Comparison between Open Reduction and Internal Fixation and Minimally Invasive Plate Osteosynthesis for Treatment of Distal Tibia Fractures

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Purpose: *To compare the results of distal tibia fractures treated by open reduction and internal fixation (ORIF) with minimally invasive plate osteosynthesis (MIPO).*
Methods: *A prospective randomized controlled study of 36 patients with distal tibia fractures (Type A, AO/OTA classification) in Nakhonpathom Hospital from May, 2011 to February, 2013. These patients were diagnosed as closed fracture or open fracture grade I by Gustilo classification. Twenty one were treated by ORIF and fifteen were treated by MIPO using distal tibia locking plate. The operating time, bone union time, rates of superficial infection, rates of malunion and delayed union, and functional outcome according to Teeny and Wiss criteria were analyzed at a 6-month follow-up.*
Results: *Operating time, bone union time, functional outcome, rates of superficial infection were not significantly different between both groups. No malunion and delayed union were observed in either group.*
Conclusion: *The results of distal tibia fractures treated by ORIF with MIPO were not significantly different.*

Keywords: *Distal tibia fractures, ORIF, MIPO, infection rate, functional outcome*

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Introduction

The treatment of a distal tibia fracture is still challenging because of high complication rates such as soft tissue problems, infection, osteomyelitis, delayed union, malunion and secondary osteoarthritis of the ankle.

According to the classification of distal tibia fracture (AO/OTA)[1], there are three types:

Type A: Extra-articular distal tibia fracture

Type B: Partial articular fracture

Type C: Complete metaphyseal fracture with articular involvement

The distal tibia fractures have been treated by a variety of methods, including plaster immobilization, traction, open reduction and internal fixation (ORIF) with plates, closed intramedullary, minimally invasive plate osteosynthesis (MIPO), and external fixation.

Ruedi and Allgower reported good to excellent results in 70 of 75 distal tibia fractured patients treated by open reduction and internal fixation with plates in 1960-1970[2].

MIPO technique was a new technique and used biological fixation principle[3]. The indications were periarticular fracture, metaphyseal fracture, diaphyseal fracture where intramedullary nailing was not indicated[4-8].

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Helfet et al. reported the results of distal tibia fractures treated by MIPO[9]. There was no loss of fixation or evidence of hardware fracture. Twenty distal tibia fractures were union but delayed union, deformity, and superficial cellulitis were reported.

The objective of this study was to compare the results of distal tibia fractures treated by ORIF and MIPO in Nakhonpathom Hospital.

Patients and Methods

A prospective randomized controlled study compared 36 patients with extra-articular distal tibia fracture (type A, AO/OTA classification) in Nakhonpathom Hospital from May, 2011 to February, 2013. The study was approved by the ethical committee of Nakhonpathom Hospital. These patients were diagnosed with a closed fracture or open fracture grade I by Gustilo classification. Twenty one distal tibia fractures were treated by ORIF and fifteen were treated by MIPO. The associated injury, routine pre-anesthetic investigation, standard anteroposterior and lateral radiographs of the ankle joint which included the tibia were recorded (Fig. 1).

Closed fractures or open fractures of distal tibia grade I by Gustilo classification (type A1, A2, A3, AO/OTA classification) were included in this study. Patients with distal tibia fractures (type B, C, AO/OTA classification), open fractures of the distal tibia grade II and III by Gustilo classification, multiple fractures, uncontrolled diabetes or vascular

diseases were excluded. Informed consent was obtained from the patients.

The patients with closed fracture were treated by anti-edema drug for 5-7 days until the skin was wrinkled. Preoperative antibiotics (first-generation cephalosporin) were administered 30 minutes before the operation.

The patients with an open fracture were debrided in the first operation and initially stabilized with a long leg slab. Postoperative management included anti-edema drug and first generation cephalosporin for 5-7 days until they no longer had symptoms and signs of infection. Then the second operation was performed.

A B

Fig. 1 A 40-year-old man who sustained an injury from a motorcycle accident with an extra articular distal tibia fracture. Preoperative anteroposterior (A) and lateral (B) radiographs

Surgical technique

Under a tourniquet, the fibula was fixed firstly by open reduction and internal fixation with a one-third tubular plate and followed by the tibia.

In ORIF group, the standard anteromedial approach was performed. The distal tibia fracture was fixed to a distal tibia locking plate with at least 3 screws for each main fragment. On postoperative day1, the patient was allowed to move ankle joint without support, and ambulation with crutches in day 2. Weight bearing was protected.

In MIPO group, the patient was supine on the radiolucent operative table. An indirect reduction technique was carried out and alignment checked by fluoroscopy (Fig. 2). A distal incision was performed at the medial site of the distal tibia. The saphenous vein and nerve were identified. A proximal incision was made under fluoroscope for at least 3 screws in the proximal fragment. A subcutaneous extraperiosteal tunnel was created and follow by the insertion of a plate from the distal to proximal incision[10,11]. The locking plate position was checked until proper positioning was achieved. Locking screws were inserted with at least 3 screws in the proximal and 3 screws in the distal fragments (Fig. 3). The postoperative program was the same as the ORIF group.

Fig. 2 The indirect reduction technique was completed and alignment checked by fluoroscopy

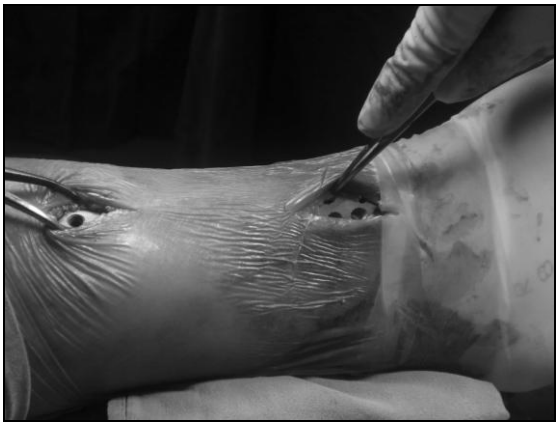
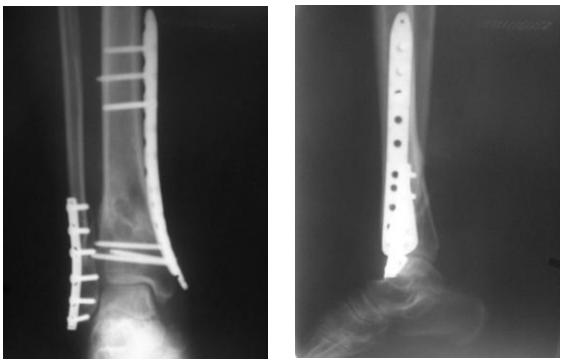


Fig. 3 The distal tibia fracture was stabilized with a locking compression plate by MIPO technique



A B

Fig. 4 Postoperative anteroposterior (A) and lateral (B) radiographs at 3 months demonstrated complete bone healing

The patient was scheduled for follow-ups every 4 weeks until the fracture united. Wound condition and range of motion of ankle were evaluated and a radiograph of distal tibia was taken. Fracture healing was defined as radiological evidence of bridging mature callus at least three cortices as seen in both anteroposterior and lateral radiographs (Fig. 4). The functional outcome was evaluated with the clinical rating system for the ankle by Teeny and Wiss criteria[12] at a 6 months follow-up (Table 1). All patients took calcium 1,250 mg/day and alfacalcidol 0.25 µg/day. The data were analyzed by the Mann-Whitney U-test and Fisher's exact test.

Table 1 Teeny and Wiss criteria (symptoms and functional evaluation of ankle)

Parameters	Points
1. Pain	
a) No pain, including long walks, running or sports.	50
b) Slight or occasional pain, pain after long walk or sports, or mild pain at end of day.	45
c) Mild pain with walking or running, but no change in activities of daily living. May have some pain going up or down stairs or walking on uneven ground. May require non-narcotic pain medicine several times a week.	40
d) Mild-moderate pain, tolerable, but requires some concessions to pain. May required daily non-narcotic pain medicine. No night pain.	30
e) Moderate pain. Definite change in activities of daily living, pain at rest or at night, despite restriction of activities. Occasional weak narcotic needed.	20
f) Continuous pain, regardless of activities, most often not relieved with non-narcotic medication. Dependent on narcotic pain medicine for significant pain relief. Severe limitations of activities.	10
g) Disabled because of pain. Constant pain, no relief with medicines.	0
2. Distance	
a) Unlimited	8
b) Limited, but greater than 6 blocks	6
c) 4-6 blocks	4
d) 1-3 blocks	2
e) Indoors only	1
f) Bed-chair, or unable to walk.	0
3. Supports or Orthosis	
a) None	8
b) Soft wrap needed for long walk	7
c) Cane or orthosis, only for long walks	6
d) Cane, single crutch or orthosis full time	4
e) Two canes or two crutches	2
f) Walker or unable to walk	0
4. Running	
a) Unlimited, as such as desired	5
b) Limited, but able to run	3
c) Unable to run	0

5. Toe raising	
a) Able to raise on toes x 10 repetitions	5
b) Able to raise on toes x 5 repetitions	3
c) Able to raise on toes x 1 repetitions	1
d) Unable to raise on toes	0
6. Hills (up or down)	
a) Up and down normally	3
b) Climbs and /or descends with foot externally rotated	2
c) Climbs and/or descends on toes or by side stepping	1
d) Unable to climb and/or descend hills	0
7. Stairs (up or down)	
a) Climbs and descends normally	3
b) Needs banister	2
c) Steps down and/or up with normal foot only	1
8. Limp	
a) None	8
b) Only when fatigued	6
c) Slight, constant	4
d) Moderate, constant	2
e) Marked	0
9. Swelling	
a) None	3
b) Only in the evening or after walking	2
c) Constant, mild (less than 1 cm difference around calf)	1
d) Marked	0
10. Plantar range of motion	
a) Greater than 30°	2
b) Greater than 10°	1
c) Less than 10°, or presence of equines contracture	0
11. Dorsal range of motion	
a) Greater than or equal to 15°	5
b) Greater than or equal to 10°, less than 15°	4
c) Greater than or equal to 0°, less than 10°	3

Results

There were 36 distal tibia fractures with 30 closed fractures and 6 open fractures grade 1 by Gustilo classification. There were 18 males and 18 females.

There were 21 patients in the ORIF group. There were 12 males (57.0%), 9 females (43.0%) and 15 close fractures (71.0%), 6 open fractures (29.0%). The mean age was 48.5 years (range 30-66 years). The superficial wound infection rate was 28.6% (6 in 21).

There were 15 patients in the MIPO group. There were 6 males (40.0%), 9 female (60.0%) and 15 close fractures (100%). The mean age was 41.2 years (range 17-71 years). The superficial wound infection rate was 6.7% (1 in 15).

Table 2 Clinical outcomes between ORIF and MIPO for treatment of distal tibia fractures

Results	ORIF group (n=21)			MIPO group (n=15)			Z	*P*-value*
	Mean (SD)	Min	Max	Mean (SD)	Min	Max		
Operating Time (minutes)	70.7 (9.3)	60.0	90.0	73.0 (15.2)	60.0	100.0	0.00	1.00
Bone Union Time (weeks)	12.3 (2.0)	10.0	14.0	13.2 (1.7)	10.0	14.0	-1.41	0.16
Teeny and Wiss Score	90.7 (5.0)	83.0	96.0	93.4 (1.4)	92.0	95.0	-0.59	0.55

*Mann-Whitney U-test

Malunion and delayed union were not found in either group. The clinical outcomes between ORIF and MIPO for treatment of distal tibia fractures are displayed in table 2.

Comparing the operating time, the MIPO group was not significantly different to the ORIF group (Mann-Whitney U-test, *P*=1.00).

Comparing the bony union time, the MIPO group was not significantly different to the ORIF group (Mann-Whitney U-test, *P*=0.16).

Comparing the functional outcome by the clinical rating system for the ankle (Teeny and Wiss criteria), the MIPO group was not significantly different to the ORIF group (Mann-Whitney U-test, *P*=0.55).

Comparing the superficial wound infection rate, the MIPO group was not significantly different to the ORIF group (Fisher's exact test *P*=0.20, odd ratio=5.6, 95% CI: 0.60-52.54).

Discussion

The goals of treatment of a distal tibia fracture are anatomical articular reduction, restoration of axial alignment, maintenance of joint stability, achievement of fracture union, pain free weight baring and motion, and no wound complications.

The treatment plan in a distal tibia fracture depends on fracture pattern, soft tissue injury, patient co-morbidity, fixation resources, and surgical experience.

The main disadvantage of ORIF for the distal tibia fracture is wound complication. Yih-Shiunn Lee et al. reported a superficial infection rate of 12.2% and malunion of 2% in distal tibia fracture treatment by ORIF technique[13]. However, this study showed that the superficial infection rate was higher (28.6%) and malunion rate was lower (0%) than the previous study. Superficial infections occurred in open fractures or high soft tissue injuries and was treated with oral antibiotics.

MIPO has gained popularity in treatment of long bone fractures. This biological fixation was a physiologic process of bone healing and optimally with minimal amount of soft tissue injury[14]. The indirect reduction principle of MIPO was reposition and realigning by manipulation at a distance away from the fracture site, preserving soft tissue (indirect induction technique), leaving comminuted out of the mechanical construct, while preserving their blood supply, using low elastic modulus, biocompatible materials, limited operative exposure.

Mahajan reported the MIPO technique in 20 patients with distal tibia fractures, 14 excellent, 4 good, and 2 fair results[15]. Two patients had superficial wound infection. However, our study demonstrated that the superficial infection rate was lower (6.7%) than the previous study. Good preparation of soft tissue in preoperative program can reduce superficial wound infection.

Webb et al. reported that functional outcomes following minimally invasive locking plate osteosynthesis in distal tibia fractures did not significantly differ from that of the general population[16]. In our study, the MIPO group did not have better functional outcome than the ORIF group. A lower infection rate in the MIPO group was not related to a good functional outcome. The superficial infection rate did not affect bone union time.

In our study, the operating time, bone union time, functional outcome and superficial infection rate were not significant difference in either group. One of the factors is, because, we do both techniques by caring of the soft tissue and not striping the periosteum unnecessarily, so we can avoid complications as a result of poor tissue handling. On the other hand, MIPO used indirect reduction under fluoroscopy. The disadvantage of MIPO is more radiation exposure to the operating team compared with ORIF. However, the advantage of MIPO is soft tissue preservation under treatment with skillful surgeons and may lower the risk of radiation exposure and avoid unfavorable results. Although this study had a small number of cases, a further study with a larger population will be required to obtain more information.

Conclusion

The present study demonstrated that patients treated by MIPO technique did not have better outcomes than patients treated by ORIF technique. MIPO was an alternative for the treatment of a distal tibia fracture.

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การเปรียบเทียบผลการรักษากระดูกหน้าแข้งส่วนปลายหักด้วยวิธีการผ่าตัดเปิดแผลมาตรฐานกับการผ่าตัดเปิดแผลเล็ก

นัทพันธุ์ คีรีวิเชียร, พบ

วัตถุประสงค์: *เปรียบเทียบผลการรักษาผู้ป่วยกระดูกหน้าแข้งส่วนปลายหักระหว่างวิธีการผ่าตัดเปิดแผลมาตรฐานกับวิธีการผ่าตัดเปิดแผลเล็ก*

วิธีการศึกษา: *ได้ทำการศึกษาแบบสุ่มตัวอย่างไปข้างหน้าโดยแบ่งผู้ป่วยกระดูกหน้าแข้งส่วนปลายหักทั้งแบบแผลปิดและแบบแผลเปิดระดับที่ 1 ออกเป็น 2 กลุ่ม โดยกลุ่มที่ 1 ใช้วิธีการผ่าตัดเปิดแผลมาตรฐาน และกลุ่มที่ 2 ใช้วิธีการผ่าตัดเปิดแผลเล็กโดยใช้อุปกรณ์ distal tibia locking plate ระยะเวลาการศึกษาตั้งแต่เดือนพฤษภาคม พ.ศ. 2554 ถึงเดือนกุมภาพันธ์ พ.ศ. 2556 ในโรงพยาบาลนครปฐมเปรียบเทียบในเรื่องของระยะเวลาในการผ่าตัด ระยะเวลาในการติดของกระดูก ผลแทรกซ้อนที่เกิดขึ้นและวัดผลลัพธ์ที่เกิดจากการใช้งานโดยอาศัย clinical rating system for the ankle ของ Teeny and Wiss criteria ที่ระยะเวลา 6 เดือนหลังการผ่าตัด*

ผลการศึกษา: *ศึกษาในผู้ป่วยทั้งหมด 36 รายแบ่งเป็นการผ่าตัดเปิดแผลมาตรฐาน 21 รายและการผ่าตัดเปิดแผลเล็ก 15 ราย พบว่าระยะเวลาการผ่าตัดของทั้งสองวิธีไม่มีความแตกต่างกัน (P=1.0) ระยะเวลาในการเชื่อมติดของกระดูกทางเอ็กซเรย์ของทั้งสองวิธีไม่มีความแตกต่างกัน (P=0.18) ผลลัพธ์จากการใช้งานจาก Teeny and Wiss criteria ของทั้งสองวิธีไม่มีความแตกต่างกัน (P=0.55) อัตราการติดเชื้อที่ผิวหนังของทั้งสองวิธีไม่มีความแตกต่างกัน (P=0.20) ผลจากการผ่าตัดทั้งสองวิธีไม่พบกระดูกติดผิดรูปและไม่พบกระดูกติดช้า*

สรุป: *การผ่าตัดเปิดแผลเล็กมีผลลัพธ์ไม่แตกต่างกันกับการผ่าตัดเปิดแผลมาตรฐานในการรักษาผู้ป่วยกระดูกหน้าแข้งส่วนปลายหัก*