



# Extra-articular distal tibia fractures—controversies regarding treatment options. A single-centre prospective comparative study

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## Abstract

Distal tibia fractures are reported to have a high complication rate pre-operatively as well as post-operatively, which can include open fractures, soft tissue damage, infection, malalignment, pseudarthrosis and ankle arthrosis. The operative treatment for the extra-articular distal tibia fractures is a controversial topic in the orthopaedic literature. Some of these fractures are proximal enough to be treated with an intramedullary nail while others are too distal for that. The aim of our study was to compare the results we have had with intramedullary nail (IMN) and minimally invasive plate osteosynthesis (MIPO) in distal metaphyseal (extra-articular) tibia fractures. The study was designed prospectively between January 2013 and March 2016 and took place on the Orthopaedics and Traumatology ward of a Clinical Emergency County Hospital in western Romania. The follow-up visits were scheduled one month, three months and six months post-operatively. For evaluating the ankle function, we used the Olerud–Molander ankle score (OMAS) and union was evaluated at six months on ankle X-rays. At the six-month follow-up visit the average scores were 75.55 (20–100) for the IMN lot and 74.23 (20–90) for the MIPO lot, without finding any statistical difference between the two groups ( $p > 0.1$ ). At the six-month follow-up, X-ray union was objected in 48 (90.5%) of our patients, the IMN lot having worse results (85.18%) than the MIPO lot (96.15%). The results we encountered showed little to no statistical difference when it comes to the functional score we used (OMAS score), leading us to believe that you can achieve comparable results with both implants.

**Keywords** Distal tibia fracture · Intramedullary nail · MIPO plating · Functional outcome · Complication rates

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## Introduction

Distal tibia fractures (DTF) are usually caused by high-traumatic accidents and affect active patients. They are reported to have a high complication rate pre-operatively as well as post-operatively, including open fractures, soft tissue damage, infection, malalignment, pseudarthrosis and ankle arthrosis. Functional cast bracing is known to have bad end-results such as a high incidence of ankle stiffness and deformity [1]. Just like in other intra-articular fractures, to obtain a proper diagnosis, we must often use other imagistic techniques such as the computer tomography (CT) [2]. This allows for a better diagnosis and indication, improving the outcome.

The operative treatment for the extra-articular distal tibia fractures is a controversial topic in the orthopaedic literature. Some of these fractures are proximal enough to be treated with an intramedullary nail while others are too distal for that. Furthermore, many surgeons are more familiar with one technique or the other, preferring plates to nails or vice versa. Surgical treatment options vary a lot, most specialists

nowadays using either minimal invasive plating osteosynthesis (MIPO), intramedullary nailing (IMN) or external fixator options (ExFix). Each of these treatment options have been discussed in the literature, emphasising on their indications, advantages and disadvantages [3–5]. Controversy still exists over the clinical efficacy of each option and its cost-effectiveness [6].

Superior results have been noticed in certain conditions (good soft tissue quality, low energy trauma) when performing open reduction and internal fixation (ORIF) [7]. It was noticed that, when performed on patients with associated nerve or vascular injury, wound complications and infections, ORIF tends to yield bad results, thus increasing the length of the hospitalisation and the number of surgical interventions done subsequently [8]. IMN allows for a minimally invasive, stable fixation with early mobilisation [9], but on the other hand causes an increased number of anterior knee pain and malunions [10].

The aim of our study was to compare the results we have had with IMN and MIPO osteosynthesis in distal metaphyseal (extra-articular) tibia fractures.

## Materials and methods

The study was designed prospectively between January 2013 and March 2016 and took place on the Orthopaedics and Traumatology ward of a Clinical Emergency County Hospital in western Romania. The patients were approached for study inclusion after being admitted in our hospital with a distal tibia fracture classified as Muller AO 43-A. The inclusion criteria were: (1) distal metaphyseal tibia fracture AO 43-A, (2) a healthy cognitive status and (3) skeletal maturity (over 18 years old). The exclusion criteria of our study were: (1) intraarticular fractures (AO 43-B/C), (2) pathologic bone fractures, (3) pre-existent trophic changes of the soft tissue, and (4) the indication for an external fixator. The patients were attributed to one of the lots (IMN/MIPO) by the surgeon's consideration, without being randomised.

The IMN technique was realised using a sub-patellar approach. We used intramedullary nails in a closed reduction internal fixation manner. We standardly used two proximal screws and two distal screws to lock the nail. The MIPO technique was achieved through an anteromedial approach (approximately 5 cm) realised near the tibial malleolus and we used the bridging plate theory. When associated with a peroneal fracture, this was operated first (standard lateral approach), to re-establish the length of the limb.

The follow-up visits were scheduled one month, three months and six months postoperatively. For evaluating the ankle function, we used the Olerud–Molander ankle score (OMAS) because this is a disease-specific test (ankle fractures) that has been validated and it also showed a high test-

retest reliability [11]. Bone consolidation was evaluated on the six-month X-rays by the same radiology specialist. Complications such as open fractures, wound complications, malunions, infections and lack of consolidation were recorded.

The statistical analysis (frequencies, means, paired t-test) was performed using the IBM SPSS Statistics 20 software (copyright IBM Corporation 2011).

The study was approved by our hospital's Ethical Committee Board and is in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

## Results

Fifty-three patients (37 males, 16 females) with an average age of 37 (18–65) years old were divided into two groups. Our IMN lot had 27 patients (19 males and 8 females) with an average age of 39.2 (18–55) years old and our MIPO lot had 26 patients (18 males and 8 females) with an average age of 33.1 (18–65) years old. Regarding the classification, 12 were AO 43-A1, 18 were AO 43-A2 and 23 were AO 43-A3. The characteristics of our studied lots can be seen in Table 1.

Open fractures were present in 14 patients and they were classified as Gustilo Anderson type I (6 patients), Gustilo Anderson type II (4 patients) and Gustilo Anderson type III (4 patients). Ten of these patients were from the IMN lot and four were from the MIPO lot.

The IMN lot's complications were four varus malunions (>5°), three patients developed pseudarthrosis, three patients presented with ankle stiffness after six months and one patient had a post-operative infection that required multiple re-interventions (external fixator, rib bone graft and plating). The MIPO lot's complications were three dehiscent wounds, four recurvatum malunions and four ankle stiffness cases after six months.

Our average one-month OMAS scores were 10.18 (0–25) for the IMN group and 8.26 (0–20) for the MIPO group. At the six-month follow-up visit the average scores were 75.55 (20–100) for the IMN lot and 74.23 (20–90) for the MIPO lot, without finding any statistical difference between the two groups ( $p > 0.1$ ). At the six-months follow-up, X-ray union was objected in 48 (90.5%) of our patients, the IMN lot having worse results (85.2%) than the MIPO lot (96.15%). Our outcome scores and our complication rates can be seen in Table 2.

We had a 7.5% (4 patients) overall infection rate, with most of the cases being superficial infections from the MIPO lot, and this rate somehow reflecting the high number of open fractures that we had (14 patients, 26.4%). These superficial infections were treated with antibiotherapy, local curettage and secondary wound suture, due to the dehiscence. The one

**Table 1** Main characteristics of our lot

Characteristic		IMN lot (N = 27) Total (percentage)	MIPO lot (N = 26) Total (percentage)
Age		39.2 (18–55)	33.1 (18–65)
Sex	Female	8 (29.6%)	8 (30.8%)
	Male	19 (70.4%)	18 (69.2%)
Classification (AO/OTA)	A1	10 (37%)	2 (7.6%)
	A2	10 (37%)	8 (30.8%)
	A3	7 (26%)	16 (61.6%)
Reamed nail	Yes	21 (77.8%)	
	No	6 (22.2)	
Associated fibula fracture	Yes	20 (74%)	23 (88.5%)
	No	7 (26%)	3 (11.5%)
Fibular osteosynthesis	Yes	21 (77.8%)	21 (80.8%)
	No	6 (22.2%)	5 (19.2%)
Open fracture classification (Gustilo Anderson)	I	2 (7.4%)	4 (15.4%)
	II	4 (14.8%)	
	III	4 (14.8%)	

case that had a deep infection was an open fracture from the IMN lot, and it required secondary external fixation, antibiotherapy and ulterior bone grafting with a vascularized rib graft. Statistically significant data was found regarding the encountered types of malunion. All the varus malunion cases were part of the IMN lot ( $p = 0.047$ ) while all the recurvatum malunions were part of the MIPO lot ( $p = 0.045$ ). As expected, ankle stiffness was seen in both lots with similar incidence.

## Discussion

Plates seem to be the obvious choice for this area and the AO group has described minimally invasive techniques (MIPO—

minimally invasive percutaneous osteosynthesis) for implanting plates percutaneously in this anatomical site [12, 13]. Plate reconstruction is also known to provide reliable results in other intra-articular fractures of the lower limb [14]. Extensive studies have been done to compare MIPO techniques with conventional ones [15–17]. The main aim of minimally invasive surgery was to get the benefits of plating (anatomic reduction, axis restoration, stable fixation) but without the soft tissue complications and the devascularisation of fracture fragments that occur during open surgery.

Zou et al. published an investigative review study and they concluded that there is no significant difference between open and closed fixation and recommended between MIPO and open reduction depending on fracture pattern [18]. A suitable

**Table 2** Outcome variables for our studied lot, including OMAS score and other complications

Outcome variable		IMN lot (N = 27) Average (min-max) $\pm$ SD	MIPO lot (N = 26) Average (min-max) $\pm$ SD
OMAS score	1 month	10.18 (0–25)	8.26 (0–20)
	6 months	75.55 (20–100) $\pm$ 18.2	74.23 (20–90) $\pm$ 17.9
Union (6 month X-ray)	Yes	23 (85.2%)	25 (96.1%)
	No	4 (14.8%)	1 (3.9%)
Varus malunion (>5°)	Yes	3 (11.1%)	0 (0.0%)
	No	24 (88.9%)	26 (100%)
Recurvatum malunion	Yes	0 (0.0%)	4 (15.4%)
	No	27 (100%)	22 (84.6%)
Ankle stiffness	Yes	3 (11.1%)	4 (15.4%)
	No	24 (88.9%)	22 (84.6%)
Superficial infection	Yes	0 (0.0%)	3 (11.5%)
	No	27 (100%)	23 (88.5%)
Deep infection	Yes	1 (3.7%)	0 (0.0%)
	No	26 (96.3%)	26 (100%)

**Fig. 1** Pre-operative and three-month post-operative, AP and lateral X-rays of the ankle and calf. Osteosynthesis was achieved with an angular stable plate with locked screws inserted with the MIPO technique for the distal tibia, and a simple plate and screws for the fibula. Union is slowly starting to occur in a 43-year-old male patient with a AO 43-A3 distal tibial fracture



alternative for decreasing local edema, and avoiding unnecessary bleeding can be the use of tranexamic acid, which has already proved its benefits in arthroplasties [19]. Paluvadi et al. concluded that the MIPO technique (Fig. 1) provides good, slightly delayed bone healing, decreases incidence of non-union and the need for bone grafting. They recommend this technique to be used where intramedullary locked nailing cannot be performed [16].

IMN can be a less obvious choice for these fractures, but if the fracture pattern allows it, meaning an extra-articular fracture of the distal tibial diaphysis, or a fracture with nondisplaced intra-articular fragments, an intramedullary nail can be a very effective solution for internal fixation (Fig. 2). El Attal et al. studied 180 tibial fractures in which they included extra-articular fractures of the distal tibia (AO 43 A1/A2/A3) treated with closed reduction and reamed IMN. They had a 10.6% rate of delayed union and a 5.4% rate of 5° or more axial malalignment [20]. Hoegel et al. compared reamed and unreamed nailing either with angle stable or conventional interlocking to plate osteosynthesis on four groups of artificial tibiae. They found out that the reamed nailing was biomechanically superior to the unreamed conventionally locked nail and unreamed distally angular stable locked nails and these implants were stiffer than the locked plate osteosynthesis, an

implant that had the highest values of torsional and axial force movement [21]. Kuhn et al. studied a prototype retrograde tibial nail in cadaveric specimens and found it to be superior to the classic MIPO technique (superior stability and higher load to failure forces) [22].

These studies all point out that for extra-articular distal tibial fractures, the IM nailing, either antegrade or retrograde, is a better choice than the classic angle stable locked MIPO technique. While the latter has been proven in clinical practice and can address fractures with articular extension or comminution it can also cause soft tissue complication, decreased distal vascularization, increased rate of delayed and non-union and later weight-bearing, all these being minimally influenced by the locked nail. This can also be extremely important in open fracture cases where a IM nail provides excellent fixation of the fracture fragments and allows, if necessary, extensive debridement and reconstructive treatment of the soft tissues without direct implant exposure.

Looking forward and already having seen the computerization of several implants such as the Taylor Spatial Frame [23–25] and patient-specific instrumentation in joint replacements and corrective osteotomies [26, 27], we hope that future solutions can be found for some further enhancement of plates and nails.

**Fig. 2** Pre-operative and three-month post-operative, AP and lateral X-rays of the ankle and calf. Osteosynthesis was achieved with a locked intramedullary nail for the distal tibia fracture, and a plate and screws with three additional neutralisation screws for the fibula. The nail was distally locked with three screws (1 anteroposterior, 1 oblique and 1 lateral). This is a 26-year-old male patient with a AO 43-A3 distal tibial fracture caused by a car accident





## Conclusion

The results we encountered showed little to no statistical difference when it comes to the functional score we used (OMAS score), leading us to believe that you can achieve comparable results with both implants. Of course, there are cases that can make the surgeon chose one implant over the other and this is where the surgeon's experience plays a far more significant role than guideline recommendations. From what we have learned, we can say that it is extremely important to avoid malalignment during fixation and applying the MIPO technique when the skin is in poor condition.

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## Compliance with ethical standards

**Conflict of interest** The authors have no conflicts of interest to declare.

**Ethical approval** All procedures performed in this study were in accordance with the ethical standards of the SCJU Pius Branzu Research Committee and with the 1964 Helsinki declaration and its later amendments.

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