Comparison study of two surgical options for distal tibia fracture—minimally invasive plate osteosynthesis vs. open reduction and internal fixation

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Abstract The aim of this study was to compare the results between two surgical options for distal tibia fracture, i.e. minimally invasive plate osteosynthesis (MIPO) vs. open reduction and internal fixation (ORIF), and explore the benefits and defects of these two techniques. Thirty cases of distal tibia fracture (15 pairs of ORIF and MIPO) were submitted for pair comparison with consistence of gender, age and AO fracture classification. Indexes for evaluation included operative time, blood loss, healing time, time of recovery to work, implant irritation symptoms, and union status. Mazur grading standard was introduced for functional evaluation. Statistical Package for Social Sciences (SPSS) 13.0 was used for analysis. No malunion occurred and one case of osteomyelitis developed in the ORIF group. In the ORIF group, ten cases were evaluated as excellent, three as good, one as fair and one as poor. In the MIPO group, ten cases were excellent and five good. Paired *t*-test found no significant differences between groups on the indexes for analysis. In conclusion, the MIPO technique is not distinctively superior to ORIF in treatment of distal tibia fracture.

Introduction

The management of unstable distal tibia fractures remains challenging for surgeons. The proximity to the ankle makes the surgical treatment more complicated than midshaft tibial fractures. Treatment selection is influenced by the proximity

of the fracture to the plafond, fracture displacement, comminution, and injury to the soft tissue envelope. Conventional open reduction and internal fixation (ORIF) techniques involve extensive dissection and periosteal stripping, which increase the risk of soft tissue complications. Nevertheless, plate fixation is effective in stabilising distal tibia fractures. Intramedullary nailing (IMN) offers a minimally invasive option; however, concerns have been raised regarding the biomechanical stability of fixation and risk of malunion or nonunion [1, 2]. However, when the fracture line is less than 5 cm proximal to the ankle joint, intramedullary nailing (IMN) is not applicable [1–3]. The minimally invasive plate osteosynthesis (MIPO) technique has gained prevalence in recent years. This percutaneous plating technique uses indirect reduction methods and allows stabilisation of distal tibia fractures while preserving the vascularity of the soft tissue envelope. As a result, the MIPO technique has gradually become the preferred option for some surgeons [4–9]. In our study, we retrospectively analysed the cases treated with MIPO or ORIF and performed a paired *t*-test to compare the efficiency of these two treatments.

Materials and methods

From January 2003 to December 2007, 58 cases of distal tibia fracture with or without fibula fractures were entered into the study with complete follow-up details. Inclusion criteria were age at least 18 years at the time of diagnosis and a closed or type I open fracture of the distal third of the tibial diaphysis. Exclusion criteria were earlier fractures of the tibial shaft on the same side and proximal intraarticular or distal intraarticular fractures of the tibia. Radiographs were used to determine the location and AO classification of the fractures in the selected patients.

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Among them, 30 cases were treated by ORIF and 28 by MIPO. Fifteen pairs were selected with regard to gender, age and AO fracture classification, and submitted for pair comparison. All of those cases selected were closed fractures. The general data of patients are illustrated in Table 1.

Surgical technique

All patients were immobilised to relieve swelling. Surgery was avoided until the swelling subsided and senior surgeons confirmed the soft tissue status was acceptable. Intravenous antibiotics were administrated 30 minutes before surgery (Cefotiam, 30 mg/kg). Pneumatic tourniquets were used in both groups. All cases were managed by the same surgical team.

In the ORIF group, an anterior-medial incision was performed and the fracture fragments were exposed to direct view. During the reduction procedure, care was taken to preserve the soft tissue and blood supply of fragments. An AO locking compression plate (LCP) or shaped plate was used for fixation and at least four screws engaging seven to eight cortices at each end to ensure the stability. In the MIPO group, closed reduction was attempted without direct visualisation. The AO LCP was used. The length of plate should be sufficient for four to eight holes at the proximal end of the fracture line. Premoulding of plates was important, if not possible a standard plate was applied. The distal end should be curved externally about 15 degrees

and the right limb plate should have a counterclockwise contortion of about 20 degrees (clockwise contortion for the left limb) to adapt with the distal anatomical shape of tibia. The plates were placed against the medial side of bone in all cases.

Essentials of MIPO technique

An anterior-medial curved incision (about 3–6 cm), exposing and protecting the saphenous vein (Fig. 1). After closed reduction, the premoulded plate is inserted upward from the distal end without periosteal resection. Next, a proximal incision about three holes long is made to expose the upper part of the plate, and the plate position adjusted as needed. Intra-operative use of the image intensifier helps to accomplish closed reduction (Figs. 2 and 3). The anterior-posterior and lateral views should both be checked and rotary restoration should be confirmed. Care should be taken with fibula reduction as it plays an important role in the restoration of rotational alignment. Once functional reduction is accomplished, the locking screws are driven in. Three screws at each end will suffice.

Fibula fixation

Fixation of fibula fractures used to be considered unnecessary; nevertheless, when instability of the inferior tibiofibular syndesmosis is diagnosed, ORIF of the fibula

Table 1 The general data of 15 pairs of patients in ORIF and MIPO groups

Patient number	ORIF			MIPO		
	Gender/age (y)	Fracture pattern	Follow-up time (months)	Gender/age (y)	Fracture pattern	Follow-up time (months)
1	Male/32	A1	47	Male/31	A1	43
2	Female/38	A1	36	Female/35	A2	31
3	Male /33	A2	31	Male/36	A2	10
4	Male /27	A3	44	Male/25	A3	18
5	Female/75	B2	44	Female/63	B2	25
6	Female/53	B3	38	Female/40	B3	40
7	Female/52	C1	42	Female/55	C1	41
8	Male/16	C3	23	Male/14	C1	41
9	Male/28	C1	30	Male/32	C3	43
10	Male/72	C3	48	Male/63	C1	27
11	Male/50	A1	31	Male/53	A2	33
12	Male/30	A1	22	Male/28	A2	12
13	Male/45	A1	30	Male/43	A2	8
14	Female/46	A1	39	Female/49	A2	32
15	Female/20	B3	48	Female/30	B2	24

MIPO minimally invasive plate osteosynthesis, ORIF open reduction and internal fixation

Fig. 1 The long saphenous vein was exposed and protected from distal incision

is necessary. Posterior malleolar fractures, with no significant displacement, should also be a matter of concern. Screw fixation could be helpful for early postoperative activity.

Postoperative management

Patients are encouraged to mobilise partial weight bearing the day after the operation and progress to full weight bearing after bone union. All patients were followed-up and plain radiographs were obtained every month until fracture healing occurred (Fig. 4). Thereafter patients were generally seen every three months, but there was no protocol for routine follow-up.

Fig. 2 A2 type fracture; Closed reduction was performed under an image intensifier

Fig. 3 A 13-hole plate was placed medially after premoulding. Postoperative anterior-posterior and lateral views confirmed restoration of the limb alignment

Postoperative assessment

Radiographic union was defined as the presence of bridging callus in three of the four cortices as seen on anterior-posterior and lateral radiographs.

Delayed union and nonunion were confirmed when eight and 11 months of time had elapsed, respectively, since the initial injury without achieving bone union. Malunion was defined as more than five degrees of angular or rotational

Fig. 4 Solid union was observed eight weeks after MIPO operation

deformity. Symptoms of nerve injury occurring in the ipsilateral lower limb evident soon after the operation was considered iatrogenic nerve palsy.

The data concerning operation time, blood loss, hospital stay, healing time, time of recovery to work, mechanical alignment of lower extremity, irritation symptoms, delayed union or nonunion and infections were recorded. Ankle function was measured using Mazur ankle score [10]. The maximum score was 100 points. A value of more than 92 points was considered an excellent result, 82–92 good, 65–86 fair, and <65 was considered poor.

Statistical strategy

Statistical analyses were conducted with Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, USA) 13.0 software. Comparison of variables between the groups was performed using paired sample *t*-test. Non-parametric Wilcoxon test was used for analysis of Mazur grading results (excellent was coded as 1; good as 2; fair as 3; poor as 4). The frequencies of the data were statistically compared between the groups using the Pearson's chi-square test or Fisher's exact test. A *P* value less than 0.05 was considered significant and less than 0.01 to be highly significant.

Results

No malunion nor internal fixation loosening occurred in either group. In the ORIF group, ten cases were evaluated as excellent, three as good, one as fair and one as poor. In the MIPO group, ten cases were evaluated as excellent and five as good. In the ORIF group, one case (AO type C1) developed postoperative tibial osteomyelitis and nonunion, which resolved after secondary surgery. One case (AO type B3) had a delayed union at 32 weeks. Two cases had local soft tissue irritation symptoms from the implants, and another case had local skin numbness and was diagnosed as iatrogenic nerve injury, which remained unresolved up to the latest re-examination. In the MIPO group, no deep infection developed. Nine cases of soft tissue irritation symptoms occurred with slight influence on daily life. One case (AO type B2) had delayed union at 48 weeks, and in another case a locking screw broke.

Paired *t*-test found no significant differences between groups on the indexes of duration of surgery, postoperative drainage volume and hospital stay ($P=0.073$, 0.096 and 0.896 , respectively); and no significant difference in healing time and time of recovery to work ($P=0.737$, 0.379 , respectively). Non-parametric Wilcoxon test found no significant differences of functional results between groups ($P=0.438$). Nevertheless, Pearson's chi-square anal-

ysis demonstrated a significantly greater implant irrigation complaints in the MIPO group ($P=0.008$). Detailed data and statistical analysis are illustrated as Tables 2 and 3. With PASS 2008, we evaluated the sample size with analysis power set at over 0.8, the minimum sample size for comparison of time of healing and recovery to work were 139 and 82 pairs, respectively.

Discussion

The optimal treatment of unstable distal tibia without articular involvement remains controversial, despite the variety of treatment options which have been suggested for these injuries, including nonoperative treatment, external fixation, intramedullary nailing, and plate fixation. However, each of these treatment options has certain defects. Nonoperative treatment may be complicated by loss of reduction and subsequent malunion; external fixation of distal tibia fractures may result in insufficient reduction, malunion, and pin tract infection; there is some concern about the use of IMN in distal tibia fractures; ORIF results in extensive soft tissue dissection and may be associated with wound complications and infections.

In recent years, numerous reports have argued that the MIPO technique is a safe and worthwhile method of managing such fractures, whilst avoiding some of the complications associated with conventional open plating methods. However, some studies have also revealed defects of the MIPO technique. Hasenboehler et al. [11] reported that although MIPO seems more advantageous for soft tissue and bone biology, prolonged healing times were observed in simple fracture patterns. Khoury et al. [12] pointed out that for the MIPO technique, reduction should be performed cautiously due to the tendency of sagittal plane malreduction. Therefore, whether the virtues of the MIPO technique exceed ORIF is not clear.

As a conventional method, ORIF has the advantages of clear exposure and definite anatomical reduction, which is especially suitable for fractures of type A and B. Nevertheless, for those cases of complex fracture, blindly pursuing anatomical reduction without taking care of the soft tissues will aggravate blood supply damage; therefore, the operation time will be extended and the risks of infection and nonunion increase. In our study, patient number 9 (AO type C1) suffered postoperative osteomyelitis which resulted in poor function. Another case (No. 6, AO type as B3) could not walk independently until 40 weeks after operation (Mazur grading scale as fair).

The MIPO technique requires only realignment of tibial mechanical axis, and clear exposure of the fracture is not necessary. The intraoperative image intensifier helps with the closed reduction and avoids excessive disturbance of the fracture fragments. For comminuted fractures, the

Table 2 Detailed data of 15 pairs of patients

Patient number	Operative time (min)		Blood loss (ml)		Hospital stay (days)		Healing time (weeks)		Time of recovery to work (weeks)		Mazur grade	
	ORIF	MIPO	ORIF	MIPO	ORIF	MIPO	ORIF	MIPO	ORIF	MIPO	ORIF	MIPO
1	90	115	130	200	10	22	8	16	10	32	E	E
2	70	130	130	100	12	10	20	6	36	10	E	E
3	105	75	70	50	9	11	6	12	12	16	E	G
4	65	165	350	100	18	11	10	16	12	20	E	E
5	90	130	220	30	9	14	16	48	24	50	G	G
6	80	125	185	100	15	11	32	16	40	20	F	E
7	60	160	100	200	14	9	24	18	48	20	G	G
8	85	90	200	30	12	10	10	6	12	8	E	E
9	120	165	400	55	9	10	100	10	120	28	P	G
10	70	150	20	320	14	18	10	10	12	12	E	E
11	110	70	180	50	21	10	16	10	24	12	G	E
12	60	45	150	20	9	8	4	16	6	20	E	E
13	90	90	180	100	7	13	8	20	16	20	E	G
14	150	70	180	130	13	13	12	28	24	28	E	E
15	60	120	130	80	10	15	12	20	20	20	E	E

MIPO minimally invasive plate osteosynthesis, ORIF open reduction and internal fixation, E excellent, G good, F fair, P poor
Blood loss was recorded as the total of intraoperative bleeding and postoperative drainage

MIPO technique is particularly advantageous over ORIF. Based on the theoretical considerations, the MIPO technique claims an earlier union process, as well as lower risks of infection, nonunion and other complications.

In our study, although statistical analysis found no significant differences between groups with regard to operative time, healing time, blood loss or ankle function, the longer time for healing and recovery to work, could be related to small sample size.

We found the irritation symptoms were more frequently encountered in the MIPO group. Similar results were reported by Lau et al. whereby 52% (25/48) of distal tibia fracture cases treated by MIPO had the implants removed due to skin impingement [13]. This could be related to the thin subcutaneous tissue and suboptimal premoulding of plates. Furthermore, the residual malreduction also contributes to the inexactness of plate and bone

contouring. However, the symptoms had no effect on their daily life.

Despite the advantages of closed reduction and slight disturbance of soft tissue, MIPO has the disadvantages of non-accurate reduction. The fragments may be not tightly compressed which could increase the risks of delayed union and nonunion, especially for simple fractures (i.e. type A3). Several studies have reported the rate of delayed union or nonunion to be 5–17% [7, 11]. Admittedly, malreduction is also inevitable in the MIPO group; however, careful management under an image intensifier and postoperative guidance should effectively prevent unacceptable deformity.

Cadaver research suggests that the MIPO technique may carry a higher risk of injury for saphenous nerve and long saphenous vein [14]. In our trial one nerve palsy was diagnosed, which should be considered as another negative factor of the MIPO technique.

Table 3 Detailed statistical results

Group / statistic	Interval from injury to surgery (days)	Duration of surgery (min)	Drainage volume (ml)	Hospital stay (days)	Healing time (weeks)	Time of recovery to work (weeks)
ORIF	7.1±4.9	87±25.7	175±96.9	12.1±3.8	19.2±23.5	27.7±28.2
MIPO	6.5±3.6	113.3±38.3	104.3±81.4	12.1±3.7	16.8±10.4	21.1±10.5
<i>t</i> value	0.443	−1.942	1.782	−0.134	−0.134	0.909
<i>P</i> value	0.664	0.073	0.096	0.896	0.737	0.379

MIPO minimally invasive plate osteosynthesis, ORIF open reduction and internal fixation

Although there was no incidence of infection in the MIPO group, a minimal incision can not ensure minimal invasion because surgeons who are unfamiliar with the technique may repeatedly insert and pull out the plate, which will induce a dead space and increase infection risk or delayed union. Therefore, overall preoperative evaluation of the risks to soft tissue are very important, especially for those with high energy injury [15].

The mean time interval from injury to surgery of the two groups was 7.1 ± 4.9 for ORIF group days and 6.5 ± 3.6 days for MIPO group, respectively. Admittedly, for those low energy injuries or type I open fractures without severe soft tissue damage, emergency surgery could provide the definitive treatment. Nevertheless, we must be cautious when dealing with these severe fractures associated with poor soft tissue status. Surgeons should be aware that wound infection or necrosis is the most common postoperative complication of distal tibia fracture [16]. Even those cases which received MIPO surgery, the incidence of wound complications was as high as 15% [13]. Therefore, considering the relatively poor soft tissue coverage and the high incidence of wound complications, delayed elective treatment is relatively more reliable and safe.

Furthermore, the MIPO technique may have a smaller range of indications. The following cases should not be considered for MIPO treatment: (1) remote fracture, (2) infection, (3) articular surface involvement, and (4) osteo-compartmental syndrome.

Finally, we consider that the MIPO technique is an efficient method for treating distal tibia fracture. Nevertheless, in a small sample paired comparison, no significant superiority of MIPO was found over ORIF. Furthermore, the MIPO technique is more challenging than ORIF as it requires closed reduction and management under X-ray control. Compared with MIPO and the IMN technique [1], ORIF should still be considered the gold standard for distal tibia fracture management.

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