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Lateral malleolus closed reduction and internal fixation with intramedullary fibular rod using minimal invasive approach for the treatment of ankle fractures

Oded Coifman[a], Jason T. Bariteau[b], Nachshon Shazar[a], Shay A. Tenenbaum[a,*]

[a] Department of Orthopedic Surgery, Chaim Sheba Medical Center at Tel Hashomer, Affiliated to the Sackler Faculty of Medicine, Tel Aviv University, Ramat Gan, 5262100 Tel Aviv, Israel
[b] Emory University School Medicine Department of Orthopedics, 59 Executive Park South Atlanta, GA 30329, United States

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ABSTRACT

Background: Ankle fractures are extremely common and represent nearly one quarter of all lower-limb fractures. Techniques for fixation of displaced fractures of the lateral malleolus have remained essentially unchanged in recent decades. The current gold standard of treating unstable fractures is with open reduction and internal fixation (ORIF), using plates and screws construct. This study evaluates the use of fibula intramedullary nailing based on minimal invasive surgical approach.
Methods: Thirty-nine cases treated with fibula intramedullary nailing between the years 2014–2016 were retrospectively studied. A fibular nail was utilized for the treatment of various ankle fractures either as the sole method of fixation or combined with another method. Patient charts were reviewed for fracture patterns, comorbidities, quality of reduction, complications and additional surgeries.
Results: Out of 39 cases in the study cohort, 37 were closed fractures while 2 had an associated medial malleolus open injury. According to Weber classification of lateral malleolus fractures, 20 cases were type B, 18 cases type C, and one case of a pathologic fracture type B like fracture.
Quality of reduction was based on previously published criteria. It was determined to be good in 32 cases, fair in 5 cases and poor in 2 cases that were revised intraoperatively to plate fixation.
Overall no systemic complications occurred. Eight patients have undergone additional surgeries, namely hardware removals. In two cases, the nail was later revised to a different fixation method: one case to a plate, due to secondary displacement at 2 weeks, and one to an intramedullary tibiotalocalcaneal arthrodesis secondary to hardware failure and Charcot neuroarthropathy.
Conclusion: Intramedullary fibular nail offers a satisfactory and safe procedure to establish good reduction and fixation of lateral malleoli fractures. It may be considered as treatment of choice for patients with soft tissue problems due to its minimal invasive approach. The current study shows that while good fracture reduction can be achieved, without major complications, more than fifth of patients, required secondary procedures, mainly hardware removals.
Level of evidence: Level IV

1. Introduction

Ankle fractures are very common, and represent about tenth of all fractures [1]. Population based studies have shown that the incidence of ankle fractures has increased significantly since the 1960s, and this even more true for elderly patients [2–4]. Overall, about two-thirds of ankle fractures are isolated malleolar fractures, one-fourth are bimalleolar and the remaining 7% are trimalleolar fractures [1]. Techniques for fixation of fractures of the lateral malleolus have remained essentially unchanged since the 1960s. The current gold standard in treating unstable fractures is with open reduction and internal fixation (ORIF) using a plate and screws construct. This technique is some series is associated with a complication rate of up to 30% [5]. Studies have shown that wound associated complications occur in up to 26% of cases [6], symptoms related to prominent hardware occurs in up to 50% of cases [7], and mechanical hardware failure in 14% of cases [8]. Those patients with diabetes patients, who are neuropathic, or elderly are at higher risk for post-surgical complications [9]. The use of an intramedullary fibula fixation was first introduced with the use of

* Corresponding author.
E-mail address: shaytmd@gmail.com (S.A. Tenenbaum).

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Inyo nail in the mid 80's [10]. This technique aims to mitigate some of these surgical complications associated with an ORIF. However, early nail designs were met with complications, secondary to poor rotational and axial instability, which led to nail migration and malunion. Modern nail designs with newer screw technology have been used to eliminate many of the shortcomings of early-generation devices [11]. With a small skin incision and minimal soft tissue dissection the rod offers less prominent hardware, fewer wound complications and potentially greater mechanical stability [1,11,12]. There is paucity of literature to determine reliably whether intramedullary fixation of lateral malleolus fracture offers satisfactory outcome. The purpose of this study is to evaluate our experience of treating unstable ankle fractures with a fibular nail and to assess the outcome of this method of treatment.

2. Materials and methods

A retrospective study was conducted on 39 patients treated with Acumed Fibular nail™ (Hillsboro, Oregon) treated between 2014–2016, either exclusively or combined with other method of fixation.

Patient cohort included 19 males and 20 females, with mean age of 50 years (range 18–97), of them 36 patients were available for follow up. Mean follow up was 9.79 months (range 2–35 months). Patient's charts and imaging studies were analyzed for fracture epidemiological data, patient comorbidities, quality of reduction, incidence of complications, and related additional surgeries.

Quality and adequacy of reduction was determined based on the method described by McLennan and Ungersma [10]. Good reduction was defined as the fibula being out to length; <2 mm posterior displacement; and <1 mm increase in medial clear space. A fair reduction was described as fibular shortening of <2 mm; 2 mm–4 mm posterior displacement; 2 mm lateral displacement; and 1 mm–3 mm increase in medial clear space. A poor reduction was defined as fibular shortening >2 mm; >4 mm posterior displacement; >2 mm lateral displacement; and >3 mm increase in medial clear space (Table 1).

2.1. Surgical technique

The Acumed fibular nail is a solid titanium nail. Surgery is performed under general or spinal anesthesia with the patient supine. A tourniquet is required only if open reduction of the medial side is planned. A preliminary closed reduction of the ankle fracture is performed. Depending on surgeon's preference fibular reduction can be achieved and maintained with a clamp prior to nail insertion, or the nail can be inserted first and following distal fixation it can be manipulated (distraction and rotation) to achieve lateral malleolus reduction. First, a 1 cm longitudinal incision is made just distal to the tip of the lateral malleolus. The fibula distal metaphysis is prepared with a cannulated drill over a guide wire. The diaphysis is reamed, after which the nail is inserted. One or two anterior to- posterior distal locking screw which stabilize the distal fragment, are inserted up to the posterior fibular cortex but do not penetrate it, so as to avoid peroneal tendon irritation. Following the distal fixation, if reduction was achieved and held with a clamp, the nail is fixated with a transverse syndesmotic screw, which prevents secondary displacement. If reduction was not achieved yet, the nail should be manipulated (with distraction and rotation), under fluoroscopic guidance, to achieve anatomical reduction of the mortise. Once reduction is achieved, the nail is fixated with a transverse syndesmotic screw, which prevents secondary displacement.

Post-operative rehabilitation protocol consisted of non-weight bearing aided walking for 6 weeks with a splint/boot, with active range of motion commencing at 2 weeks after surgery. Fig. 1a–d depicts an exemplary case of an ankle trimalleolar fracture dislocation treated successfully with the AFR.

3. Results

Of 39 cases reviewed, 37 patients had closed fractures, and 2 had associated open fractures of the medial malleoli graded 1 and 3 by Gustillo classification. According to Weber classification, 20 cases were type B and 18 cases type C. One case was a pathologic fracture (Metastatic Lung Adenocarcinoma) type B like fracture.

This case was an 87 year-old man who presented with a pathological fracture of the distal tibia and the medial cortex of the distal fibula. Patient was treated with plate and cement construct for fixation of the tibia, and intramedullary nail to the fibula.

The pattern of fractures and fixation methods other than the fibular intramedullary nail for the lateral malleolus is presented in Table 2.

Patients were operated on average 6.61 days following injury (30 on the first 7 days, 8 were operated later due to soft tissue problems, and a pathologic fracture operated 6 weeks following fracture diagnosis).

On average, each patient had 1.1 comorbidities (Table 3).

Quality of reduction based on specific criteria as published by McLennan and Ungersma [10] was good in 32 cases, fair in 5 cases and poor in 2 cases that were revised intraoperatively to plate fixation. All but one fractures proceeded to union.

Overall no systemic complications occurred, one deep wound infection was observed and a single minor superficial infection was noticed and successfully treated with oral antibiotics.

Eight patients out of 34 patients treated with a nail and available for followup, had undergone additional surgeries. Three patients had soft tissue irritation due to prominent hardware and were treated with nail removal. One patient had undergone syndesmotic screw removal and SPN neuroma excision. One patient was treated with a syndesmotic screw removal, and one patient with deep wound infection 3 months following index surgery, was treated with hardware removal and debridement.

In two cases, the nail was revised to a different fixation method. One case was revised to a plate, due to secondary displacement 2 weeks following nail insertion. In In one case, the patient was not identified before surgery to have severe diabetic neuropathy, and developed Charcot arthropathy. Unfortunately, this resulted in hardware failure and loss of reduction (Fig. 2). The patient was revised with tibiotalocalcaneal arthrodesis and intramedullary nail fixation.

Summary of complications is presented in Table 4.

Table 1
Quality of reduction based on McLennan et al. criteria.

Quality of reduction	MCS widening	Posterior displacement	Fibular shortening
Good	<1 mm	<2 mm	None
Fair	1–3 mm	2–4 mm	<2 mm
Poor	>3 mm	>4 mm	>2 mm

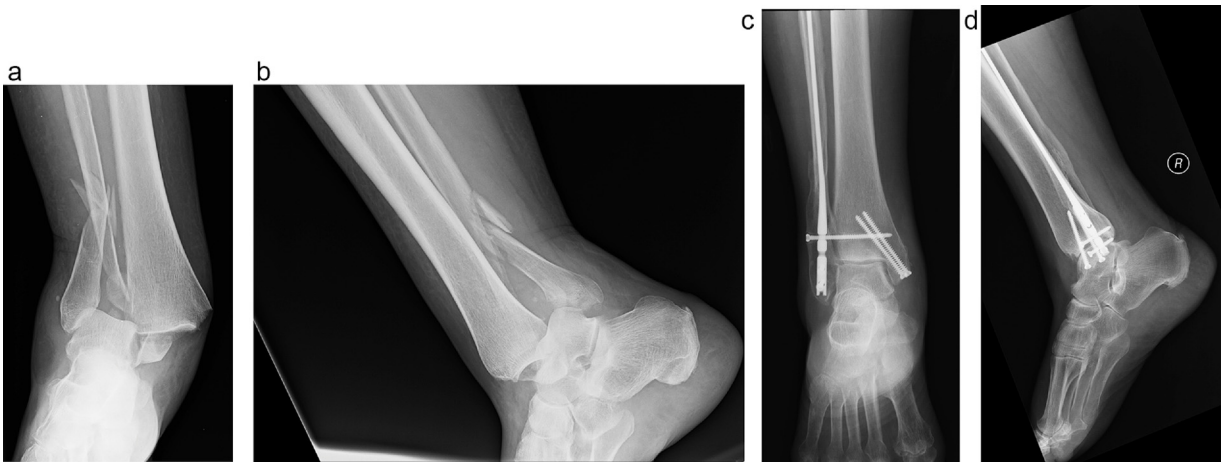

Fig. 1. (a and b) (AP and LAT views) showing the preoperative and postoperative (c and d) result of ankle fracture-dislocation reduction and fixation using the AFR.

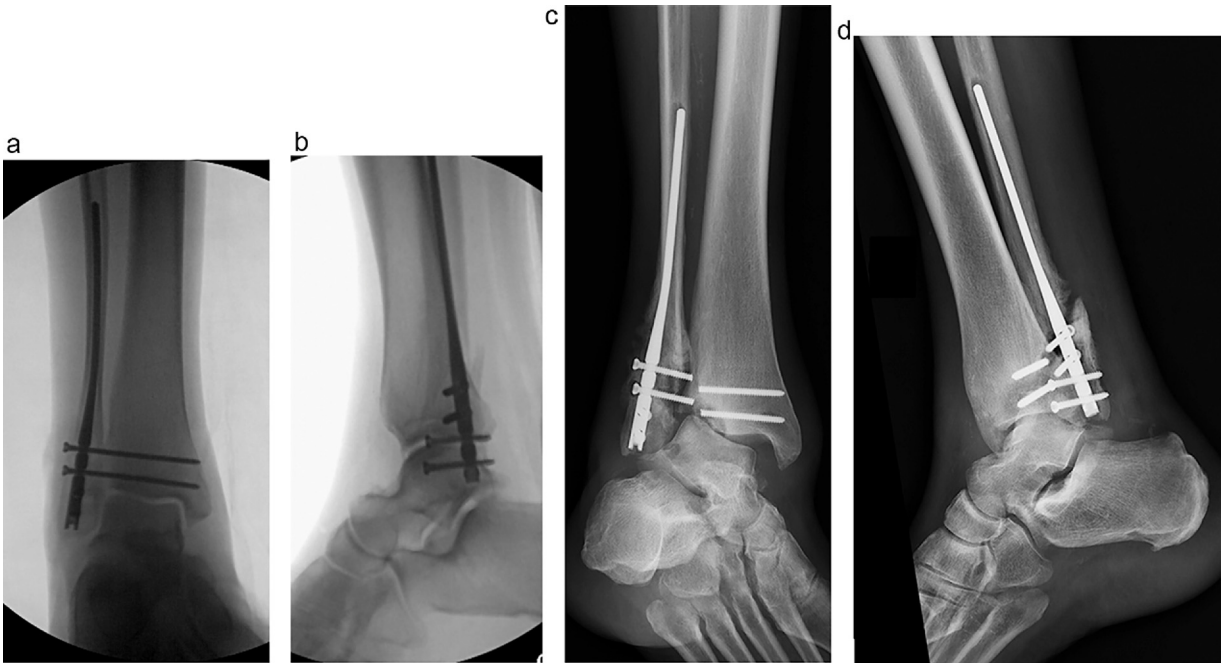

Fig. 2. (a and b) (AP and LAT views) showing immediate postoperative result, and (c and d) (AP and LAT views) taken 4 months following surgery showing hardware failure in a patient with neuroarthropathy.

4. Discussion

Unstable or displaced ankle fractures are most commonly treated by open reduction and internal fixation, using techniques that have not changed significantly for many years and are associated with a considerable rate of complications, particularly in osteoporotic bone. Hardware and scarring can be symptomatic and may require secondary surgery. The complication rate following ORIF in the elderly is up to 40% in some reports [13]. Complication rate is also considerably higher in patients with systemic disease, particularly diabetes and neuropathy [9], in those with compromised local soft tissues, and smokers [14]. Intramedullary fixation of the fibula minimizes soft tissue dissection. Successful results with lower rates of wound breakdown and hardware prominence compared with standard open reduction and plating have been reported [2,10,15–19].

Table 2
Ankle fracture patterns and added fixation methods (other than AFR).

Type of fracture	Number of cases (n, % of cohort)	Added fixation methods
Isolated lateral malleolus	14 (36%)	–
Bimalleolar	23 (59%)	13 Tension band wire 10 screw fixation (for medial mall. Fracture)
Lateral malleolus and distal tibia	1 (2.5%)	Intra medullary nail for tibia
Pathological fracture	1 (2.5%)	Distal tibia was partly resected and fixated with cement and plate construct

Table 3
Patients' comorbidities.

Comorbidities	Number of patients
Hypertension	13
IHD	5
DM	8
Smoking	3
Obesity	2
Neuropathy	1
CRF	1
Hypothyroid	2
CVA	2
Mental	7
Epilepsy	1
None	19

The main criticism of this technique is that it is not rigid enough [20]. However, an interlocking nailing system cannot be compared to simple percutaneous nailing systems.

The AFR is unique in allowing secure cross-locking of the fracture fragments and syndesmotic fixation, thereby maintaining tibiotalar congruence as well as fibular length and rotation.

The current study shows that satisfactory reduction was achieved in the vast majority of cases, with a small rate of complications. However, 23.5% (8 of 34) patients required additional surgeries, of whom five cases were hardware removals. A major complication with loss of reduction and failure of the fixation occurred in a patient with Charcot neuroarthropathy. This is in accordance with the literature showing major complications and loss of fixation in this patient population subset [21,22].

A study by Bugler et al. [2] described the evolving surgical technique of using the AFR with various fixation options. Authors reported on a group of a total 105 patients, of which 21 were treated with the same fixation method as described in the current study i.e. using a distal syndesmotic locking screw. In that cohort there were no significant wound complications and only one superficial infection. Good fracture reduction was achieved in all of the patients, without fracture nonunion. However, authors reported one case of complete syndesmotic diastasis 10 weeks following surgery, in a morbidly obese patient. The patient was full weight bearing immediately after surgery, and although the fracture united uneventfully, the diastasis recurred after ten weeks. Patient was treated successfully with reduction and second syndesmotic screw.

Asloum et al. [20] reported similar results in a prospective, randomized and comparative study of internal fixation with a plate versus a nail. The authors reported that fibular nailing using the Epifisa nail resulted in union in all cases (100%) with postoperative complications in 7% of cases, compared with 94% onion rate and 56% postoperative complications in the plating group. Interestingly, authors reported on 7 cases in which intramedullary nailing was technically impossible (fracture was severally comminuted, fibula too narrow proximally or persistent tibiofibular diathesis) and converted to plate fixation. These situations were encountered by the authors of the current study as well, who share the same experience as Asloum et al.

White et al. [23] conducted a randomized controlled study, comparing standard plate and screw fixation to fixation with a fibular intramedullary nail. Authors reported that patients treated with fibular nail had significantly fewer wound complications. Furthermore, at one year followup, no significant difference in functional outcome scores (Olerud and Molander) was detected. However, authors reported that in 10% of patients, hardware removal was performed.

Comparing the current study to previous reports, there is no difference in the rate of union or complications. However, this study reports a higher rate of secondary procedures, specifically hardware removals.

Also, based on our cohort, special consideration and caution should be applied when choosing a fixation method for patients with Charcot neuroarthropathy. It is the authors opinion that the fact the only catastrophic mechanical failure was observed and treated in a patient with Charcot arthropathy, should raise concern and caution the surgeon against using the AFR in this subset of patient population. The mechanical strength of fixation achieved with the AFR alone, may not suffice in these cases. Although definite conclusions on this matter should be subjected to further research, the authors of this study, cannot recommend using the AFR in patients with recognized preoperative neuroarthropathy.

A few limitations of the current study should be recognized. First, the current study does not provide data regarding clinical outcomes based on questionnaires or outcome scores. Second, this is a retrospective study, with a small cohort of patients, with a few cases lost in followup. Third, in part of cases, only short term followup data were available.

Table 4
Summary of complications.

Description	No.
HWR removal	3 nail removals d/t irritation 2 syndesmotic screw removals
Deep infection	1 treated with HWR removal and debridement
Superficial infection	1 treated with oral antibiotics
Non union	1 case
Nerve injury (neuroma)	1 SPN neuroma excision
Post operative revisions	2 d/t secondary displacement

5. Conclusion

In this study, it is shown that fixation of fibula fractures with an intramedullary nail, using minimal invasive approach, can result in satisfactory reduction and fixation. However, while a low rate of complications was observed, many patients required secondary procedures, mainly hardware removals.

This technique can be considered as treatment of choice for those patients with soft tissue envelope problems prior to surgery or for patients with higher risk for post-surgical complications such as elderly and diabetic patients.

Further randomized comparative studies should be performed to show the non-inferiority or the equivalence of this technique in a larger number of patients to clearly validate this surgical indication.

Conflict of interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. The authors received no financial support. All authors were fully involved in the study and preparation of the manuscript and that the material within has not been and will not be submitted for publication elsewhere.

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