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Extra-articular Distal Tibial Fracture: A Comparative Study of the Outcome Between Closed IMLN and MIPO

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Abstract

Background: The treatment of distal tibial fractures (DTF) is still up for debate. For DTF, minimally invasive plate osteosynthesis (MIPO) and intramedullary nailing (IMLN) are potentially effective techniques; however, they have been linked to complications. Thus, this study was aimed to evaluate and compare clinical and functional results in individuals with DTF that were managed with MIPO or IMLN. **Patients and Methods:** Between August 2020 and February 2022, 31 patients with closed extra-articular distal tibia fractures were enrolled in a comparative study of locking plate by MIPO versus closed IMLN at the Sulaimani Teaching Hospital and Shar Teaching Hospital. The Foot and Ankle Ability Measure (FAAM) and Johner and Wruh's criteria were used to evaluate the results. **Results:** IMLN was used on 16 individuals, while MIPO was used on 15 patients that underwent surgery. In terms of time, there was no significant difference ($p>0.05$) in fracture union, malunion, or functional results. However, there was a significant difference in total weight-bearing following surgery, blood loss, and complications in terms of the operation time. **Conclusions:** Both techniques were effective in treating a distal tibial extra-articular fracture. IMLN had a faster complete weight-bearing time and a shorter operation time. At the same time, MIPO had less blood loss and equal time in complete union. Thus, we recommend using FAAM as a valuable tool in evaluating functional outcomes after distal tibia fracture.

Introduction

Tibial shaft fracture is one of the most common fractures in orthopedics. Distal tibia fracture (within 10 cm) is the second most common after middle shaft fracture ***[1]***. It is one of the most demanding fractures to manage due to its nearness to the ankle joint and its superficial nature; however, based on more recent reports, its incidence declines ***[2]***. The structure of the distal tibia is unique in that it has a minimal amount of soft tissue coverage when injured and operated on, which results in possibly catastrophic wound complications ***[3]***. In this regard, many fixation methods are generally suggested, such as classical open reduction and internal fixation methods that led to soft tissue complications and nonunion. From this emerged the idea of not opening the fracture site and spanning it. Minimally invasive plate osteosynthesis (MIPO) and intramedullary nailing (IMLN) are the two most commonly used techniques in closely treating this kind of fracture ***[4]***.

MIPO is done through small incisions both proximal and distal to the fracture area for introducing the plate and screws without opening the fracture site. The plate is inserted under the soft tissue without extensive dissection, the periosteum is not disrupted, and the blood supply is preserved ***[5]***. Researches have demonstrated that the extra-osseous blood supply is adequately maintained when the plate is applied. It appears to enhance fracture union, reduce chances of infection, and lower the demand for bone grafting ***[6]***. Instantly, MIPO is achieved with partial soft tissue dissection, but still, there are fears of soft tissue problems in the acute

setting. Additionally, implant prominence, especially on the middle part of the distal tibia, is considered a late management outcome ***[1]***.

On the other hand, IMLN is a pointing device with three-point fixation properties. It is inserted antegrade from the proximal tibia with proximal and distal screw fixation ***[7]***. It is a relative intramedullary fixation situated closer to the central axis of the bone, and hence it is less stress shielding. It allows micromotion at the fracture site and promotes callus formation. In this mode of fixation, there is no injury to the periosteal blood supply ***[8]***.

The Foot and Ankle Ability Measure (FAAM) ***[9]*** and Johner and Wruh's score ***[10]*** are generally used to determine the functional results of patients who underwent MIPO and IMLN. FAAM is a self-report outcome tool designed to evaluate physical function in people with foot and ankle problems. It consists of a 29-item questionnaire with two subscales, the daily living subscale and the sports subscale, which assess more challenging tasks that are important in sports, and it is a population-specific subscale created for athletes ***[11]***. Thus, this study targeted to evaluate clinical and radiological outcomes in DTF that originated outside the joint.

Patients and methods

A. Study setting

This was a prospective comparative study that was conducted between August 01, 2020, to February 01, 2022, at Shar Teaching Hospital and Sulaimaniyah Teaching Hospital, Sulaimaniyah, Republic of Iraq.

B. Patients and study sample

Thirty-one patients were enrolled in this study that was divided into two groups. Group 1 were 16 patients (11 males and 5 females) with IMLN and group 2 were 15 patients (10 males and 5 females) with MIPO.

C. Ethical approval and patient consent

The ethical approval for the conduction of this surgical study was obtained from the Kurdistan Board for Medical Specialties. All patients signed an informed written consent form to participate in this study.

D. Inclusion criteria

Victims with closed distal tibia extra-articular fracture (ankle end of the tibia) within 10 cm of the distal articular surface with or without fibula fracture (AO classification 43) aged more than 18 years old were enrolled in this study.

E. Exclusion criteria

Patients with pathological fractures, intra-articular fractures, pre-existing anatomical abnormality in the bone and those who refused to participate in this study were excluded.

F. Data collection and patient preparation

Once patients were admitted to the hospital, socio-demographic data (age, sex, and body mass index) were collected using a well-designed questionnaire. Then, the preoperative preparation, such as necessary investigations, pain management and immobilization of the fracture, was done according to the local protocol. Then, the fracture was diagnosed clinically by plain radiography and computed tomography (CT) scan when needed. Finally, preoperative antibiotics were given 30 - 60 minutes before incision.

G. Treatment protocol

In the MIPO group, the tibial bone was fixed as well as the fibula fracture was fixed when necessary using a minimally invasive technique with indirect reduction (Figure 1). In the IMLN group, fracture fixation was performed using locking tibial nails with reaming in all cases, and the nail was locked both proximally and distally. Both modalities were aided by fluoroscopy (Figure 2).

Postoperative management for both groups included pain killers, elevation, early movements, gait training without weight-bearing and the dressing was changed on the 3rd day. Patient's follow-up was done after 2 weeks for stitches removal, while Anterior-Posterior (AP) and lateral radiographs of the fracture site and entire leg were taken 4 and 6 weeks postoperatively. Full weight-bearing started when there were signs of callus formation. Furthermore, the FAAM and Johner and Wruh's scores were used to determine the functional result in this study in which nonunion, infection, neurovascular damage, deformity, and mobility factors were taken into account.

Figure- 1: X-ray graphs of distal tibia fracture; a. Injury radiograph, b. Immediate postoperative radiograph, and c. One year follow up.

Figure-2: X-ray graphs of distal tibia fracture; a. Injury radiograph, b. Immediate postoperative radiograph, and c. One year follow up.

I. Statistical analysis

All statistical computation was enhanced using Statistical Package for Social Science (SPSS, version 25). The data had been coded, tabulated, and presented in a descriptive form, including frequency, percentage, mean, and stander deviation. In addition, the criteria of the probability level for determining the significance of the test were set as significant ($p<0.05$) and non-significant ($p>0.05$).

Results

In this study, patients with distal tibia extra-articular fractures were operated on using closed IMLN (16 patients) and MIPO (15 patients). The average age was 34 years in both groups. The mean age in IMLN patients was 33.43±13.64 years and in MIPO patients was 36.0±13.88 years. The majority of the participants in both groups were males (67.74), of which 68.75% were in the IMLN group and 66.67% were in the MIPO group. The patients' body mass index (BMI) was normal in 43.75% and 40% of IMLN and MIPO groups, respectively. There was no significant difference between IMLN and MIPO groups regarding age (p=0.35), sex (p=0.901), and BMI (p=0.623) (Table 1).

Table- 1: Socio-demographic data of patients in both IMLN and MIPO groups.

Sociodemographic data	**Item**	**IMLN group**		**MIPO group**		**All**		**Significant test**
		Fr.	%	Fr.	%	Fr.	%	
Age (Year)	< 20	2.0	12.5	2.0	13.33	4.0	12.9	=2.099 (p= 0.35)χ^2
	20 – 30	7.0	43.75	3.0	20.0	10.0	32.26	
	> 30	7.0	43.75	10.0	66.67	17.0	54.84	
	Mean ± SD	33.43±13.64		36.0±13.88		34.78±13.59		T=-0.518 (p=0.608)
Sex	Female	5.0	31.25	5.0	33.33	10.0	32.26	=0.015χ^2
	Male	11.0	68.75	10.0	66.67	21.0	67.74	p= 0.901
BMI (Kg/m^2)	Underweight	0.0	0.0	0.0	0.0	0.0	0.0	=0.946χ^2
	Normal	7.0	43.75	6.0	40.0	13.0	41.94	(p= 0.623)
	Overweight	6.0	37.5	4.0	26.67	10.0	32.26	
	Obese	3.0	18.75	5.0	33.33	8.0	25.81	
	Mean ± SD	25.5±4.18		27.0±6.46		26.23±5.36		T=-0.773 (p=0.446)
Total		16.0	100.0	15.0	100.0	31.0	100.0	

BMI: Body mass index, Fr: Frequency, SD: Standard deviation

In this study, the mechanism of injury was primarily because of road traffic accidents (RTA) (67.74%), followed by falls (29.03%), and then assault (3.23%), with no significant difference between the groups (p=0.47). Furthermore, the type of fractures was short oblique (32.26%), transverse (25.81%), wedge (19.35%), spiral (16.13%), and comminuted (6.45%) the patients. The time for a total weight-bearing from surgery was 9.06±2.52 weeks in IMLN and 11.87±0.92 weeks in the MIPO group. The fibula was fractured in 87.10%. There was no statistical difference (p=0.175) in the time from trauma to operation in IMLN (23.81±14.73 hours) and MIPO (12.87±0.92 hours), and it was 24.23±14.26 hours in both groups with no significant difference (p= 0.705). Additionally, fluoroscopy time (C-arm shoot) was not significant according to the type of fixation (p=0.281). Blood loss was more in the IMLN group (215.94±30.73 mL) than MIPO group (60.0±16.48 mL), with a significant difference (p=0.00). Operation time in the IMLN and MIPO groups were 57.31±6.32 and 64.93±5.52 minutes, respectively with a considerable difference (p=0.008). This indicates that the IMLN group started total weight-bearing earlier than the other group with a significant difference (p=0.006). Complete union time in the IMLN group was 19.5 weeks and 20.28 weeks in the MIPO group with no significant difference (p=0.417) (Table 2).

Table- 2: Association between IMLN and MIPO groups in operation detail.

Operation detail	Items	IMLN group		MIPO group		All		Significant test
		Fr.	%	Fr.	%	Fr.	%	
Mechanism of injury	Assault	0.0	0.0	1.0	6.7	1.0	3.23	=1.509χ^2 P=0.47
	Fall	4.0	25.0	5.0	33.3	9.0	29.03	
	RTA	12.0	75.0	9.0	60.0	21.0	67.74	
Operation time (Minute)	< 50	1.0	6.3	0.0	0.0	1.0	3.23	=9.549χ^2 P=0.008
	50 – 60	11.0	68.8	3.0	20.0	14.0	45.16	
	> 60	4.0	25.0	12.0	80.0	16.0	51.61	
	Mean ± SD	57.31±6.32		64.93±5.52		61.00±7.01		T=-3.564(0.001)
C-arm shoots	< 40	1.0	6.3	4.0	26.7	5.0	16.13	=2.54χ^2 P=0.281
	40 – 50	7.0	43.8	6.0	40.0	13.0	41.94	
	> 50	8.0	50.0	5.0	33.3	13.0	41.94	
	Mean ± SD	51.43±7.59		45.27±9.41		48.45±8.94		T=17.437
Blood loss (mL)	< 50	0.0	0.0	3.0	20.0	3.0	9.68	=31.001χ^2 P=0.000
	50 – 100	0.0	0.0	12.0	80.0	12.0	38.71	
	> 100	16.0	100.0	0.0	0.0	16.0	51.61	
	Mean ± SD	250±30.73		60.00±16.48		78.23±23.65		T=6.269(0.000)
Type of fracture	Wedge	3.0	18.8	3.0	20.0	6.0	19.35	=2.17χ^2 P=0.705
	Transverse	4.0	25.0	4.0	26.7	8.0	25.81	
	Comminuted	1.0	6.3	1.0	6.7	2.0	6.45	
	Short oblique	4.0	25.0	6.0	40.0	10.0	32.26	
	Spiral	4.0	25.0	1.0	6.7	5.0	16.13	
Full weight-bearing (Week)	Complication	1.0	6.3.0	0.0	0.0	1.0	3.23	=12.454χ^2 P=0.006
	< 10	7.0	43.8	0.0	0.0	7.0	22.58	
	10-12	8.0	50.0	11.0	73.3	19.0	61.29	
	> 12	0.0	0.0	4.0	26.7	4.0	12.90	
	Mean ± SD	9.06±2.52		11.87±0.92		10.42±2.36		T=-4.068(0.000)
Time from trauma to operation (Hour)	< 20	5.0	31.3	7.0	46.7	12.0	38.71	=3.482χ^2 P=0.175
	20-29	7.0	43.8	2.0	13.3	9.0	29.03	
	> 29	4.0	25.0	6.0	40.0	10.0	32.26	
	Mean ± SD	23.81±14.73		12.87±0.92		24.23±14.26		T=-0.164(0.871)
Fibula fracture	No	2.0	12.5	2.0	13.3	4.0	12.90	=0.005χ^2 P=0.945
	Yes	14.0	87.5	13.0	86.7	27.0	87.10	
Complete union time (Week)	Complication	2.0	12.5	1.0	6.7	3.0	9.68	=2.837χ^2 P=0.417
	< 19	2.0	12.5	1.0	6.7	3.0	9.68	
	19 - 20	9.0	56.3	6.0	40	15.0	48.39	
	> 20	3.0	18.8	7.0	46.7	10.0	32.26	
	Mean ± SD	17.06±6.75		18.93±5.36		17.97±6.09		T=-0.851(0.402)
Total		16.0	100.0	15.0	100.0	31.0	100.0	

RTA: Roads and transport authority, SD: Standard deviation

In IMLN, the anterior knee pain was 37.50%, while ankle pain and implant irritation in the MIPO group was 33.33%. There were two and four cases of superficial infection in the IMLN and MIPO groups, respectively, with no significant difference (p=0.318), while only 1 case of deep infection in the MIPO group was observed. Concerning angulation > 5 degrees, there was no significant finding between the two groups. Knee stiffness was 6.25% and ankle stiffness was 20% in IMLN group. There were 2 cases and 1 case of nonunion in the IMLN and MIPO (p=0.583) groups, respectively. Also, 1 case of a delayed union in each group was found (Figure 3).

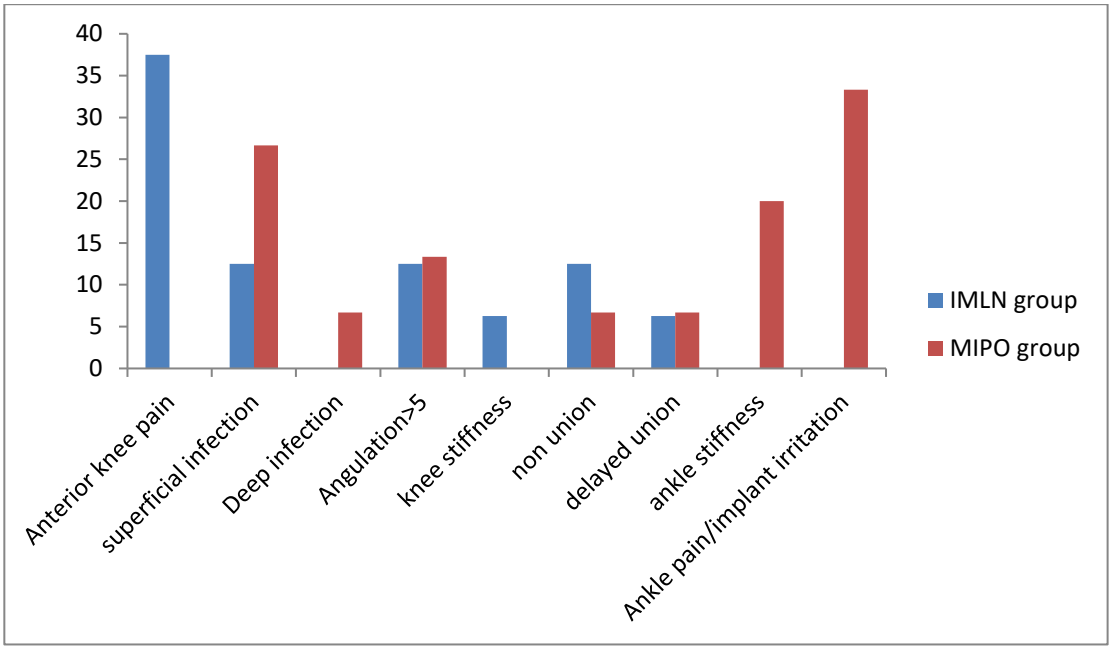

Figure- 3: Complication rates of studied patients in both MIPO and IMLN groups.

At one year follow up, FAAM was 90.62% in IMLN and 91% in plating with no significant difference (p=0.443). According to Johner and Wruh's score, 37.5% of the patients that underwent IMLN reported excellent recovery, 43.75% were good, 12.5% were fair, and 6.67% showed poor recovery. Among the patients who had undergone plating, 46.67% were excellent, 40.0% were good, 6.67% were fair, and 6.67% showed poor recovery. There was no difference in scores between the two groups (p=0.443 and p=0.929, respectively) (Table 3 and Table 4).

Table- 3: FAMM and Johner and Wruh's scores in IMLN and MIPO groups

Score	Item	IMLN group		MIPO group		MIPO group		Significant test
		Fr.	%	Fr.	%	Fr.	%	
FAAM score (%)	< 70	1.0	6.25	1.0	6.67	2.0	6.45	$=2.685\chi^2$ (p=0.443)
	70 - 80	1.0	6.25	0.0	0.0	1.0	3.23	
	81 - 90	2.0	12.5	5.0	33.33	7.0	22.58	
	91 - 100	12.0	75	9.0	60	21.0	67.74	
	Mean ± SD	90.63±12.98		91.0±13.56		90.81±13.04		T=-0.079 (0.936)
Johner and Wruh's score (%)	Poor	1.0	6.25	1.0	6.67	2.0	6.45	$=0.455\chi^2$ (p=0.929)
	Fair	2.0	12.5	1.0	6.67	3.0	9.68	
	Good	7.0	43.75	6.0	40	13.0	41.94	
	Excellent	6.0	37.5	7.0	46.67	13.0	41.94	
Total		16.0	100.0	15.0	100.0	31.0	100.0	

Table- 4: Johner and Wruh's score result in in IMLN and MIPO groups.

Criteria	Excellent	Good	Fair	Poor
Nonunion/infection	None	None	None	Yes
Neurovascular injury	None	Minimum	Moderate	Severe
Deformity				
Varus/Valgus	None	$2-5^0$	$6-10^0$	$>10^0$
Anterior/Posterior	$0-5^0$	$6-10^0$	$11-20^0$	$>20^0$
Shortening (mm)	0 - 5	6 - 10	11 - 20	20 >
Mobility				
Knee	Full	90% >	90 – 75%	75%<
Ankle	Full	75% >	75 – 50%	50%<
Pain	None	Occasional	Moderate	Severe
Gait	Normal	Normal	Mild limp	Significant limp

Discussion

Distal tibial extra-articular fracture is considered one of the common fractures with a high risk of nonunion because the bone is subcutaneous, and there is minimal soft tissue coverage with low vascularity ***[12]***. The current study operated on 31 patients with the extra-articular distal tibia using IMLN and MIPO techniques to minimize soft tissue damage and the patients were tracked for a year after their discharge.

According to Gonsalves, 2018; the mean age of participants (30 patients, 15 in each IMLN and MIPO group) was 40 years; the majority of them were male (90%) as well as RTA was the leading cause of injury in > 60% ***[13]***. All these outcomes are close to our findings, except for participant sex, in which male patients in our study were less predominant (67.74%). He also mentioned that the average operation time was 57.33 and 70.36 minutes in the IMLN and MIPO groups, respectively, whereas the plating technique in our study took less time (64.93 minutes). The operation time in both studies were significantly different ($p<0.005$). Additionally, our study is in agreement with his study about the average time of weight-bearing as it was 9.53 weeks in IMLN group and 13.29 weeks in MIPO group, while in our study, the average time was 9.6 weeks in IMLN group and 11.86 weeks in MIPO group, with a significant difference ($p<0.005$). In contrary to his study, the IMLN group had a shorter total union time than the MIPO group in our observation. However, there was no significant difference ($p>0.005$) in both studies. Regarding the complication rates, both studies showed similar outcomes. Furthermore, based on Johner and Wruh's score, there was no significant difference ($p>0.005$) in the functional outcome between our study and Gonsalves, 2018 study.

Moreover, in a retrospective examination of 46 patients, Li et al., 2012 discovered that the mean operating time for the IMLN group was 76.1±16.6 minutes and for the MIPO group was 90.4±20.3 minutes. In addition, their MIPO group took 11.1±1.7 weeks to reach full weight-bearing, which was significantly different ($p<0.005$) than the IMLN group (9.0±1.4 weeks). As a result, they concluded that MIPO might be a preferable surgical alternative because it benefits mean operating time and complete weight-bearing time while the IMLN reduces operational time and facilitates early weight-bearing ***[14]***. Collectively, all these results were compatible with our study outcomes.

Furthermore, based on FAAM score, our findings revealed that MIPO and IMLN techniques are equally beneficial in functional outcomes. Similarly, different ratings were utilized for functional evaluation in several earlier studies. In this regards, Guo et al., 2010 evaluated MIPO and IMLN in 85 patients with DTF and found that the AOFAS ratings in both groups were statistically equivalent ***[15]***. Li et al. examined three distinct surgical procedures (MIPO, IMLN, and external fixation) to manage DTF using the Mazur ankle score and found that all groups had identical functional outcomes ***[14]***. On the other hand, a study of 64 patients by Borrelli et al., 2002 evaluated closed reduction and IMLN with open reduction and plate/screw fixation for DTF. Despite having similar functional ankle scores, participants in the IMLN group had better ankle

dorsiflexion, while four individuals showed minor ankle stiffness ***[16]***. The results of all these 3 researches were in agreement to our study outcomes.

The ankle plafond is intact in distal tibial extra-articular fractures, thus, ankle function is frequently preserved regardless of the technique employed for fixing. In addition, it is generally recognized that IMLN can cause anterior knee pain. The MIPO approach is devoid of this problem as it does not require any surgical incisions around the knee. Yang et al., 2006 evaluated the results of IMLN with open reduction and plating in DTF and found that nearly 6/13 of their patients had anterior knee pain; meanwhile, the plating group had no knee complaints ***[17]***. Janssen et al., 2007 assessed MIPO and IMLN techniques in a comparison group of patients with DTF. They discovered that the IMLN group had higher anterior knee discomfort during bending and squatting ***[18]***. Likewise, in our study, 6/16 patients underwent IMLN and developed anterior knee pain. Ankle pain and implant irritation were found in 16% of our patients, which was compatible with Gonsalves, 2018 findings ***[13]***. Because a MIPO incision is performed distally on the ankle, and the implant is fixed anatomically to the distal tibia; implant discomfort and ankle pain will develop that was also found by Polat et al., 2015 ***[19]***.

Instantly, any malalignment in the tibia might develop posttraumatic osteoarthritis in surrounding ankle and knee joints in the long run, an optimal fracture treatment procedure should produce anatomic or at least acceptable fracture alignment in the tibia. Malalignment was shown to be equivalent to researches of Guo et al., 2010 ***[15]***, Li et al., 2012 ***[14]***, and Polat et al., 2015 ***[19]***. Similarly, there was no discernible change in angular malalignment in our operated patients.

Consequently, we compared the full union time in both groups and no significant differences ($p>0.005$) was found. This outcome was consistent with what was discovered in relevant literature ***[14,15,19]***. However, blood loss was higher in IMLN technique with significant difference ($p<0.005$). This was due to increased blood loss following intramedullary reaming, and the IMLN group did not utilized a tourniquet, whereas the MIPO group did. This discovery was also made by Polat et al., 2015 ***[19]***.

Finally, we realized that the infection rate did not differ significantly ($p>0.005$) in both techniques which is similar to the findings of a meta-analysis study by Kwok et al., 2014 ***[20]***. However, due to the indirect reduction technique, which is more complex than IMLN, Guo et al., 2010 noted that the fluoroscopy duration was longer with MIPO, which was the case in our research ***[15]***.

Conclusions

According to the findings of this study, both closed IMLN and MIPO techniques for extra-articular distal tibia fracture surgery are comparably safe and effective. In addition, IMLN was found to be superior in terms of early total weight-bearing and operating time, while anterior knee pain caused discomfort in this group. On the other hand, MIPO had less blood loss and equal complete union time. Thus, we recommend using FAAM as a valuable tool in evaluating functional outcomes after distal tibia fracture.

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Conflict Of Interest

Not declared.

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