Distal tibia fractures and medial plating: factors influencing re-operation

Vasanth Sathiyakumar · Rachel V. Thakore ·
Rivka C. Ihejirika · William T. Obremskey ·
Manish K. Sethi

Received: 27 February 2014 / Accepted: 27 March 2014 / Published online: 27 April 2014
© Springer-Verlag Berlin Heidelberg 2014

Abstract

Purpose We compared types of complications leading to re-operations in open and closed distal tibia fractures treated by locking or nonlocking medial plates.

Methods Ninety-three patients from 2002 to 2012 who underwent open reduction and internal fixation (ORIF) and medial plating for distal extra-articular or partial articular tibia fractures were identified. Charts were retrospectively reviewed to determine the incidence of re-operation based on the type of complication that developed. Fisher's exact and chi-square tests were performed to analyze the incidence of complications based on injury and type of plate used.

Results Thirty-three (35.5 %) patients required re-operations: 28.6 % ($n=16$) with closed injuries had complications leading to re-operations compared with 45.9 % ($n=17$) of patients with open injuries ($p=0.12$). Patients with closed injuries were more likely to require re-operation due to hardware pain/prominence ($p=0.03$), whereas patients with open injuries were more likely to require re-operation due to nonunion ($p=0.04$). There were no significant differences in infection ($p=0.66$) or malunion ($p=0.99$) between groups. Locking

plates showed higher costs but were not associated with decreased risk of re-operation.

Conclusions There was a high re-operation rate associated with distal tibia medial plating, with significant differences in the reason for re-operation between open versus closed groups. Complication rates were not influenced by the use of locking plates. Results of this study suggest that methods be considered to reduce re-operation based on type of fracture, such as early bone grafting or the use of alternate implants for open fractures.

Keywords Re-operation rates · Tibial fractures · Non-union · Tibial internal fixation · Locking plates

Introduction

Surgical fixation of distal tibia fractures is often associated with high risks of developing complications [1–4]. Although infection, pain, and mechanical instability are responsible for the majority of orthopaedic surgical readmissions [5], they are frequently unavoidable and result in re-operations. Identifying re-operation risks based on surgical approach for distal tibia fractures is especially important considering future changes in the healthcare system that may penalise re-operations. In the treatment of distal tibia fractures, intramedullary nailing (IMN) is associated with an increased risk of malalignment [6, 7], and minimally invasive plate osteosynthesis (MIPO) is a challenging technique with contested advantages over plating via open reduction and internal fixation (ORIF) [8–10]. Several comparative studies on distal tibia fractures have demonstrated the utility of ORIF compared with alternative approaches due to the relatively low risk of complication development [11–16]. A comparative study by Cheng et al. demonstrated no significant differences in outcomes among distal tibia fracture patients treated with MIPO compared with ORIF [8]. A retrospective review by Janssen and colleagues

V. Sathiyakumar · R. V. Thakore · R. C. Ihejirika ·
W. T. Obremskey · M. K. Sethi (✉)
The Vanderbilt Orthopaedic Institute Center for Health Policy, 1215
21st Avenue South, Suite 4200 Medical Center East, South Tower,
Nashville, TN 37232, USA
e-mail: manish.sethi@vanderbilt.edu

V. Sathiyakumar
e-mail: vasanth.sathiyakumar@vanderbilt.edu

R. V. Thakore
e-mail: rachel.thakore@vanderbilt.edu

R. C. Ihejirika
e-mail: rivka.c.ihejirika@vanderbilt.edu

W. T. Obremskey
e-mail: william.obremskey@vanderbilt.edu

found ORIF resulted in lower malalignment rates compared with IMN, with similar rates of hardware failure and infection [11]. Joveniaux et al. reviewed 101 cases of distal tibia fractures and recommend the use of ORIF over definitive external fixation due to stable reduction without increased infections [1]. Because ORIF allows for greater ease of anatomical reduction, studies on re-operation rates following ORIF remain highly relevant in the treatment of distal tibia fracture patients.

When considering ORIF for treating distal tibia fractures, there is debate as to whether a medial or lateral approach affords superior outcomes. Lee et al. reviewed 88 distal tibia fractures treated with either medial or lateral plates and found significantly lower complication rates and fewer hardware problems with lateral plating [16]. Yenna's group simulated tibial loading and found no significant difference in mean stiffness between medial and lateral plates [17]. Encinas-Ullan and colleagues conducted a prospective study of 40 patients treated with medial versus lateral plating and found no statistical differences between groups regarding time to union and infection rates [18].

Given that medial plating provides good tibial exposure with minimal dissection, ORIF with medial plating for distal tibia fractures is used in centres across the country. However, relatively few studies in the literature have reported re-operation rates following ORIF with a medial approach [12, 13, 16, 19]. Furthermore, no study has yet investigated factors leading to re-operation (i.e. use of locking versus nonlocking plates, open versus closed injury, etc.) for patients treated with medial tibia plates. In an era in which healthcare costs are rising, investigating these factors and their impact on re-operation rates is important. For example, although locking plates have many benefits, including fixed angular stability [9, 19–21], they also are vastly more expensive than nonlocking plates and not always reduce the risk of complications [22].

In this study, we sought to explore factors influencing re-operation in distal tibia fractures treated with medial plates and, more specifically, whether using locking implants reduces the risk of re-operation. By noting the factors that have significant effects on re-operations, better pre-operative planning for definitive treatment of distal tibia fractures may be facilitated by identifying whether ORIF with medial plating is a viable option.

Methods

Following Institutional Review Board approval, a retrospective chart review was performed using the electronic medical records system of a single, level I trauma centre. A search of the institution's orthopaedic database using Current Procedure Terminology (CPT) code 27758 found 2,246 patients who sustained an extra-articular or partial articular distal tibia fracture and who were subsequently treated with ORIF between 1

January 2002 and 30 January 2012. Of these patients, only cases that included treatment with medial plating were included. Cases that used other approaches to plating (i.e. lateral) or that combined medial plating with other surgical techniques (i.e. medial plating + lateral plating) were excluded. Patients with pathological fractures or incomplete medical records were also excluded. Records were searched for basic demographic data such as age, sex, race, and gender. The number of clinic and emergency department (ED) visits for patients, as well as mechanism of injury (high vs. low energy) was also obtained.

Radiographs and operative notes were reviewed to categorize patients with either open or closed injuries and fractures based on Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) classification. The type of plate used was also recorded. Patients were treated with either Synthes locking compression (LCP) or nonlocking plates with a variety of hole sizes. To calculate average differences in costs, the average cost of Synthes 3.5 LCP Low-Bend Medial Distal Tibia Plates with six, eight, or ten holes was compared with nonlocking Synthes 3.5 Medial Distal Tibia Plates with six, eight, or ten holes. The average cost for each type of plate was subsequently calculated.

Postoperative complications leading to re-operations were determined by reviewing the electronic medical records. Each type of classification was categorised into one of six groups: postoperative infections, fracture nonunion, fracture malunion, hardware pain or prominence, delayed wound healing, and compartment syndrome. All data were recorded into a secure REDCap database.

Baseline demographics were compared between patients sustaining open versus closed injuries using chi-squared or Student's *t* test. Differences in re-operation rates based on locking versus nonlocking plates were analysed using Fisher's exact test. Among all patients who required re-operation for complications, differences in the type of complication sustained by patients in the open versus the closed injury group were analysed using Fisher's exact test. A *p* value <0.05 was used to determine significance. All statistical analyses were conducted using standard IBM SPSS software.

Results

A total of 2,246 patients were identified using a CPT code search for individuals who sustained a distal tibia fracture and were treated at a single, level I trauma centre. Of these patients, we obtained 398 complete medical records of patients treated with a distal tibia plate. Ninety-three patients ultimately met inclusion criteria for analysis (Fig. 1).

Table 1 provides demographic information for patients with medial plates based on fracture presentation. The average age for patients with closed and open injuries was 40 and 42 years, respectively. Most patients in both groups were men.

Fig. 1 Consolidated Standards of Reporting Trials (CONSORT) diagram

For patients with open fractures, 43 % were categorized with grade II fractures; based on AO/OTA classification, only six patients had partial articular involvement. Patients with closed injuries had a majority of A.1 fractures (59 %), and patients with open injuries had a majority of A.3 fractures (65 %). The majority of open (84 %) and closed (80 %) fracture patients in this study were treated with locking plates. There was no significant difference in the use of locking and nonlocking plates between patients with open and closed injuries ($p=0.79$). Table 2 provides demographic information for patients categorised by use of locking versus nonlocking plates.

Table 3 shows types of complications leading to reoperation based on open or closed injuries. The overall complication rate for all patients was 35.5 % ($n=33$). Patients with closed injuries had a complication rate of 28.6 % ($n=16$) and those with open injuries had a complication rate of 45.9 % ($n=17$), showing no significant difference ($p=0.12$). However, there was a significant difference in the reason for re-operation between the closed and open groups. In the closed group, re-operation was driven by hardware removal due to pain or prominence: 50 % of those patients ($n=8$) required hardware removal due to pain, compared with 11.8 % ($n=2$) with open fractures who needed re-operation ($p=0.03$). In the open group, re-operation was driven by nonunion: 70.6 % ($n=12$)

of those patients required revision due to nonunion compared with 37.5 % ($n=6$) with closed injuries who needed re-operation ($p=0.04$).

Only one patient in the study (1.1 %)—who was treated with a nonlocking plate for an open grade 3B (AO/OTA B1) fracture—developed malunion, with 10° of varus malalignment. There was no significant difference in re-operation rates for infection based on open versus closed fracture status ($p=0.66$). There were no incidences of compartment syndrome or delayed wound healing in this cohort of patients.

Table 4 shows differences in the number of patients requiring re-operations based on plate type used; plate type had no significant impact on re-operations in either the open ($p=0.71$) or closed ($p=0.99$) groups or on the type of complication that led to re-operation ($p=0.69$).

Figure 2 shows the differences in costs based on the use of locking (average US \$1,823.33) and nonlocking (average of US \$815.67) plates.

Table 4 also shows re-operation rates based on OTA classification of the tibia fracture, associated fibular fractures and mechanism of injury (high vs. low energy) that led to the distal tibia fracture. Based on Fisher's exact or chi-square tests, these factors did not have a significant influence on re-operation rates (AO/OTA classification p values 0.28–0.68; associated fibular fracture p value 0.22; mechanism of injury p value: 0.07).

Discussion

Our study demonstrates an overall high re-operation rate for patients with distal tibia fractures treated with medial plates. We found significant differences in reasons for re-operation between closed versus open injuries. Patients with closed fractures were more likely to require re-operations due to hardware pain or prominence. On the other hand, in patients with open fractures, re-operation was more likely due to nonunion. Plate type had no significant impact on readmission rates between the closed and open groups, despite locking plates costing nearly US \$1,000 more than nonlocking plates. Of the 33 (35.5 %) patients in our study who required re-operations, those with open fractures were more likely to require re-operations due to nonunion than those with closed fractures, regardless of plate type used. Considering that 76.5 % of all re-operations among open fracture patients were due to problems with bone healing, alternative implants and early bone grafting may be considered. To this end, a few studies have suggest that IMN followed by early bone grafting increases the chances of fracture union and could potentially be an appropriate alternative for treating open injuries [23, 24]. However, a study by Vallier et al. comparing distal tibia plating and IMN found that 11 of 48 patients (22.9 %) with distal tibia fractures treated with a medial plate required a secondary procedure following complications, which was

Table 1 Demographics of patients with closed versus open fractures treated with medial plates

Demographic	Closed (n=56)	Open (n=37)	P value
Age			
Mean (SD)	40 (16)	42 (17)	0.46
Clinic visits			
Mean (SD)	5.1 (3.4)	8.7 (5.2)	<0.01
ED visits			
Mean (SD)	1.0 (0.1)	1.0 (0.0)	0.43
Gender n (%)			
Male	35 (62.5 %)	28 (75.7 %)	0.25
Female	21 (37.5 %)	9 (24.3 %)	
Fracture grade n (%)			
Grade I		10 (27.0 %)	
Grade II		16 (43.2 %)	
Grade IIIA		5 (13.5 %)	
Grade IIIB		6 (16.2 %)	
AO/OTA classification n (%)			
A.1	33 (58.9 %)	10 (27.0 %)	<0.01
A.2	6 (10.7 %)	0 (0.0 %)	
A.3	14 (25.0 %)	24 (64.9 %)	
B	3 (5.4 %)	3 (8.1 %)	
Associated distal fibular fixation n (%)	38 (67.9 %)	31 (83.8 %)	
Mechanism of injury n (%)			
Low energy	29 (51.8 %)	11 (29.7 %)	0.10
High energy	27 (48.2 %)	26 (70.3 %)	0.05
Plate type n (%)			
Locking	45 (80.4 %)	31 (83.8 %)	0.79
Nonlocking	11 (19.6 %)	6 (16.2 %)	

SD standard deviation, ED emergency department, AO/OTA Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association

not significantly different from patients treated with IMN [13]. Their study also found higher rates of nonunion and malunions for open fractures ($p=0.0007$ and $p=0.04$, respectively), but overall rates of re-operation due to nonunion or malunion were not reported based on surgical approach. IMN therefore may be a viable alternative in the treatment of open distal tibia fractures.

Hardware pain or prominence resulting in re-operation was much more likely among patients with closed injuries, regardless of plate type used. Due to the high rate of re-operations for hardware pain among patients with closed fractures (14.5 %), alternate surgical methods of repair may be recommended. For example, in a comparison of medial and lateral plating techniques among patients with mostly closed fractures, Lee and colleagues found that patients treated with ORIF and medial plating (75.5 %) were more likely to require hardware

Table 2 Demographics of patients treated with locking versus nonlocking plates

Demographic	Locking plate (n=76)	Nonlocking plate (n=17)	P value
Age			
Mean (SD)	43 (17)	32 (11)	0.01
Clinic visits			
Mean (SD)	6.4 (4.5)	6.7 (4.1)	0.81
ED visits			
Mean (SD)	1.0 (0.1)	1.1 (0.2)	0.4
Gender n (%)			
Male	50 (65.8 %)	13 (76.5 %)	0.57
Female	26 (34.2 %)	4 (23.5 %)	
Fracture grade n (%)			
Closed	45 (59.2 %)	11 (64.7 %)	0.71
Grade I	9 (11.8 %)	1 (5.9 %)	
Grade II	12 (15.8 %)	4 (23.5 %)	
Grade IIIA	5 (6.6 %)	0 (0.0 %)	
Grade IIIB	5 (6.6 %)	1 (5.9 %)	
AO/OTA classification n (%)			
A.1	49 (64.5 %)	9 (52.9 %)	<0.01
A.2	6 (7.9 %)	0 (0.0 %)	
A.3	20 (26.3 %)	3 (17.6 %)	
B	1 (1.3 %)	5 (29.4 %)	
Association distal fibular fixation n (%)	57 (75.0 %)	11 (64.7 %)	
Mechanism of injury n (%)			
Low energy	34 (44.7 %)	6 (35.3 %)	0.59
High energy	42 (55.3 %)	11 (64.7 %)	

SD standard deviation, ED emergency department, AO/OTA Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association

removal compared with patients treated with ORIF and lateral plating [16]. It is therefore suggested that ORIF with lateral plating may reduce the rate of re-operations following distal tibial plating. In our study, the majority (68 %) of patients with closed fractures had an associated fibular fracture, which

Table 3 Complications leading to reoperation for open versus closed groups

	Closed (n=16)	Open (n=17)	P value
Nonunion	5	12	0.04
Malunion	0	1	0.99
Implant pain/prominence	8	2	0.03
Wound infection	3	2	0.66
Total	16	17	0.12

Table 4 Reoperation rates based on plate and injury type

	Closed (<i>n</i> =16)	Open (<i>n</i> =17)	<i>P</i> value
Plate type			
Locking	12	14	–
Nonlocking	4	3	–
<i>P</i> value	0.71	0.99	
AO/OTA classification			
A1	10	11	0.28
A2	0	0	–
A3	6	5	0.68
B	0	1	0.40
Fibular fixation	12	15	0.22
High energy	8	14	
Low energy	8	3	0.07

AO/OTA Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association

would make lateral plating enticing given that a single lateral approach can provide fixation of both the tibia and fibula. Janssen et al. studied outcomes following ORIF and dynamic compression plates and screws versus IMN among patients with closed or type I open fractures [11]. Although there was no significant difference in hardware failure between the two methods, there was a greater risk of malalignment of the tibia with IMN. In light of these studies and our results, lateral plating for treating closed distal tibia fractures with fibular injuries may be an alternative to medial plating. In cases without associated fibular fractures, medial plating may be used with concerted efforts to reduce implant pain.

Our results show that re-operation following complications was not associated with plate type. Because locking plates allow for fixed angular stability, they have become more

commonly used to treat distal tibia fractures [9, 19–21]. For example, a pooled analysis by Li and colleagues found minimally invasive locking plates showed no significant difference in complication rates compared with nonlocking plates placed by traditional open techniques, but the analysis was not limited to re-operations or the use of medial plates [25]. Furthermore, a study by Gao et al. investigating distal tibia fractures treated with polyaxial plates following either ORIF or MIPO demonstrated a 0 % secondary operation rate for fracture healing [19]. However, their study did not provide a comparative evaluation on reoperation rates with the use of conventional nonlocking plates and was limited by a sample of patients who had fractures with very short metaphyseal segments. In our study, we found that medial locking plates were not only more expensive (by ~US\$1,000), but that they were also not associated with a significant decrease in re-operation rates. The type of plate used also did not have a significant association with the type of complication sustained. We therefore question the cost-effectiveness of the use of locking plates for distal tibia fractures. However, it is important to note that the number of patients treated with nonlocking plates in this study was low (11 with closed fractures; six with open fractures). Therefore, larger studies may be needed to confirm whether plate type has an effect on re-operation rate.

As policies aimed at reducing the costs of surgical care continue to develop, investigating all aspects of surgical care related to ORIF of distal tibia fractures with medial plates—such as mechanism of injury, AO/OTA classification or associated fibular fractures—is important for peri-operative planning. In our study, mechanism of injury and associated fibular fractures had significant impacts on re-operations for patients treated with a medial plate. Furthermore, whereas AO/OTA classification did not statistically have a significant effect on re-operations, only 12 patients in the study had a fracture

Fig. 2 Average cost for locking and nonlocking plates

classification that was not a simple extra-articular (A1) or a comminuted extra-articular (A3) fracture. Therefore, larger studies may be needed to fully elucidate whether AO/OTA classification truly has an effect on re-operation rates. Nevertheless, to our knowledge, no other study has investigated whether the mechanism of injury or baseline AO/OTA classification may have significant impacts on complications or re-operation rates for patients treated with medial plates for distal tibia fractures.

Our study has some limitations that restrict its generalisability. One is its retrospective design. Although we had a fairly large sample size ($n=93$) compared with other studies focusing on distal tibia medial plating, the number of patients who required re-operations was fairly small. Therefore, the final number of patients who required re-operations for wound infection was low, with no incidences of delayed wound healing or compartment syndrome found in this cohort. Therefore, the lack of significant differences in re-operation rates related to these complications may be due simply to the small sample size. Additionally, all patients were treated at a single, level I trauma centre, which reduces the generalisability of our results. Because our patients were treated by several different orthopaedic surgeons, surgical skill was not controlled for and may be an additional source of bias.

Despite these limitations, our study provides preliminary evidence on differences in types of complications that lead to re-operations based on types of injury, without any influence contributed by the type of plate used. A randomised prospective study with a matched-pairs patient population is recommended to determine a more accurate representation of how these factors influence re-operations following distal tibia fractures.

Conflicts of interest and source of funding William Obremskey previously consulted for biometrics and provided expert testimony in legal matters. The institution of WTO received a grant from the Department of Defense. For the remaining authors, there are no conflicts of interest.

References

- Joveniaux P, Ohl X, Harisboure A et al (2010) Distal tibia fractures: management and complications of 101 cases. *Int Orthop* 34:583–588
- Koval KJ, Clapper MF, Brumback RJ et al (1991) Complications of reamed intramedullary nailing of the tibia. *J Orthop Trauma* 5:184–189
- Lau TW, Leung F, Chan CF et al (2008) Wound complication of minimally invasive plate osteosynthesis in distal tibia fractures. *Int Orthop* 32:697–703
- Borg T, Sune L, Ulf L (2004) Percutaneous plating of distal tibial fractures: preliminary results in 21 patients. *Injury* 35:608–614
- Dailey EA, Cizik A, Kasten J et al (2013) Risk factors for readmission of orthopaedic surgical patients. *J Bone Joint Surg Am* 95:1012–1019
- Chen AL, Tejwani NC, Joseph TN et al (2001) The effect of distal screw orientation on the intrinsic stability of a tibial intramedullary nail. *Bull Hosp Jt Dis* 60:80–83
- Strauss EJ, Alfonso D, Kummer FJ et al (2007) The effect of concurrent fibular fracture on the fixation of distal tibia fractures: a laboratory comparison of intramedullary nails with locked plates. *J Orthop Trauma* 21:172–177
- Cheng W, Li Y, Manyi W (2011) Comparison study of two surgical options for distal tibia fracture—minimally invasive plate osteosynthesis vs. open reduction and internal fixation. *Int Orthop* 35:737–742
- Hasenboehler E, Rikli D, Babst R (2007) Locking compression plate with minimally invasive plate osteosynthesis in diaphyseal and distal tibial fracture: a retrospective study of 32 patients. *Injury* 38:365–370
- Khoury A, Liebergall M, London E et al (2002) Percutaneous plating of distal tibial fractures. *Foot Ankle Int* 23:818–824
- Janssen KW, Biert J, van Kampen A (2007) Treatment of distal tibial fractures: plate versus nail. *Int Orthop* 31(5):709–714
- Vallier HA, Le TT, Bedi A (2008) Radiographic and clinical comparisons of distal tibia shaft fractures (4 to 11 cm proximal to the plafond): plating versus intramedullary nailing. *J Orthop Trauma* 22:307–311
- Vallier HA, Cureton BA, Patterson BM (2011) Randomized, prospective comparison of plate versus intramedullary nail fixation for distal tibia shaft fractures. *J Orthop Trauma* 25:736–741
- Im GI, Tae SK (2005) Distal metaphyseal fractures of tibia: a prospective randomized trial of closed reduction and intramedullary nail versus open reduction and plate and screws fixation. *J Trauma Acute Care Surg* 59:1219–1223
- Zelle BA, Bhandari M, Espiritu M et al (2006) Treatment of distal tibia fractures without articular involvement: a systematic review of 1125 fractures. *J Orthop Trauma* 20:76–79
- Lee YS, Chen SH, Lin JC et al (2009) Surgical treatment of distal tibia fractures: a comparison of medial and lateral plating. *Orthopedics* 32:163
- Yenna ZC, Bhadra AK, Ojike NI et al (2011) Anterolateral and medial locking plate stiffness in distal tibia fracture model. *Foot Ankle Int* 32(6):630–637
- Encinas-Ullan C, Fernandez-Fernandez R, Rubio-Suarez JC et al (2013) Medial versus lateral plating in distal tibia fractures: a prospective study of 40 fractures. *Rev Esp Cir Ortop Traumatol* 57(2):117–122
- Gao H, Zu-Bin Z, Bing-Fang Z (2009) Fractures of the distal tibia treated with polyaxial locking plating. *Clin Orthop Relat Res* 467:831–837
- Namazi H, Mozaffarian K (2007) Awful considerations with LCP instrumentation: a new pitfall. *Arch Orthop Trauma Surg* 127:573–575
- Gosling T, Schandelmaier P, Muller M et al (2005) Single lateral locked screw plating of bicondylar tibial plateau fractures. *Clin Orthop Relat Res* 439:207–214
- Egol KA, Kubiak EN, Fulkerson E et al (2004) Biomechanics of locked plates and screws. *J Orthop Trauma* 18:488–493
- Robinson CM, McLauchlan GJ, McLean IP et al (1995) Distal metaphyseal fractures of the tibia with minimal involvement of the ankle. *J Bone Joint Surg (Br)* 77-B:781–787
- Nork SE, Schwartz AK, Agel J et al (2005) Intramedullary nailing of distal metaphyseal tibial fractures. *J Bone Joint Surg Am* 87:1213–1221
- Li B, Yang Y, Jian L-S (2013) Plate fixation versus intramedullary nailing for displaced extra-articular distal tibia fractures: a system review. *Eur J Orthop Surg Traumatol*. doi:10.1007/s00590-013-1362-3