterior-to-posterior screws in the distal part of the nail. One small incision encompassing the proximal aspect of the distal screw and the distal side of the proximal screw is made instead of 2 separate stab incisions for the anterior-to-posterior screws in the distal fragment as well as the syndesmotic screws. This step prevents a skin bridge in these high-risk patients (Fig. 2).

Depending on the severity of the fracture and the quality of bone, 1 or 2 threaded tricortical 3.5-mm syndesmotic screws are inserted proximally from lateral to medial, engaging the nail and the tibia to lock the fibula rod and stabilize the syndesmosis. Fracture reduction clamps are not necessary to achieve reduction. Syndesmotic screws are used even if the syndesmosis is reduced after nailing the fibula to give more stability to the construct. The intent is for these screws to remain with the patient unless future complications necessitate their removal. Stability of the ankle joint is assessed intraoperatively with stress views. If the ankle is found to be well-reduced and stable, no medial malleolus fixation is done (especially in cases at very high risk for skin and wound complications). Posterior malleolar fractures are not fixed in all patients, and syndesmotic fixation only is sufficient. The decision to use 1 or 2 screws depends on the tibial-fibular distance intraoperatively, compared with the contralateral normal side. Wounds are then copiously irrigated and closed with nylon suture with no subcutaneous sutures needed.



Fig. 2. Small incisions for the entry point of nail, syndesmotic screws, and anteroposterior locking screws.

Postoperatively, all patients are scheduled to follow-up within 2 weeks for monitoring of the fixation and progress of the wounds. All patients are made non-weightbearing in a splint during this period. Patients are encouraged to follow-up postoperatively and contacted via telephone numbers provided at the time of registration. At 2 weeks, the splint is changed to a controlled ankle movement boot. Progressive weightbearing or further immobilization is based on clinical examination and radiographic healing findings.

Results

Eighteen patients underwent minimally invasive internal fixation using the Fibula Rod system (Acumed®). There were 8 male patients (44.4%) and 10 female patients (55.6%) with an average age of 61 (range 22 to 89) years. Six patients had isolated lateral malleolus fractures (33.3%), 8 had bimalleolar fractures (44.4%), and 4 had a trimalleolar pattern (22.2%). There were 2 (11.1%) patients with fracture dislocations and 6 (33.3%) patients with open fractures. Both patients with preoperative dislocations had good fracture reductions and stability that held with the fibular intramedullary nail. The average follow-up time was 291.1 (range 31 to 820) days. Four (22%) patients had medial malleolus fixation in which medial malleolus fracture was found to affect the stability of the ankle. Of those 4 patients, one was done at the time of irrigation, debridement, and external fixation during the index surgery for an open bimalleolar fracture dislocation (Fig. 3A–E). The other 3 were done at the time of definitive fixation. None underwent posterior malleolus fixation. In 6 (33.3%) of the 18 patients, we used 1 syndesmotic screw; the remaining 12 (66.6%) patients received 2 syndesmotic screws (this was determined by the senior author [A.A.] based on the severity of the fracture and the quality of bone). None of the syndesmotic screws broke or required reoperative removal. The average time to surgery was 14 (range 1 to 60) days. All patients healed without complications, subluxations, or widening of the syndesmosis.



Fig. 3. (A) A female, aged 55 years, with severe sequelae of diabetes in the foot and previous great toe amputation. The patient fell down and suffered an ankle fracture dislocation. Owing to complications in her foot because of diabetes, previous amputation, and severe contusion of the soft tissue, external fixation was applied. (B, C) Anteroposterior (AP) and lateral (LAT) view of the ankle showing bimalleolar fracture. (D, E) AP and LAT views of the ankle at 12 weeks of follow-up with maintenance of reduction.

Three of the 18 (16.7%) patients were lost to follow-up. None of the other 15 (83.3%) patients had wound or implant complications, and all of them had maintenance of reduction at the time of weightbearing. None of the syndesmotic screws broke or required postoperative adjustment. The duration to weightbearing was determined by the senior author (A.A.) and ranged from 2 to 6 weeks, with the upper limit of that range being necessary for the patients who underwent fixation for severe bimalleolar/trimalleolar fractures. Most patients did not adhere to the non-weightbearing protocol. The exact time to weightbearing was difficult to document because many patients reported

being non-weightbearing, despite being able to walk with full weight-bearing in the clinic.

Seven (38.9%) of the 18 patients provided answers to the functional outcome questionnaire (American Academy of Orthopedic Surgery Foot and Ankle Outcomes Instrument) with an average score of 83 and a median of 91 (range 36 to 98). The 1 patient with a reported score of 36 sustained an open bimalleolar fracture dislocation and was found down after an unknown amount of time. The other 11 (61.1%) patients were not reachable for the functional outcome score.

Ten (55.6%) patients were diagnosed with diabetes mellitus (Fig. 4A–F). Three (16.7%) patients were chronic alcoholics with 1 of the 3 having end-stage liver disease. Five (27.8%) patients had severe hemorrhagic blisters that necessitated external fixator placement as temporary management before the definitive fixation.

Discussion

ORIF of lateral malleolus ankle fracture using standard plating techniques remains the most well-established method for the treatment of ankle fractures, but it includes a considerable incidence of postoperative complications, especially in elderly patients and those with multiple comorbidities (11,13,17). In a retrospective review of 25 patients over the age of 65 years and 46 patients under the age of 65 years age who underwent operative treatment of ankle fractures, Anderson et al (11) found that the number of postoperative complications and the need for nursing home placement was higher in the above 65 year age group.

Fibular intramedullary nailing has been proposed as a viable alternative for distal fibular fracture fixation in high-risk patient populations. A prior randomized controlled trial presented the intramedullary nail as an attractive option over conventional ORIF, reporting a 16% wound infection rate in the ORIF group and 0% in the intramedullary nail group. These investigators also found more favorable functional outcomes in the intramedullary nail fixation group, as well as an overall decreased cost despite an initially more expensive implant choice (18).

A recent prospective randomized study comparing ORIF with intramedullary nailing for lateral malleolar fractures showed no significant difference in the rate of union between the 2 types of fixation and significantly fewer complications (7% vs 56%), with better functional scores with intramedullary nailing than with plate fixation (19). A 2014 systematic review article by Jain et al (14) on clinical and functional outcomes after fibular intramedullary nailing found that the mean union rate was reported to be 98.5% (including a union rate of 100% for unlocked nails and 98% for locked intramedullary nails). The intramedullary nail has also been found to allow for earlier weightbearing than conventional fixation, as much as 6 weeks earlier (20).

Rajeev et al (21) and Walton et al (22) also found that the use of fibular nails (SST Small Bone Locking Nail, Biomet Orthopedics, Warsaw, IN) and (Fibulock, Sonoma Orthopedics, Buffalo Grove, IL) were an advantageous and successful method of treating fragility fractures with a very low risk of complications, as well as restoration of function and patient satisfaction. Their data showed that this treatment modality is effective for high-risk patients, because the minimally invasive nature of this approach can decrease the most common complications of wound breakdown and infection. Our results mirrored the established literature; we also found low complication rates (both wound complications and fixation complications) in our series of patients.

A study that reviewed an American College of Surgeons National Surgical Quality Improvement Program database of 4412 patients discussed those who underwent ORIF of ankle fractures with insulin-dependent diabetes mellitus. The study found that insulin-dependent diabetes mellitus was associated with an increased rate of adverse events (10) (Table 2).

More than one half of our patients were diabetics, with some controlled, but the majority were uncontrolled according to the

hemoglobin A1C levels obtained while under our care. All included patients had additional comorbidities and all exhibited signs of diabetic-related complications such as neuropathy and poor skin on distal regions of extremities.

Poor wound healing is a known complication of advanced diabetes. Vascular damage and poor blood flow inhibit angiogenesis and tissue



Fig. 4. (A) A male, aged 64 years. The patient has severe diabetic neuropathy that resulted in Charcot foot. The patient underwent surgery to partially correct the shape of the foot 1 year before this ankle surgery. The patient presented in another facility and was told that he cannot have surgery owing to the high chance of complication and possible amputation. (B, C) Anteroposterior (AP) and lateral (LAT) radiographs of the foot showing the rocker bottom deformity, implant of previous surgery and Charcot changes of the foot. (D) AP radiograph showing bimalleolar ankle fracture. (E, F) Radiographs taken at 10 weeks follow-up showing maintenance of reduction despite patient weightbearing. Intraoperative final radiographs. Patient started weightbearing few weeks after surgery in a boot.

Table 2
Literature review

Author, Year	Class of trial	Fixation Method	No. of Patients	Age of Patients, Mean (Range)	Rate of Union (%)	Complications (%)	1+ Year OMS, Mean (SD)
White et al (2016) (18)	Randomized controlled trial	Nail	50	74 (65–88)	98	12	62.5 (17.6)
		ORIF	50	74 (65–93)	98	36	58.9 (19.9)
Asloum et al (2014) (19)	Randomized prospective study	Nail	28	55 (22–81)	100	2	97.32 (3.72)
		ORIF	32	52 (18–90)	94	56.25	82.66 (15.24)
Rajeev et al (2011) (21)	Retrospective review	Nail	24	79 (71–91)		0	58.125 (6.00)
Anderson et al (2008) (11)	Retrospective review	ORIF	25	48.5 (18–64)	100	11	74
		ORIF	25	77 (65–93)	4	40	73
Basques et al (2015) (10)	Retrospective cohort study	ORIF	4412	51 (N/A)		5	
Jain et al (2014) (14)	Systematic Review	Unlocked nail	290	51.6 (37–74)	100	Mean 8.5; range 0–16	
		Locked nail	627	60.7 (36.3–79)	98	Mean 12; range 0–33.3	

Abbreviations: N/A, not applicable; OMS, Olerud-Molander score; ORIF, open reduction and internal fixation; SD, standard deviation.

remodeling and cause wounds to remain open to infection. The integumentary system is a vital part of the innate immune system and is compromised in these individuals. Chemotaxis and phagocytosis are also decreasing in diabetic patients, reducing their ability to fight infection. Additionally, diabetic neuropathy can lead to patients neglecting wounds and believing that they can bear weight earlier than a healthy individual would owing to a decreased pain response (23–25). This finding was critical to our decision to act conservatively in postoperative management and to maintain patients non-weightbearing longer than we might for healthier patients to decrease the complications associated with this risk.

In addition to the successful implementation of the fibular intramedullary nail for unstable ankle fractures in these high-risk patients, we also noted the ability to maintain reduction and restoration of the mortise in bimalleolar fractures without fixation of the medial malleolus. In most cases, the most significant contributor to normalization of ankle biomechanics is the integrity of the medial buttress (26). In 2009, Davidovitch and Egol reviewed (27) the importance of the medial malleolus osteoligamentous complex in ankle fractures, described the shifting trends throughout history in treating bimalleolar ankle fractures. The necessity of medial malleolar fixation in bimalleolar ankle fractures is debated in our patient population (26).

Fixation of the fibula was able to restore the mortise in most of our patients. Medial malleolus fixation was added in cases of increased medial clear space after fixation of the fibular fracture. Our small study cohort was able to demonstrate maintenance of ankle stability with isolated fixation of the fibula in bimalleolar ankle fracture. In these high-risk patients, decreases the need for medial fixation helps to prevent another insult to the already compromised soft tissue envelope.

In our series, we used syndesmotic fixation (through the nail) in all patients. We stressed the ankle after fibular fixation to assess the stability of the ankle joint and the need of medial malleolus fixation. Our theory was that, in these high-risk patients, the added stability of intranail syndesmotic fixation was warranted even if the syndesmosis was stable, with the plan to leave the screws without reoperation for removal.

Despite our low complication rate using locked fibular intramedullary nails, we only consider this method of treatment for a subset of patients. Several circumstances factored into patients being appraised for fibular intramedullary nail as a treatment modality for ankle fracture, including comorbidities and risk factors for postoperative complications, as well as likelihood of follow-up and compliance with postoperative instructions. Only about 2% to 3% of our patients treated for ankle fracture met our criterion to undergo fibular intramedullary nailing.

For several of our patients, resources and ability to travel were considered, whereas others presented with poorly controlled diabetes and/or histories of substance abuse. Follow-up for patients with alcoholism and other psychosocial factors is historically poor, and it was one of the

decisive factors to offer this treatment option to these patients (28). The greatest possible efforts were made to ensure a complete follow-up in the form of multiple telephone call attempts. As a result of this poor follow-up, we were unable to collect meaningful functional and outcome-related data for all patients. Despite this inherent weakness, our study, at least in the short term, does demonstrate the merits of using a fibular intramedullary nail in the treatment of ankle fractures in patients who are at high risk for postoperative wound complications, hardware failure, or who may not be compliant with follow-up intervals or with postoperative protocols. All of our patients healed without any complications or hardware failure (nail or broken syndesmotic screws).

Noncompliance with postoperative weightbearing restrictions in a significant percentage of our patients did not result in fixation failure. Our protocol is to be conservative with these high-risk patients and let them be non-weightbearing for 2 to 6 weeks after surgery, follow them closely, and let them gradually bear weight. We understand that this practice may be more conservative than the current trend to weight bear as early as possible, but we are confident that care plan this is the best possible to avoid postoperative complications in this particular group of patients. Medial malleolus fixation was not needed for most patients and was not found to affect the stability of the ankle joint.

The use of a fibular intramedullary nail in high-risk patients with multiple medical comorbidities is a viable alternative for fracture fixation. It is minimally invasive and a relatively quick procedure. Surgeons should consider fibular intramedullary nail fixation for ankle fracture when treating patients with increased risk factors and when compliance with follow-up and protocols are a concern.

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