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Intramedullary nail fixation of fibular fractures in combination with extra-articular distal tibial fractures (AO/OTA 43A): a single-center retrospective study

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Treatment of fibular fractures associated with extra-articular distal tibia fractures is technically challenging and the purpose of this study was to evaluate the use of intramedullary nail fixation of fibular fractures when associated with this fracture. Between January 2018 and December 2021, 33 patients presenting extra-articular distal tibia fractures and fibular fractures (AO/OTA 43A) were treated. Clinical and radiological data were collected during routine postoperative follow-ups. Thirty-one patients were monitored for a period of time ranging from 12 to 23 months, with an average follow-up of 17.5 ± 3.3 months. Fibular bone union took an average of 3.6 ± 0.9 months. At the last follow-up, the average fibular alignment and postoperative ankle talocrural angles were 1.8° and 9.1°, respectively. No detectable radiographic rotational malalignment and serious complications related to the fibular incision was observed. The average AOFAS and OMAS scores at the most recent follow-up were 88.3 ± 6.2 and 87.4 ± 6.0, respectively. Intramedullary nail fixation worked well to keep the fibula in place in fibular fractures connected to extra-articular distal tibia fractures.

Keywords: Distal tibial metaphyseal fractures, fibular fractures, intramedullary nail, AO/OTA classification, soft tissue injury.

INTRODUCTION

Intramedullary nail fixation is a well-established technique for stabilizing non-pilon fractures of the distal tibia metaphysis[1]. However, comparative biomechanical studies have shown that a concomitant fibula fracture can make the distal tibia more unstable[2] regardless of the use of locking plates or intramedullary nails. Therefore, obtaining fibular alignment helps in the reduction of distal tibial fractures and allows for reduction prior to placement of a tibia intramedullary nail. In addition, when treating distal extra-articular tibiofibular fractures with intramedullary nailing, fibular fixation will reduce the likelihood of late malalignment[3]. In intramedullary nailing of the distal tibial epiphysis, one method of achieving length, alignment, and rotation is through the use of a fibular plate, which has been shown to be closely associated with the ability to maintain tibial fracture reduction[4]. The use of a plate, however, may increase the risk of soft tissue injury in patients with pre-existing soft tissue damage over the fibula the leading to complications such as hardware failure or prominence, irritated soft tissues, and nerve damage[5,6].

To address these issues, a small-diameter intramedullary device that can be implanted percutaneously has been developed to stabilize fibula fractures and reduce soft tissue stress. Its superiority has been extensively reported to be comparable to the fibular plating[7,8]. Therefore, this study aims to evaluate the radiological outcomes, rate of union, and incidence of postoperative complications following intramedullary nail fixation of fibular fractures associated with AO/OTA 43A extra-articular distal tibia fractures.

METHODS

This retrospective study analyzed consecutive clinical cases in which written informed consent was obtained from all patients prior to the procedure. All techniques used throughout this investigation complied with the 2013 revision of the 2013 Helsinki Declaration and the institutional research committee's ethical guidelines. Between January 2018 and December 2021, patients

Table I. — Clinical parameters of the patients

Patients No	Age/ Gender	Causes Of Injury	Injury Type	Fracture Type	Combined Injury	Comorbidities
1	29/Male	Heavy object crushes	Open fracture	43A3.3, Gustilo IIIa	Ipsilateral phalangeal fracture	-
2	40/Male	Traffic accident	Closed fracture	43A3.1	-	Hypertension
3	19/Male	Fall from height	Closed fracture	43A1.2	-	-
4	58/Male	Traffic accident	Closed fracture	43A1.2	-	-
5	61/Male	Heavy object crushes	Closed fracture	43A1.3	Contralateral calcaneal fracture	-
6	72/Female	Sprain	Closed fracture	43A1.1	-	Hypertension, Diabetes
7	59/Female	Sprain	Closed fracture	43A1.3	-	-
8	50/Male	Fall from height	Closed fracture	43A2.3	Traumatic brain injury	Diabetes
9	36/Female	Heavy object crushes	Open fracture	43A3.3, Gustilo IIIa	Ipsilateral metacarpal fractures	-
10	25/Male	Traffic accident	Closed fracture	43A3.2	-	-
11	31/Male	Traffic accident	Closed fracture	43A3.2	-	-
12	48/Female	Traffic accident	Open fracture	43A2.2, Gustilo II	-	-
13	56/Male	Heavy object crushes	Open fracture	43A1.1, Gustilo I	-	Diabetes
14	23/Female	Traffic accident	Closed fracture	43A2.1	-	-
15	36/Female	Traffic accident	Closed fracture	43A2.3	-	-
16	30/Male	Traffic accident	Closed fracture	43A2.2	Rib fractures	-
17	52/Male	Fall from height	Open fracture	43A3.1, Gustilo IIIa	Ipsilateral fifth metatarsal fracture	-
18	34/Female	Traffic accident	Closed fracture	43A1.3	Hematopneumothorax	-
19	71/Male	Traffic accident	Open fracture	43A3.2, Gustilo II	Ipsilateral distal radius fracture	COPD*
20	26/Female	Fall from height	Open fracture	43A2.3, Gustilo II	-	-
21	33/Female	Heavy object crushes	Open fracture	43A2.3, Gustilo II	Ipsilateral patella fracture	-
22	25/Male	Traffic accident	Open fracture	43A3.1, Gustilo I	-	-
23	18/Male	Traffic accident	Open fracture	43A2.1, Gustilo I	Traumatic brain injury	-
24	49/Male	Traffic accident	Closed fracture	43A3.1	-	-
25	52/Female	Traffic accident	Closed fracture	43A1.1	-	Coronary artery disease
26	27/Male	Traffic accident	Closed fracture	43A1.3	-	-
27	63/Female	Sprain	Closed fracture	43A1.2	-	COPD*
28	69/Female	Sprain	Closed fracture	43A1.2	-	Diabetes
29	29/Male	Traffic accident	Open fracture	43A3.1, Gustilo II	Hematopneumothorax	-
30	36/Male	Traffic accident	Closed fracture	43A2.1	Contralateral tibial fracture	-
31	41/Male	Traffic accident	Closed fracture	43A3.1	-	-
32	53/Male	Sprain	Closed fracture	43A2.1	-	-
33	24/Female	Fall from height	Open fracture	43A3.2, Gustilo II	-	-

*COPD = chronic obstructive pulmonary disease.

diagnosed with extra-articular distal tibia fractures and fibular fractures we examined at our level 1 trauma center. Of the 33 patients identified, 20 were male and 13 were female, ranging in age from 19 to 72 years (mean age: 41.6 ± 15.7 years). The AO/OTA classification identified 11 patients with 43A1 fractures, 10 with 43A2 fractures, and 12 with 43A3 fractures.

Twelve of the 33 patients had open fractures (3 Gustilo I, 6 Gustilo II, and 3 Gustilo III), while 12 had associated injuries, including traumatic brain injury (2), hemopneumothorax (2), multiple rib fractures (1), phalangeal fracture (1), calcaneal fracture (1), fifth metatarsal fracture (1), distal radius fracture (1), patella fracture (1), and tibial fracture (1). Eight of the patients had comorbidities, such as diabetes (3), chronic obstructive pulmonary disease (2), hypertension (2), and coronary artery disease (1). Table I displayed detail clinical patient parameters.

Patients with systemic conditions or organ ailments were prioritized and stabilized prior to the treatment of their fracture. Three patients presented with open Gustilo I fractures and received suturing and debridement. For patients with Gustilo II or III open fractures, debridement and first external fixation were performed on the day of admission. Surgery was then performed after the condition of the soft tissue in proximity to the operation site had improved. In all patients, the afflicted leg was elevated and ultrasound was performed to rule out thrombosis in the affected deep vein. Patients were also encouraged to perform ankle pump exercises to minimize swelling of the affected limb. Surgery was performed after the swelling had decreased and there were no apparent contraindications; the mean duration before surgery was 6.8 ± 2.5 days, ranging from 4 to 11 days.

Table II. — Outcomes of the patients

Patients No	Follow-up (months)	Bone union (months)	Fibular alignment (°)	Talocrural angles (°)	AOFAS score	OMAS score	Complications
1	21	4	0	8	69	71	-
2	16	5	1	7	95	94	-
3	15	3	2	11	92	90	-
4	22	2.5	4	11	90	88	-
5	23	4	2	14	89	89	-
6	17	5	1	6	85	83	-
7	16	3	1	13	93	94	-
8	18	4	0	8	87	89	-
9	15	3	1	9	81	78	-
10	20	3	3	6	94	95	-
11	23	2.5	0	6	95	93	-
12	15	5	2	7	88	86	-
13	17	3	4	9	96	96	-
14	20	4	1	6	92	90	screw loosening
15	21	3	0	12	93	94	-
16	13	5	1	8	86	85	-
17	19	4	2	6	79	77	-
18	14	4	2	11	81	80	-
19	17	3	3	10	84	82	-
20	17	3	1	7	90	88	-
21	20	2.5	2	11	92	89	-
22	15	3	0	10	82	84	-
23	20	5	4	9	91	90	screw loosening
24	22	3	2	7	92	90	-
25	17	5	3	7	90	87	-
26	12	4	3	13	78	79	-
27	Lost to follow-up	-	-	-	-	-	-
28	15	3	1	8	94	92	-
29	21	4	1	10	85	84	-
30	13	4	4	11	88	87	-
31	12	4	3	9	90	90	-
32	16	2.5	2	10	96	95	-
33	Lost to follow-up	-	-	-	-	-	-

In supine position on a fluoroscopic surgical table, the patients underwent general or epidural anesthesia. The fibula had an indirect reduction at first. Then, at the ankle, a 1~2 cm incision was made directly distal to the lateral malleolus. With a 2.5-mm drill, the fibular intramedullary canal was initially opened and retrogradely bored throughout the fracture site. A 3.5-mm drill was then used to bore the canal along the whole shaft. The implant (Acumed fibular nail, Acumed, Hillsboro, OR, USA) was implanted backwards. Laterally, a 5-mm incision was created at the ankle. A 2.7-mm unicortical screw was then used to secure the nail into the lateral malleolus through the nail's eyelet.

Twelve patients with open fractures received the fibular intramedullary nail at their second surgery after definitive debridement surgery with or without temporary external fixation, while twenty-one patients with closed fractures were treated with definitive fixation of the fibula and tibia at their first surgical procedure. All tibia fractures were treated with either an intramedullary nail (13) or standard screw and plate fixation (20) depending on the patient's condition.

All patients received 24 hours of intravenous antibiotics postoperatively, active and passive functional exercises were initiated postopratively. Full weight-bearing exercise was allowed once bridging callus formation was evident on radiographs.

After surgery, patients were closely monitored and radiographic analysis was performed to assess fracture healing, fibular alignment, talar angulation, and unhealed rates. The Olerud Molander Ankle Score (OMAS) and the American Orthopaedic Foot and Ankle Society (AOFAS) score were used to assess functional outcomes.

RESULTS

All but two patients were monitored for a mean follow-up time of 17.48 ± 3.25 months (range: 12-23 months) after surgery. All patients achieved solid fibular fracture

Figure 1. — Representative images of patient 2 (40-year-old male, 43A3.1 closed fracture) — a, b: X-rays at admission. c, d: X-rays at 5 days after surgery. e, f: X-rays at patient's follow-up visit two months later. g, h: X-rays at 4 months later, with visible bone union.

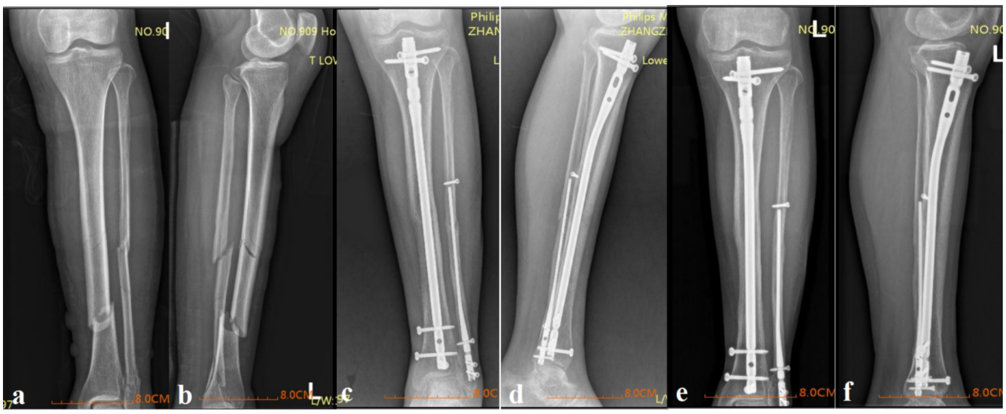

Figure 2. — Representative images of patient 7 (59-year-old female with a sprain to her left ankle). — a, b: Radiographs at admission. c, d: Follow-up radiographs at 2 months. e, f: Follow-up radiographs at 4 months, all fractures were united and the fibula was in good alignment and length.

union, with an average healing time of 3.6 ± 0.9 months (range: 2.5~5.0 months). The average fibular alignment and postoperative ankle talocrural angles at the final follow-up were 1.8° (range: 0~4°) and 9.1° (range: 6~14°), respectively, with no noticeable rotational malalignment. Two patients required removal of the distal interlocking screws due to soreness caused by screw loosening, but no further complications resulted from the fibular incision. The average AOFAS and OMAS scores at the final follow-up were 88.29 ± 6.19 and 87.39 ± 6.01, respectively. Outcomes of the patients were shown in Table II while typical cases were shown in Figure 1 (Case 2), Figure 2 (Case 7), Figure 3 (Case 9) and Figure 4 (Case 23).

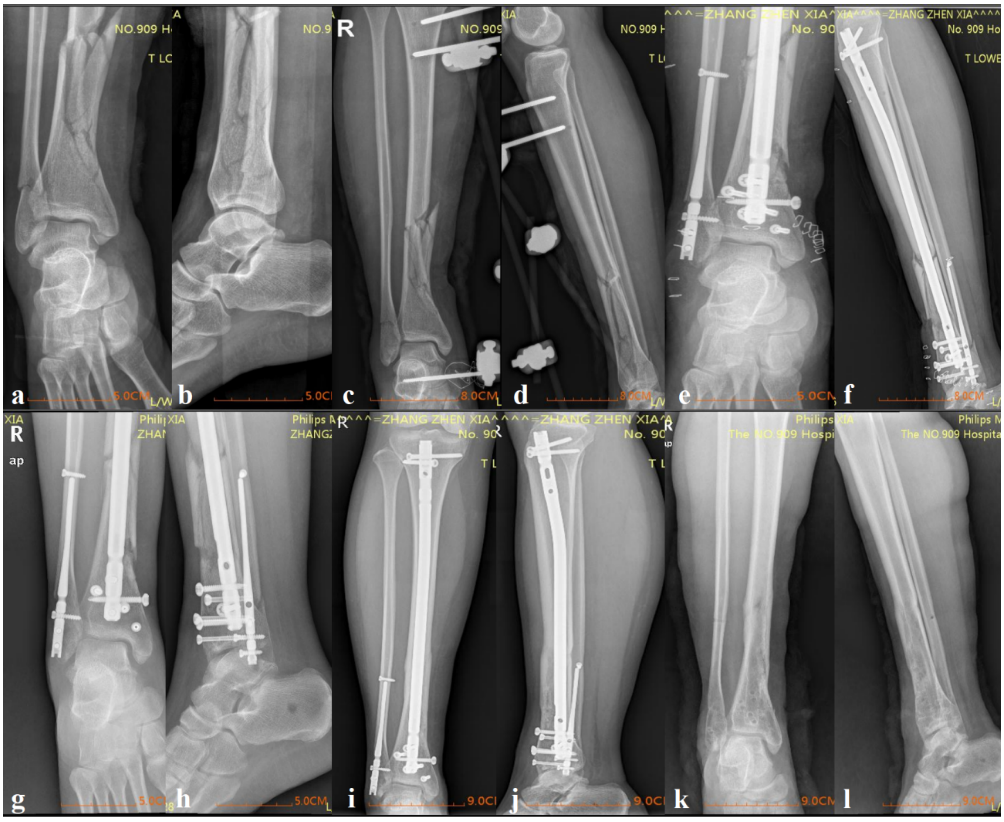

Figure 3. — Representative images of patient 9 (36-year-old female patient with a Gustilo IIIa fracture resulting from a heavy object crush). — a,b: X-rays at admission. c,d: X-rays of temporary external fixation. e, f: X-rays after 4 days of simultaneous fixation of the fibula and tibial intramedullary nail. g, h: Follow-up X-rays after 2 months. k, l: Follow-up X-rays after 4 months. i, j: Removal of all implants after 12 months.

DISCUSSION

Orthopedic surgeons face numerous challenges when operating on distal extra-articular tibial fractures. Radiographic and clinical outcomes may be poor due to the paucity of surrounding soft tissue and the typical high-energy mechanism of injury. Complications such as nonunion, infection, soft tissue compromise, subsequent osteoarthritis of the knee and ankle, and other common comorbidities have been reported[9]. Therefore, preserving hip-knee-ankle alignment, improving functional outcomes and lowering nonunion and malunion rates of these fractures have become primary goals of surgery[10]. Several surgical fixation techniques have been used to achieve these goals, including intramedullary nailing, minimally invasive plate osteosynthesis (MIPO), and open reduction internal fixation (ORIF) with plates. Although all the three techniques produce good outcomes, each has its own set of limitations. The use of intramedullary nails, for example, has been linked to an increased incidence of malunion and anterior knee pain[11,12]. On the other hand, ORIF and MIPO are associated with an increased risk of infection and longer operating times and radiation exposure[11,12].

The fibula is generally believed to contribute to weight bearing by supporting 6% to 17% of total body weight[13]. Fibular fixation is widely considered necessary to repair the ankle skeleton and reduce the risk of secondary osteoarthritis in cases of combined ankle injuries[14]. However, the role of fibular fixation in the extra-articular distal tibial fracture pattern is a topic of ongoing debate. Biomechanical studies have reported that fibular fixation provides greater stability and helps to maintain reduction of the distal tibial fracture[15]. However, some clinical investigations have yielded conflicting results. Daniel et al.[16] suggested that fibular fixation may increase distal tibia nonunion due to the construct's improved stability. A Meta-analysis revealed that fibular fixation of distal tibial fractures did not decrease the prevalence of varus deformity, anterior-posterior deformity, or reduction, nor did it slow the union process or raise the risk of infection[17]. Infection, revision surgery, and angular malalignment are reported to be more common when the fibula was repaired in individuals with stabilized distal tibia

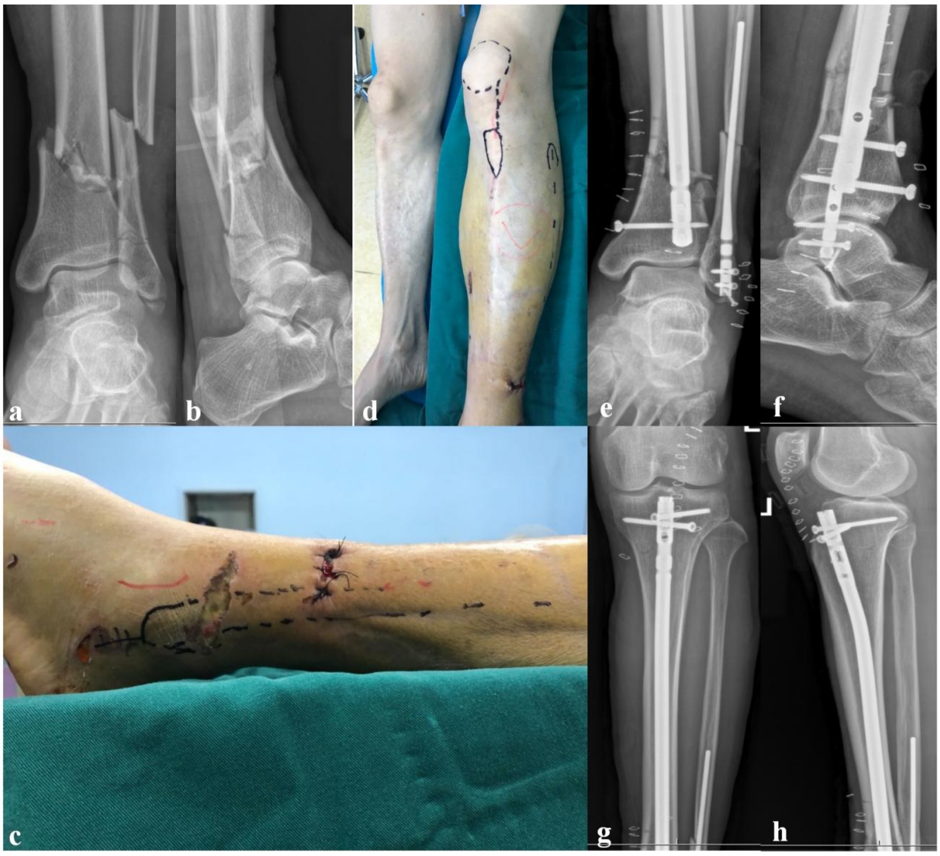

Figure 4. — Representative images of patient 23 (18-year-old female patient with a Gustilo I fracture resulting from traffic accident). — a, b: X-rays at admission. c: Soft tissue injuries to the distal leg. d: Diagram of operation incision. e, f, g, h: Simultaneous fixation of the fibula and tibial intramedullary nail (lateral parapatellar approach). X-rays at 3 days after operation.

fractures[18]. The use of fibular fixation is nonetheless supported by data, particularly in patients who have soft tissue injuries to the distal leg and ankle [10,19]. Therefore, the aim of this study was to evaluate the clinical and functional outcomes of fibular fracture repair using an intramedullary device in an extra-articular distal tibia fracture pattern.

Nail osteosynthesis for the treatment of fibula fractures was first described in 1972[20]. Since then, a less invasive, percutaneous approach and intraosseous fixation have been made possible by the use of intramedullary devices, in which rotation is controlled by distal screws. Thus, the use of a fibular intramedullary nail is currently a common, low risk treatment option for ankle fractures[21, 22], fibular fractures linked to mid- and distal-tibia fractures, and pilon fractures[10, 19, 23, 24]. One benefit of fibular intramedullary fixation is the ability to achieve stability with a smaller incision, which may allow for quicker definitive steadiness in patients with significant edema or fracture blisters. Additionally, the intramedullary location may result in a lower incidence of hardware removal and peroneal tendon irritation[24].

In this study, the patients either had severe soft tissue injuries or multiple serious medical comorbidities. The decision to perform minimally invasive fibular fixation was based on the overall health of the patient and the condition of the soft tissues at the time of the first surgery. Twelve patients had open tibia fractures – including three with Gustilo I, six with Gustilo II, and three with Gustilo III – which often have more flexibility in tibial fixation, fewer wound problems, and skin bridges between incisions are often not required due to the minimally invasive nature of fibular fixation. Fibular stabilization, together with distal tibia intramedullary nailing, has been shown to be considerably more effective in maintaining fracture reduction in previous studies[25]. Furthermore, tibial nailing requires less technical skill since fibular fixation indirectly resets the tibia. Therefore, thirteen patients in this study who received concurrent fibular and tibial fixation had fibular nail performed before tibial intramedullary fixation at the second surgery.

This study had a number of limitations, including its retrospective design, the limited number of patients investigated. To further corroborate this findings, a long-term randomized controlled trial research with a larger significant patient and control group and different fixation techniques should be carried out.

CONCLUSION

Intramedullary nail fixation is a widely used and clinically effective treatment for fibular fractures associated with extra-articular distal tibia fractures. This minimally invasive procedure has a low risk of complication and offers secure internal fixation while preserving fibular alignment and length and delivering a perfect fibular union.

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Conflict of Interest: The authors declare that there were no commercial or financial relationships that could be considered potential conflicts of interest at the time the research was conducted.

Informed Consent: Written Informed consent was obtained from all patients.

Ethics Approval: This study was approved by the School of Medicine, Xiamen University Ethics Committee [Approval No. 2022-5671].

Authors'Contribution: JW and YX wrote the manuscript, analyzed and interpreted the patient data. JZ was responsible for acquisition of data, and analyzed and interpreted the patient data. HL, TC, and WX were responsible for designing the study, and the analysis and interpretation of the data. All authors have read and approved the final manuscript.

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