



# Fibula Fracture: Plate versus Nail Fixation

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**Background:** Intramedullary fixation has only uncommonly been used in the fibula although it may confer some advantages. Our goal was to investigate a single surgeon's learning curve with initial usage of an intramedullary device for fibular fixation based on surgical time and quality of reduction.

**Methods:** Prior to initiation of this study, an experienced ankle fracture surgeon performed fibular nail fixation in a sawbones and a cadaver setting. Between February and August 2018, all patients who suffered from a distal fibula fracture underwent fibula fixation ( $n = 20$ ) using the Fibulock (Arthrex). Patients were retrospectively investigated and compared with a control of fibular plate fixation. The tourniquet time, time of anesthesia, and surgery time were recorded as well as the quality of reduction.

**Results:** In the 20 cases, the mean tourniquet time was  $68.9 \pm 23.2$  minutes for nail fixation, while in the fibular plate fixation group, the mean time was  $75.8 \pm 23.9$  minutes ( $p = 0.37$ ). Two patients had slight malreductions (first and third cases): one was corrected with a lag screw outside the nail, the other was an elderly patient with significant blistering in whom an entirely percutaneous reduction was performed.

**Conclusions:** Intramedullary fixation for fibular fractures does not appear to have a significant learning curve for an experienced ankle fracture surgeon.

**Keywords:** *Intramedullary, Nail, Rod, Fibula, Fracture, Learning curve*

To achieve adequate bony healing after any fracture, a combination of biology and stability must be present.<sup>1)</sup> In ankle fractures that are deemed unstable, open reduction internal fixation (ORIF) is required in an effort to minimize the risk of posttraumatic arthritis. In this setting, the quality of reduction is thought to be of paramount importance and to most closely relate to the risk of subsequent arthritis. Indications include patients with significant medical or social problems as well as smokers and non-compliant patients to lower the complication rate. Lowest complication rates can be observed in minimally comminuted transverse oblique fractures.<sup>2)</sup> What internal fixation is used is ultimately up to the surgeon, with a variety of options available. The basic necessity of internal fixation

for any fracture is that it can first hold the fracture in a reduced position and, second, maintain that position until the fracture is healed. Stated another way, this internal fixation must be able to consistently win the race between fracture healing and hardware failure.

Plate fixation with or without an interfragmentary compression screw is currently used most commonly for internal fixation of these injuries. The track record of plate fixation is quite good, as the rate of both nonunion and hardware-related complications is quite low, although hardware removal rates are relatively high.<sup>3,4)</sup> Any other means of fixation would have to maintain those good results and perhaps improve on the few shortcomings of plate fixation. A potential advantage of an intramedullary device for fibular fixation is that it can be implanted through a smaller incision with less hardware ultimately prominent. These differences could certainly hold advantages in patients in whom wound healing can be an issue, especially in diabetics and the elderly, and it is possible that a smaller incision and less dissection could elicit less postoperative pain in all patients. Further, the lack

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of prominence of intramedullary fixation may lessen the need for hardware removal. In this study, intramedullary fixation was used for all rotational fractures of the distal fibula.

The purpose of this study was to investigate the learning curve of a single surgeon in using an intramedullary implant for distal fibular fixation based on the surgery time, tourniquet time, time of anaesthesia, and quality of reduction. Therefore, a retrospective comparison between the nail group and control of plate fixation was performed.

## METHODS

In February 2018, a single surgeon (JTV) began using an intramedullary device (Fibulock; Arthrex, Naples, FL,

USA) for ankle fracture fixation. The decision for surgery was made based on the stability of the mortise. The senior author (JTV) is an experienced ankle fracture surgeon who participated in both sawbones and cadaveric training prior to using the intramedullary nail in practice. All data were collected from the medical charts to determine the duration of surgery, the tourniquet time, and the time of anaesthesia. The quality of reduction was assessed based on plain radiographs. Of note, the operating surgeon routinely leaves the tourniquet inflated until the incisions are closed and an initial wrap is placed. Surgery time is defined as the period between time-out and end of surgery and anaesthesia time, between the start and end of anaesthesia. The quality of reduction was evaluated based on plain radiography (mortise, anteroposterior, and lateral

**Table 1.** All Fibular Nail Fixation Cases Classified According to the Fracture Type and Case Number

No.	Type of fracture	Age (yr)	Tourniquet time (min)	Surgery time (min)	Anaesthesia time (min)	Type of reduction
	Total (n = 20)	52.7	68	90	141	
1	Syndesmotic bimalleolar	35	104	156	196	3-mm dorsal malreduction, corrected by lag screw outside the nail
2	Bimalleolar	58	61	75	149	Anatomic
3	Bimalleolar	83	53	86	131	4-mm lateral and 2.5-mm dorsal malreduction
4	Syndesmotic trimalleolar	46	94	120	150	Anatomic
5	Isolated fibular	52	36	47	95	Anatomic
6	Isolated fibular	42	30	36	87	Anatomic
7	Bimalleolar	61	91	109	163	Anatomic
8	Isolated fibular	34	92	102	140	Anatomic
9	Syndesmotic isolated fibular	29	77	101	159	Anatomic
10	Syndesmotic bimalleolar	66	63	66	139	Anatomic
11	Bimalleolar	74	45	97	143	Anatomic
12	Isolated fibular	63	106	117	179	Anatomic
13	Syndesmotic isolated fibular	68	64	73	116	Anatomic
14	Bimalleolar	63	61	80	112	Anatomic
15	Syndesmotic isolated fibular	41	60	66	97	Anatomic
16	Isolated fibular	36	37	46	77	Anatomic
17	Bimalleolar	26	103	143	193	Well aligned comminuted fracture
18	Bimalleolar	43	61	91	160	Anatomic
19	Bimalleolar	64	86	101	222	Anatomic
20	Bimalleolar	63	53	62	93	Anatomic

views) in the first postoperative follow-up visit. The maximum fracture gap was measured and illustrated in Table 1.

The findings of the fibular nail were compared with a control of fibular plate osteosynthesis performed within the last year or so before introduction of the fibular nail. A case match control was performed based on similar fracture pattern and presence of syndesmotic injury. During the study period, 20 patients underwent fibular nail fixation, while for the case match control another 20 patients who underwent fibular plate osteosynthesis were chosen. These 20 control patients were taken from the operating surgeon's cases working backwards from the time of the switch to the nail and had surgery between July 2016 and December 2017.

All calculations and graphs were performed with the Microsoft Excel spreadsheet and Origin Lab, using a case match control test, analysis of variance, *t*-test, and post-hoc power analysis. Institutional Review Board approval of Columbia University Medical Center was obtained for the study (AAAS0272).

### Surgical Technique

The patient was placed in supine position with a bump under the ipsilateral buttock and a pneumatic tourniquet placed on the thigh. The fracture was localized on X-ray with a small incision made laterally. The fracture was manually reduced and held with reduction clamps. The guidewire for nail fixation was then percutaneously placed distally. Once it was appropriately placed into the fibula, then a small incision was made over the wire to allow for reaming. The canal was then reamed with a 6.2-mm distal reamer and then a smaller proximal reamer depending on what size nail was to be used. Insertion of the fibular nail was then performed. For proximal locking, the proximal talons were released, allowing for an interference fit. Finally, 2 or 3 distal locking screws were inserted after drilling through the outrigger (Fig. 1).

## RESULTS

The mean age of our fibular nail cohort was  $52.5 \pm 15.7$  years and 75.0% were women. The mean follow-up was  $27.7 \pm 7.4$  weeks (range, 9.7–41.7 weeks). Most patients suffered a bimalleolar ankle fracture (11/20, 55.0%). The remaining 9 cases involved 8 isolated fibular fractures, or supination-external rotation, type 4 equivalent, (8/20, 40.0%) and 1 trimalleolar fracture (1/20, 5.0%). Within the 20 patients, 6 suffered a syndesmotic rupture in 3 fibular fractures, 2 bimalleolar fractures, and 1 trimalleolar fracture. Those patients achieved stabilization using a suture



**Fig. 1.** Fibular nail fixation with a screw and fibular nail.

button construct placed through the nail. The mean tourniquet time was  $68.9 \pm 23.2$  minutes for nail fixation, with a surgery time of  $88.7 \pm 30.7$  minutes and a mean anaesthesia time of  $140.1 \pm 38.7$  minutes. In the first and third cases, a slight malreduction with some posterior sag of the distal fibular fragment was observed. One patient (the first case) required a lag screw outside of the nail to correct this sag. In the other case, the patient had significant blistering in which early stabilization was sought and reduction was performed entirely percutaneously to avoid wound complications and allow for earlier surgical stabilization. This patient went on to a nonunion requiring revision surgery. The overall union rate was 95% (19/20) and no other complications were observed.

The longest tourniquet time was in the twelfth case with 106 minutes, followed by the first case with 104 minutes. The shortest surgery took 30 minutes. In those fractures in which no syndesmosis stabilization was required, the mean tourniquet time was  $67.9 \pm 25.8$  minutes, whereas it took  $71.6 \pm 12.6$  minutes for the syndesmosis stabilization group. The mean surgery time for the first 10 cases was  $70.1 \pm 24.3$  minutes, whereas it was  $67.6 \pm 22.1$  minutes for the second 10 cases ( $p = 0.82$ ). All cases of fibular nail fixation are listed in Table 1.

When comparing the fibular nail with plate fixation, we found an average tourniquet time of  $75.8 \pm 23.9$  minutes for plate fixation. No significant difference between the overall tourniquet time of fibular nail fixation and plate fixation was identified ( $p = 0.37$ ). All times are listed in Tables 2 and 3. No significant differences were identified in any of the groups. In terms of reduction, all fibular

**Table 2.** All Fibular Plate Fixation Cases Classified According to the Fracture Type and Case Number

No.	Type of fracture	Age (yr)	Tourniquet time (min)	Surgery time (min)	Anaesthesia time (min)	Type of reduction
	Total (n = 20)	43.9	76	96	134	
1	Syndesmotic bimalleolar	29	60	124	311	Anatomic
2	Bimalleolar	50	126	165	190	Anatomic
3	Bimalleolar	43	86	96	158	Anatomic
4	Syndesmotic trimalleolar	48	101	107	144	Anatomic
5	Isolated fibular	39	101	117	149	Anatomic
6	Isolated fibular	41	52	68	130	Anatomic
7	Bimalleolar	25	47	62	85	Anatomic
8	Isolated fibular	29	78	87	140	Anatomic
9	Syndesmotic isolated fibular	35	48	70	132	Anatomic
10	Syndesmotic bimalleolar	37	70	108	158	Anatomic
11	Bimalleolar	55	33	78	117	Anatomic
12	Isolated fibular	27	64	64	123	Anatomic
13	Syndesmotic isolated fibular	83	94	100	139	Anatomic
14	Bimalleolar	78	95	99	205	Anatomic
15	Syndesmotic isolated fibular	21	63	72	120	Anatomic
16	Isolated fibular	35	56	84	85	Anatomic
17	Bimalleolar	31	97	117	144	Anatomic
18	Bimalleolar	47	98	134	87	Anatomic
19	Bimalleolar	63	52	64	88	Anatomic
20	Bimalleolar	61	95	99	153	Anatomic

**Table 3.** Comparison between Fibular Nail Fixation and Fibular Plate Osteosynthesis

Type of fracture	No.	Age (yr)	Tourniquet time (min)	Surgery time (min)	Anaesthesia time (min)	p-value (nail vs. plate)
Fibular nail fixation	20	52.5	68.9	88.7	140.1	
Isolated fibular	4	45.5	60.2	69.6	115.6	
Bimalleolar	8	59.7	68.2	93.8	151.8	
Others	8	47.5	71.6	85.2	132.2	
Fibular plate fixation	20	41.8	74.0	97.6	132.4	0.37
Isolated fibular	4	31.4	59.4	73.0	112.6	0.96
Bimalleolar	8	51.9	87.0	107.7	143.4	0.12
Others	8	42.2	72.7	96.8	138.6	0.71

fractures were anatomically reduced in the fibular plate group ( $n = 20/20$ , 100%).

For surgery time, our post hoc analysis revealed a power of 80.6% at the probability of a type I error of 0.95. Similar power was identified for the nonunion rate with 82.4% at alpha 0.95. However, this implies that with increasing experience and numbers, the surgery time and complication rate would decrease and therefore, even less significances would be observed.

## DISCUSSION

Any new surgical implant or procedure requires a period of transition and learning from the surgeon. In the present study, we assessed the learning curve associated with adoption of a fibular nail for ankle fracture fixation. We did not find a significant learning curve, as the tourniquet time for surgery with a nail was not different from that for plate fixation. Tourniquet time also did not significantly change from the first 10 to the second 10 cases.

The fundamental concept of surgical fracture treatment is fracture reduction followed by internal fixation. Various forms of internal fixation have been used and certainly can be successful. Intramedullary nails have shown high rates of union and most importantly may allow to help lower the soft-tissue infection and skin complication rates. Biomechanical studies showed that these implants can share compressive, bending and torsional loads with the surrounding osseous structures. Furthermore, they act as a splint and reaming increases extraosseous circulation as endosteal and cortical blood flow are reduced.<sup>5,6)</sup> The fibular rod was first described in 1972. While it has existed in various forms over the years, interest has been somewhat rekindled recently. There are potential advantages to the use of an intramedullary implant, such as the ability to use a smaller incision, less local soft-tissue irritation, and lower hardware removal rates, although it remains to be seen if intramedullary fixation can match the generally good results associated with plate fixation. In the very few studies with a longer term follow-up, the fibular nail showed good functional outcome scores<sup>7)</sup> with low complication rates. However, the literature on fibular nail osteosynthesis is at present quite limited.<sup>8)</sup>

The concept of a learning curve with any new surgical implant or procedure is well established in the literature.<sup>9,10)</sup> The concern is certainly that a surgeon's relative unfamiliarity with a procedure or implant may lead to greater risks. To be sure, the onus is on the surgeons to familiarize themselves with the implant and procedure to try to minimize this effect. A host of studies in orthopaedics

have noted a learning curve in subspecialties as diverse as spine surgery, limb lengthening surgery, and shoulder arthroplasty.<sup>11-13)</sup>

In the field of foot and ankle surgery, a strong learning curve effect has been noted in total ankle arthroplasty. In the early phase of clinical usage, more malalignment and nerve and tendon injuries have been described in comparison to later stages.<sup>14)</sup> Other authors described differences in complication rates that, although not statistically significant (36.7% vs. 16.7%,  $p = 0.08$ ), could well be argued as very clinically significant.<sup>15)</sup> One study noted that operative time decreased with increasing experience and stabilized after the 14th case, while complication rates stabilized and reached an equilibrium by the 24th case.<sup>16)</sup> A systematic review of studies assessing the learning curve for total ankle replacement showed that within 25 studies, the overall incidence of complications was 44.2% during the learning curve phase.<sup>17)</sup>

When looking for the learning curve in the treatment of fracture fixation, there is less data. One group assessed operative time for internal fixation of nondisplaced femoral neck fractures, noting that the mean operative time for the first 25 cases was  $52.2 \pm 15.2$  minutes, while it was  $38.4 \pm 13.0$  minutes for the subsequent 25 cases. No failures were observed in either group, although the procedure was fairly straightforward.<sup>18)</sup>

One would not expect the learning curve for ankle ORIF to be as significant as that for ankle arthroplasty, a procedure to which there are often many steps, many of which a surgeon may be unaccustomed to performing routinely. Indeed, as with fixation of a nondisplaced femoral neck fracture, procedures that are generally simpler are likely to have less of a learning curve and less complications in the surgeon's initial cases. The steps of ankle fracture surgery are essentially reduction and then fixation. To be sure, the choice of implant does not greatly influence achieving a reduction. Further, the authors have found the implant to be comparatively simple and intuitive. Our experience emphasizes this notion, as operative times did not change greatly with more cases.

To our knowledge, no comparable study exists investigating the learning curve of a new implant in trauma surgery. We could not identify any significant difference in operative time between the new device and plate fixation in our single-surgeon study. Two nonanatomic reductions were observed: in the first case, a lag screw was able to improve the reduction such that it was anatomic and in the other case, a percutaneous fixation led to a nonanatomic reduction that was accepted. In this specific case, if ORIF using plate osteosynthesis had been performed, at least an-

other 10–14 days would have been required for resolution of the swelling and blistering prior to proceeding with the larger incision that would have been necessary for plate ORIF. Further, the patient also had a medial malleolar nonunion. The patient required revision ORIF, vitamin D supplementation, and the use of the bone stimulator before her lateral fracture finally healed. Her medial fracture partially healed on computed tomography after revision. Although the medial fracture remained mildly symptomatic, the patient declined further surgery.

Limitations of this study are that the assisting staff such as residents and nurses varied over time, which may have influenced the operative time somewhat. Also, we did not record the fibular fixation time alone, instead looking at the surgery time and tourniquet time, although that data most closely approximated the time of fixation. Finally, we did try to match the injuries so that they were

similar between the 2 groups, this process was ultimately based on what data we had available.

In conclusion, there does not appear to be a significant learning curve in switching from fibular plate fixation to fibular nail fixation. No significant differences in tourniquet time and surgery time were identified between nail fixation and plate fixation. While surgeons should certainly be circumspect in adopting new techniques and learn them well prior to using them in practice, it appears that fibular nail fixation is not associated with a significant learning curve.

### CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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