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## Original Article

### Distal tibia metaphyseal fractures: Which is better, intra-medullary nailing or minimally invasive plate osteosynthesis?

### 脛骨幹骺端骨折：哪種更好，髓內釘或微創鋼板內固定？



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#### ABSTRACT

**Introduction:** Tibia fractures are the most common long bone fractures encountered by the orthopedic surgeons and distal tibia fractures have the second highest incidence of all tibia fractures after the middle third of tibia the distal tibial fractures are unique and are considered as most challenging fractures to treat due to its proximity to the ankle joint and its superficial nature. The objective of this study is to compare two osteosynthesis systems developed for surgical treatment of distal tibia fractures: the intramedullary nailing and the MIPPO technique.

**Methods:** The study was conducted between Jan 2011 to Dec 2012. 63 patients with extra-articular distal tibia fracture treated with intramedullary nailing and MIPPO technique were reviewed retrospectively and clinical outcome was evaluated according to American Orthopaedic Foot and Ankle Score.

**Results:** 31 patients were treated with intramedullary nail & 32 with MIPPO technique. Fibular fixation was done in cases where fibular fracture was at or below the level of tibial fractures. We found no difference in terms of time for fracture union, mal-union, non-union, duration of surgery and amount of blood loss. But there was significant difference in terms of infection and duration of hospital stay. Also weight bearing was possible much earlier in intramedullary group as compared to the MIPPO group.

**Conclusion:** Thus we conclude that intramedullary nailing is better choice of implant in patients with extra-articular distal tibia fractures & helps in early weight bearing and ambulation of patient with fewer complications.

#### 中文摘要

引言：脛骨骨折是骨科醫生遇到的最常見的長骨骨折；脛骨骨折中，遠端骨折比較中段三分之一骨折的發生率少，居第二位。由於其接近踝關節及其表面位置，脛骨遠端骨折是獨特的，被認為是治療難度最大的骨折。本研究的目的是比較兩種脛骨遠端骨折內固定手術治療：髓內釘和微創鋼板內固定(MIPPO)技術。

方法：回顧性分析2011年1月至2012年12月間的63例脛骨遠端骨折髓內釘和MIPPO技術治療。根據美國骨科足踝評分標準，對患者的臨床資料評價。

結果：31例患者採用髓內釘治療，32例採用MIPPO技術。當腓骨骨折處於或低於脛骨骨折水平的情況下，進行腓骨固定。我們發現骨折癒合時間、畸形癒合、不癒合率、手術時間和失血量沒有差異。但感染率和住院時間差異有統計學意義。與MIPPO組相比，髓內組可以更早負重。

結論：因此，我們認為髓內釘是關節外脛骨遠端骨折患者更好的選擇，有助於患者早期負重和移動和較少並發症。

#### Background

Tibia fractures are the most common long bone fractures encountered by the orthopaedic surgeons and distal tibia fractures have the second highest incidence of all tibia fractures after the

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middle third of tibia.<sup>1</sup> The distal tibia fractures are unique and are considered as most challenging fractures to treat because of its proximity to the ankle joint and its superficial nature. Thus, complications like non-union, delayed union and infections are very common; also, there is difficulty in maintenance of reduction, and thus management of these fractures is very controversial.<sup>2</sup>

In literature, several kinds of treatment for distal tibia fractures are described. However, two of the most used techniques are *locked intra-medullary interlocking nail* and *minimally invasive plate osteosynthesis (MIPO)*.<sup>3</sup> Intra-medullary nails for distal tibia fractures are technically difficult to perform and must be addressed with care. Also, the maintenance of reduction of proximal and distal metaphyseal fractures can be difficult to control with an intra-medullary device, leading to mal-alignment; rates varying from 5% to 58%. Failures in controlling distal fragments may lead to deformities and problems in union like mal-union and non-union. Intra-medullary nailing of the tibia has also been associated with knee pain in up to 71% of patients.<sup>4</sup> But, the advantages of closed intra-medullary nailing are that it minimizes surgical insult to the fracture and adjacent soft tissues have been associated with shorter time to union and a shorter period of disability. MIPO is an alternative treatment for these fractures, because it does not need large exposure for reduction, thus providing biological fixation. However, failure to achieve satisfactory reduction may result in angular deviations, non-union and pseudoarthrosis.<sup>5</sup>

## Materials and methods

The study was conducted between January 2011 and December 2012. Sixty-three skeletally mature patients with extra-articular distal tibia fracture treated with intra-medullary interlocking nailing and MIPO technique were reviewed retrospectively. Selection of implant for particular fracture was entirely based on operating surgeon's discretion and no other factors were taken into consideration. Patients with pathological fractures, non-osteoporotic osteopathy were excluded. Those with open fractures according to Gustilo and Anderson types II or III<sup>6</sup> or fractures with intra-articular extension were also excluded. The fractures were classified according to the Orthopedic Trauma Association (OTA) classification.<sup>7</sup>

The criterion for inclusion was the presence of a distal fragment of at least 2.5 cm in length, with no articular incongruity and located within 10 cm from the tibial plafond, which corresponded to an OTA type 43 A. OTA types 43 B and C were not included in the study group.

Tscherne classification was used to assess the extent of the soft-tissue injuries in closed fractures: C0 was little or no soft-tissue injury; C1 was superficial abrasion; C2 was deep contaminated contusion associated with a localized skin or muscle contusion and C3 was extensively contused or crushed skin and possibly severe muscle damage.<sup>8</sup> Only types C0, C1 and C2 were included in the study. Tscherne type C3 fractures were excluded from the study.

The associated fibular fracture was fixed either with plate or intra-medullary nail, only if it was at or below the level of tibial fractures. Initial management consisted of splinting with long leg plaster slab or calcaneal traction. Thirty-one patients were treated with tip locking distal tibia nail and 32 patients were fixed with stainless steel or titanium distal tibia locking plates (Figure 1, 2).

Intravenous antibiotics consisting of ceftriaxone + sulbactam and gentamicin were administered pre-operatively and for 3 days post-operatively for the nailing group and 5 days post-operatively for the MIPO group. Non-weight bearing was recommended for at least 8 weeks post-operatively for both groups. Surgeon discretion was used to determine progression of weight bearing based on

fracture pattern, soft tissue injury, bone quality and patient comorbidities. Patients were followed up for a minimum period of 12 months post-operatively.

Patients were evaluated with radiographs in both anteroposterior and lateral views of ankle joint and distal tibia pre-operatively, immediate post-operatively and at approximately 6-week intervals thereafter until fracture union. Mal-union was defined as 5° of angular deformity or translation/shortening of 10 mm. Fracture union was defined clinically as no pain or tenderness at the fracture site and radiologically as healing of at least three of four cortices on bi-planar plain radiographs. Delayed union was defined as lack of any healing on plain radiographs within 3 months. Non-union was defined as lack of any healing on plain radiographs within 6 months. At the end of follow-up (after 1 year), clinical outcome was evaluated according to the American Orthopedic Foot and Ankle score as excellent (90–100), good (75–89), fair (50–74) and poor (<50).

## Statistical analysis

The two groups were compared with respect to age, sex, Arbeitsgemeinschaft für Osteosynthesefragen (AO) fracture type, number of closed and open fractures (Gustilo-Anderson type I), pre-operating waiting period, operating time, duration of hospital stay, bony union time, incidence of wound complications, mal-union and non-union of the fracture and the American orthopedic Foot and Ankle score. Unpaired Student *t* test and uncorrected  $\chi^2$  test were used as the statistical test, and analysis was performed using "open EPI" online site (data analysis online site). The chosen level of significance was  $p < 0.05$ .

## Results

All the patients included in the study were followed at least for 1 year, the mean follow-up period for the interlocking nail group was 15.8 months (range 13–21 months) and for the MIPO group was 16.2 months (range 13–23 months) ( $p = 0.17$ ). The mean age of the patients was 41 years (range 19–79 years) in the interlocking intra-medullary nail group and 48 years (range 18–72 years) in the MIPO group ( $p = 0.12$ ). There were 28 men and three women in the interlocking nail group and 20 men and 12 women in the MIPO group ( $p = 0.054$ ). The two groups were comparable in the fracture types, according to OTA system, number of open fractures ( $p = 0.52$ ) and degree of the soft-tissue injury, according to the Tscherne classification ( $p = 0.23$ ).

The mean pre-operative waiting period was 3 days (range 1–5 days) for the interlocking intra-medullary nail group and 6 days (range 3–12 days) for the MIPO group ( $p = 0.01$ ). The mean duration of surgery was 72 minutes (range 40–100 minutes) in the interlocking intra-medullary nail group and 94 minutes (range 55–150 minutes) in the MIPO group ( $p = 0.08$ ). Mean duration of hospital stay was 6 days (range 4–10 days) in the interlocking intra-medullary nail group and 13 days (range 7–20 days) in the MIPO group ( $p = 0.01$ ).

The amount of blood loss for interlocking nail group and MIPO group was around 50 mL. As both the procedures were carried out under tourniquet control, the blood loss was not significant. Also, because of the retrospective nature of study, it was not possible to measure exact amount of blood loss, and the measurement was performed using soaked sponge count, which is an arbitrary method.

The period before the radiologic union was 18 weeks (range 14–24 weeks) in the interlocking intra-medullary nail group and 19 weeks (range 16–28 weeks) in the MIPO group ( $p = 0.85$ ). Partial weight-bearing ambulation was started at 8 weeks in the



**Figure 1.** (A) Pre operative distal tibia fracture (AO/OTA 43a) AP and Lateral view. (B) 1 year Post operative treated with interlocking nail AP and Lateral view.

interlocking intra-medullary nail group as compared with 12 weeks in the MIPO group ( $p = 0.01$ ).

There was one wound complication in the interlocking intra-medullary nail group and seven in the MIPO group ( $p = 0.02$ ). Four patients had mal-union and one patient had non-union in the interlocking nail group as compared with one patient with mal-union and three patients with non-union in the MIPO group (Figure 3).

Average American Orthopedic Foot and Ankle score was 91.1% of normal side in the interlocking nail group and 88.9% of normal side in the MIPO group ( $p = 0.31$ ; Tables 1 and 2).

## Discussion

Our study consisted of 63 distal tibia fractures treated with either an MIPO or an intra-medullary interlocking nail. Our study is limited by its retrospective nature and non-randomized design. The retrospective design of this study has limitations as selection bias which is introduced by the fact that the surgeon decides which

operative treatment has to be performed. Some of this bias was eliminated by the matching of patients.

Fractures of tibial distal third are difficult to treat. When associated with a poor lining of soft tissues, these fractures are frequently comminuted or present a small metaphyseal fragment. Traditional techniques fail to achieve an appropriate reduction and maintenance of fractures or may further damage soft parts. Biological fixation of tibial distal third fractures is beneficial and technically feasible. The advantages are as follows: it reduces injuries on soft parts, it does not compromise bone vascularization and presents a low complication rate, especially when compared with open reduction and internal fixation. These fractures, when not involving joints, may be treated by two different manners: locked intra-medullary nail or bridge plate using a minimally invasive technique.<sup>5</sup> So, we have compared these two most commonly used treatment modalities for the management of distal tibia fractures.

In this study, we found that the cost of treatment for the intra-medullary nail group was lower as compared with the MIPO group.



**Figure 2.** (A) Pre operative distal tibia fracture (AO/OTA 43a) AP and Lateral view. (B) 1 year Post operative treated with MIPO AP and Lateral view.

The cost of implant for the interlocking nail group ranges between INR4000 and INR6000 as compared with the MIPO group which ranged from INR6000 to INR9000. Also, the longer duration of hospital stay in the MIPO group further increased the cost of treatment.

In randomized prospective study of 85 distal tibia fractures by Guo et al,<sup>9</sup> the operation was delayed for up to 10 days if the leg was considerably swollen and bruised when plating was used as the treatment modality in contrast intra-medullary nailing was associated with earlier operation. In the present study, the preoperative waiting period was 6 days as compared with 3 days for the interlocking nail group which was found statistically significant. Their study also concluded that the mean radiation time and operating time were significantly longer in the minimally invasive locked compression plate group as compared with intra-medullary nail group, which was also the case in the present study. Thus, there was

longer duration of hospital stay in the MIPO group as compared with the intra-medullary nailing group adding to the cost of treatment.

Li et al<sup>10</sup> in their retrospective study including 46 patients found that the mean operating time and mean duration of hospital stay was  $76.1 \pm 16.6$  minutes and  $5.8 \pm 2.1$  days, respectively, for the interlocking nail group was significantly shorter when compared with  $90.4 \pm 20.3$  minutes and  $8.9 \pm 3.1$  days, respectively, in the MIPO group. Also, the time for full weight bearing was  $11.1 \pm 1.7$  weeks in the MIPO group, which was significantly longer than  $9.0 \pm 1.4$  weeks in the interlocking nail group. So, they concluded that multidirectional locked nailing may be considered a better surgical option as it offers advantages in terms of mean operating time, hospital stay and full weight-bearing time. Thus, interlocking intra-medullary nail saves operative time, helps in early weight bearing and reducing the duration of hospital stay.



Figure 3. Wound complications following MIPO.

**Table 1**  
Demographic data (paired t test used for statistical analysis).

	Interlocking nail group	MIPO group	p Value
Number of patients	31	32	
Mean age (yr)	41	48	0.12
Mean follow-up period (mo)	15.8	16.2	0.17
Gender			0.054
Male	28 (90%)	20 (63%)	
Female	03 (10%)	12 (27%)	
Mechanism of injury			—
Road traffic accident	18 (58%)	20 (62.5%)	
Fall from height	07 (23%)	04 (12.5%)	
Fall from standing height	06 (19%)	08 (25%)	
Type of fracture			—
Closed	23 (74%)	28 (87.5%)	
Type I open	8 (26%)	04 (12.5%)	
AO/OTA classification			0.52
43A1	27 (87%)	18 (56%)	
43A2	04 (13%)	12 (38)	
43A3	00 (0%)	02 (6%)	
Tscherne classification			0.23
C0	14 (45%)	20 (62.5%)	
C1	12 (39%)	11 (34%)	
C2	05 (16%)	01 (3.5%)	
Associated fibula fracture	23 (74%)	21 (66%)	—
Associated co-morbidities			—
Diabetes mellitus	07 (23%)	04 (12.5%)	
Immunocompromised state	00	00	

AO = arbeitsgemeinschaft für osteosynthesefragen; MIPO = minimally invasive plate osteosynthesis; OTA = Orthopaedic Trauma Association.

**Table 2**  
Results and complications (paired and unpaired t test used for statistical analysis).

		Interlocking nail group	MIPO group	p Value
1	Mean pre-operative waiting period (d)	03	06	<b>0.01</b>
2	Mean duration of surgery (min)	72	91	0.08
3	Mean duration of hospital stay (d)	06	13	<b>0.01</b>
4	Mean American foot and ankle score	91.1	89.9	0.31
5	Mean radiological union time (wk)	18	19	0.85
6	Wound complications	01	07	<b>0.02</b>
7	Non-Union	01	03	0.16
8	Mal-Union	04	01	0.09

MIPO = minimally invasive plate osteosynthesis.

Values are bold because they are statistically significant.

Surgical treatment for distal tibial metaphyseal fractures is a challenge because extensive soft-tissue injuries often disrupt the vascular supply to the fracture site and increase the risk of infection and delayed union or non-union because of the thin soft tissue envelop and precarious blood supply in this region.<sup>2</sup>

Lau et al<sup>11</sup> in a retrospective study of the clinical outcome using metaphyseal locking plate by the MIPO technique in 48 patients having acute distal tibia fractures found that there were eight cases of post-operative infection, of which one was acute and seven were late which accounted for about 17%; of these eight patients, four patients were treated by antibiotics, but one patient required debridement and other three incision and drainage, requiring further hospital stay and adding to the cost of treatment. Thus, even minimally invasive technique like MIPO has a high post-operative infection rate in this region of tibia, so closed technique of intra-medullary interlocking nailing proves to be more cost-effective.

The American Orthopaedic Foot and Ankle surgery scoring system was used by Guo et al<sup>9</sup> and the Olerud-Molander Ankle Score by Li et al<sup>10</sup> to evaluate the functional results, respectively; both the studies showed no statistically significant difference between the functional outcome of either intra-medullary interlocking or MIPO group. Thus, suggesting that closed intra-medullary interlocking nailing and a minimally invasive percutaneous plate osteosynthesis can be used safely and effectively to treat distal metaphyseal fractures of the tibia.

But, we admit that our study has few limitations. As the study is retrospective analysis, the two groups compared are not exactly

comparable. The patients were operated by different surgeons who differ in their experience in the field of orthopaedics which may confound the results. All limitations of retrospective study also apply the above study.

### Conclusion

Thus, we conclude that interlocking intra-medullary nailing and MIPO are effective options in the management of distal tibia fractures, but interlocking nailing fares better than MIPO with regards to early weight bearing, less pre-operative waiting period, shorter ambulation and wound complications. Also, as the implant is cheaper, there is less preoperative waiting and shorter duration of hospital stay. Closed intra-medullary nailing is a potentially cost-effective alternative to MIPO for the treatment of distal tibia fractures.

### Conflicts of interest

None.

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