Injury, Int. J. Care Injured 50 (2019) 978–982

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Outcomes of fixation for periprosthetic tibia fractures around and below total knee arthroplasty

Michael P. Morwood[a,*], Sandra S. Gebhart[b], Nicholas Zamith[c], Hassan R. Mir[a,c]

[a] Florida Orthopaedic Institute, Tampa, FL, United States
[b] Vanderbilt University, Nashville, TN, United States
[c] University of South Florida, United States

ARTICLE INFO

Article history:
Accepted 13 March 2019

Keywords:
Periprosthetic fracture
Tibia fractures
Total knee arthroplasty
Dual-plate fixation

ABSTRACT

Introduction: The incidence of periprosthetic fractures after total knee arthroplasty (TKA) is rising due to an increasing number of TKAs performed annually and the growing elderly population. Like periprosthetic fractures of the distal femur, periprosthetic tibia fractures are primarily treated with operative fixation; however, there is limited scientific literature that has reported outcomes of periprosthetic tibia fractures treated with modern plating techniques. To our knowledge, this is the largest series of non-intraoperative periprosthetic tibia fractures treated with open reduction internal fixation (ORIF) ever reported.
Methods: Retrospective chart review of 4557 operatively treated tibia fractures with ORIF over a 16-year period at two Level 1 Trauma Centers.
Results: 38 patients with an average follow-up of 15.3 months (range 3–24) were identified. 11 (28.9%) fractures were in the proximal tibia (four with extension into the plateau (Felix 1A) and seven adjacent to the tibial stem (Felix 2A)), six (15.8%) in the midshaft/diaphysis (Felix 3A), and 21 (55.3%) in the distal 1/3rd (metaphysis, Felix 3A). 76.3% (29/38) of fractures united by 6 months following the index procedure, leaving 9 nonunions. The overall re-operation rate was 31.6% (12/38). There were no significant differences in rates of union ($p = 1.00$), reoperation ($p = 0.66$), superficial infection ($p = 0.66$), or deep infection ($p = 0.31$) in patients treated with single versus dual plating.
Conclusion: Periprosthetic tibia fractures are difficult to treat and have a high risk of nonunion and reoperation even with modern plating techniques. Most patients can be treated to union with operative fixation and do not require revision arthroplasty, if the components are stable initially. We recommend dual plating for fractures in the proximal third, and either single plating or nailing for fractures in the middle and distal thirds depending on bone quality, implant positioning, and fracture morphology.

Introduction

The incidence of periprosthetic fractures after total knee arthroplasty (TKA) is rising due to an increasing number of TKAs performed annually and the growing elderly population [1–4]. Periprosthetic fractures of the tibia, or fractures below TKAs, are less common than periprosthetic fractures of the distal femur, with a prevalence of between 0.4% and 1.7% [2,4–8]. Like periprosthetic fractures of the distal femur, periprosthetic tibia fractures are primarily treated with operative fixation; however, there is limited scientific literature that has reported outcomes of periprosthetic tibia fractures treated with modern techniques. The difficult nature of these fractures often stems from the lack of bone stock available for fixation around the tibial tray/stem and the osteoporotic bone typically encountered in this patient population. Revision arthroplasty is an option in certain fractures, but is typically reserved for fractures with loose components or in situations with severe bone loss [7],

In 1997, Felix et al. [6] reported on a series of 102 periprosthetic tibial fractures and developed a classification system based on the timing (intraoperative or postoperative), location (at the level of the plateau (Type 1), adjacent to (Type 2) or below the tibial stem (Type 3), or involving the tibial tubercle (Type 4)), and status of fixation of the tibial stem (well-fixed (A), loose (B), or occurring intraoperatively (C) (Fig. 1)). Since that time, many authors have reported on several fixation options to treat these difficult fractures [2,4,9], including locked and non-locked plating, intramedullary

* Corresponding author.
E-mail address: mike.morwood@gmail.com (M.P. Morwood).

https://doi.org/10.1016/j.injury.2019.03.014
0020-1383/

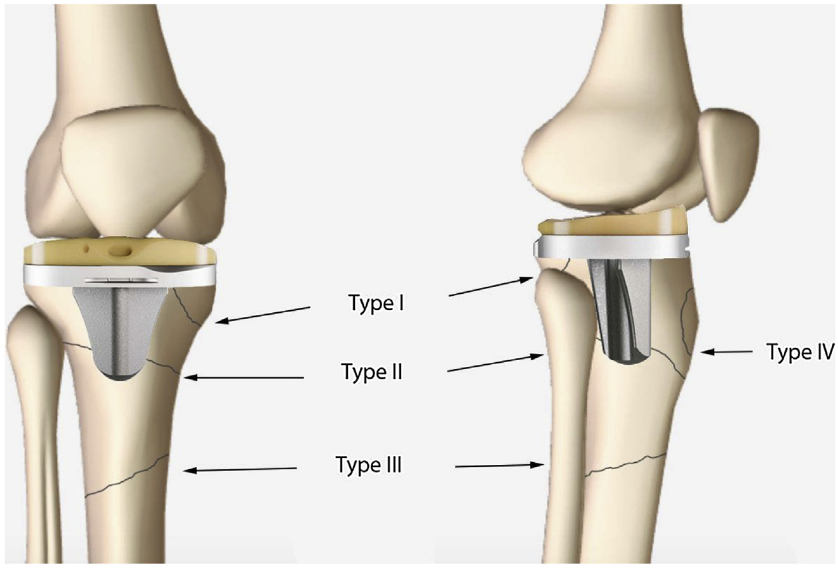

Fig. 1. Periprosthetic tibial fracture classification as described by Felix et al. [6].

nailing, external fixation and closed treatment with casting. However, no consensus exists regarding the optimal fixation for periprosthetic tibia fractures.

The primary objective of this study was to describe the treatment and outcomes for periprosthetic fractures of the tibia around and below a total knee arthroplasty at two Level 1 trauma centers. To our knowledge, this is the largest series of non-intraoperative periprosthetic tibia fractures treated operatively reported in the literature.

Methods

Following IRB approval, we performed a retrospective chart review of 4557 operatively treated tibia fractures with ORIF over a 16-year period at two Level 1 Trauma Centers. Inclusion criteria included all tibial fractures treated below an ipsilateral total knee arthroplasty, including primary and revision type prostheses. Exclusion criteria included fractures associated with tumors. Data collected included basic demographics, smoking history, mechanism of injury, fracture type, open versus closed injury, type of fixation used, post-operative complications (infection, reoperation), prosthetic survival, and final knee range of motion. Final statistical analysis was performed as follows: descriptive statistics are shown as means and standard deviations for continuous variables and as percentages for categorical variables. Univariate tests of continuous variables were conducted using either an Independent *t*-test or a Mann-Whitney *U* test. For categorical comparisons, Chi-Square tests of Independence and Fisher's Exact tests were used. A post-hoc power analysis using a one-tailed exact test, with alpha = .05 and N = 53, demonstrated the obtained power (1-β) = 0.62.

Results

53 patients (38 women and 15 men; average age 68.2) with tibia fractures around and below an ipsilateral TKA were identified. Patients without follow-up to clinical and radiographic union were excluded, leaving 38 patients for final statistical analysis with an average follow-up of 15.3 months (range 3–24).

Injuries were sustained through both high-energy (55.3%) and low-energy (44.7%) mechanisms. 31/38 (82%) fractures were treated with plate osteosynthesis, 2/38 (5.3%) were treated with intramedullary nailing, 4/38 (10.5%) had acute tibiotalar fusion, and one patient was treated definitively in an external fixator (1/38, 2.6%). There were 11 (28.9%) fractures in the proximal tibia (four with extension into the plateau (Felix 1A) and seven adjacent to the tibial stem (Felix 2A)), six (15.8%) in the midshaft/diaphysis (Felix 3A), and 21 (55.2%) in the distal 1/3rd (metaphysis, Felix 3A). There were 8 open fractures (0 Type 1, 4 Type 2, 2 Type 3A, 1 Type 3B, 1 Type 3C) (Table 1).

Overall, 76.3% (29/38) of fractures united by 6 months following the index procedure, leaving 9 nonunions. When classified by Felix classification, non-union occurred in 25.0% (1/4) of Felix 1A, 42.9% (3/7) of Felix 2A, and 18.5% (5/27) of Felix 3A fractures (p = .409). When classifying the fracture by location, nonunion occurred in 36.4% (4/11) of proximal, 16.7% (1/6) of midshaft, and 19.0% (4/21) of distal tibia fractures, respectively (p = .573).

The overall re-operation rate was 31.6% (12/38), which included debridement and irrigation (4), nonunion repair (5), amputation (1 above knee amputation and 1 below knee amputation, both for intractable infection), and revision arthroplasty (1 megaprosthesis). Reoperation rate by Felix type was as follows: 0% (0/4) of Felix 1A, 71.4% (5/7) of Felix 2A, and 25.9% (7/27) of Felix 3A (p = .015). When classifying the fracture by location, reoperation

Table 1
Outcomes by Felix classification [6].

	Felix 1A (n = 4)	Felix 2A (n = 7)	Felix 3A (n = 27)	Notes
Union at 6 months	75% (3/4)	57% (4/7)	81.5% (n = 22)	Overall Union rate = 76.3%
Reoperation Rate	0% (0/4)	71.4% (5/7)^{A}	33.3% (7/21) ^{B}	Overall Reoperation rate = 31.6%
Final Knee ROM (Extension-Flexion, degrees)	1.7-96.7	0.7-107.1	0.6-112.8	

A, B: Reason for reoperation—A = superficial infection (1), non-union repair (1), infected non-union leading to below knee amputation (1), revision to megaprosthesis (1), I&D for TKA infection (1). B = non-union repair (3), superficial infection (2), deep infection (1), above knee amputation (1).

occurred in 45.5% (5/11) of proximal, 16.7% (1/6) of midshaft, and 28.6% (6/21) of distal fractures (p = .241). Aside from the single revision to a megaprosthesis, and the above knee amputation, none of the remaining index TKAs (n = 37) needed revision at the time of final follow-up.

Dual plating of the tibia on the medial and lateral surface was not correlated with improved union rates overall when considering Felix class (p = 1.00), or in any of the three locations (proximal, midshaft, distal) (p = 1.00). There were also no significant differences in rates of reoperation (p = 0.66), superficial infection (p = 0.66), or deep infection (p = 0.31) in patients treated with single versus dual plating.

Discussion

Periprosthetic tibia fractures are difficult to treat and have a high risk of nonunion and reoperation even with modern plating techniques. In our study, we found a union rate of 76.3% at 6 months overall for Felix type 1, 2 and 3 fractures. Although not statistically significant, a high proportion of non-unions occurred in Felix type 2A fractures (42.9%), or those near and around the tibial stem tip (Fig. 1) (p = .409). The reoperation rate of Felix 2A fractures, however, was significantly higher, 71.4%, than Felix 1A and 3A fractures (p = .015). Proximal third fractures (Felix 1A and 2A combined) also trended towards an increased risk for non-union, but was not statistically significant (p = .573). We chose to report our results both by Felix classification, which is consistent with reporting in previous studies in the literature, and by fracture location (proximal, midshaft, distal) as the Felix classification groups all fractures distal to the stem tip as "Felix 3A" fractures. We felt there would be utility in subdividing our Felix 3A fractures into midshaft and distal, although the rate of reoperation and number of fractures united at 6 months did not change significantly when we performed this analysis.

Dual plating did not result in statistically significant increased rates of union in this limited series, but also did not increase complication rates or adverse outcomes. After treating several of these difficult proximal 1/3rd fractures, we hypothesized that dual plating would lead to increased rates of union, but were unable to find a statistically significant difference, perhaps due to small sample size. However, owing to the osteoporotic nature of the bone typically encountered in these patients, as well as the limited bone available for fixation around the tibial stem, the authors feel that adding a second column of fixation for proximal 1/3rd provides increased construct stability.

In our practice, we routinely use dual plating (medial/lateral) for proximal 1/3rd (Felix 2A) periprosthetic tibia fractures (Fig. 2A, B). For midshaft/diaphyseal fractures or distal 1/3rd fractures, a single plate construct may suffice (Fig. 3A, B). Alternatively, an intramedullary nail technique has also been described by Haller et. al. to be effective for fractures distal to the tibial stem (Felix 3A) [10]. The authors described 5 technical points: "1. A more distal transpatellar tendinous approach; 2. Hand reaming of the proximal tibia, in proximity to the TKA; 3. Use of the Yankauer suction tip to guide the bulb-tipped wire past the posterior cortex proximally; 4. Choice of small diameter nail (9 mm or less); and 5. Intraoperative bending of the tip of the nail using a bending press to allow the nail to pass the posterior cortex proximally." We utilized this fixation strategy in one revision case for non-union with good results (Fig. 4A–C).

In their original series, Felix, et al. [6] retrospectively reviewed one hundred two periprosthetic tibial fractures and noted that19 occurred intraoperatively and 83 occurred post-operatively. Of the 83 post-operative fractures, 61 were determined to be type 1, either a "split or depression of the tibial plateau." 50 of these had a loose tibial tray, likely representing subsidence or catastrophic failure of the prosthesis, rather than a sequelae of overt trauma. This means that roughly 31 fractures in their series were the result of acute trauma. The authors reported good results with "closed reduction and casting" for most of these fractures, including those adjacent to the tibial stem. Their proposed algorithm stated that displaced fractures "may require open reduction internal fixation," but did not give specifics on which fractures they felt required surgical management or the specific outcomes (alignment, time to union, etc.) of those fractures treated by simple casting.

In a recent retrospective analysis, Kim, et al. [2] reviewed the records of 16 patients who had suffered periprosthetic tibial fractures after TKA and undergone minimally invasive plate osteosynthesis (MIPO). This study included only patients whose fractures were classified as Felix Type II (6 patients) and Felix Type III (10 patients). Reduction was done using double plates in 10 patients and a single plate in 6 patients. 14 of the fractures achieved primary union (mean time of 17 weeks; range: 14–24 weeks), with 15 showing acceptable alignment (mean mFTA, 1.4°; range: -2.3° to 4.5°). Mean follow-up time was 29.7 months (range: 12–102 months), with the mean ROM at final follow-up being 108.8° (range: 15° to 135°). The mean Knee Society knee score was 88.9 (range: 77–100) at the final follow-up. The single plate group had failures in 2 of the 6 patients, while the double plate group had no failures, although this was not statistically significant (p = 0.125). Fracture type and location showed no statistically significant difference in final outcomes or complications (p = 0.5), similar to our results.

A meta-analysis performed in 2015 found only 144 patients with periprosthetic tibia fractures reported in the literature [4].

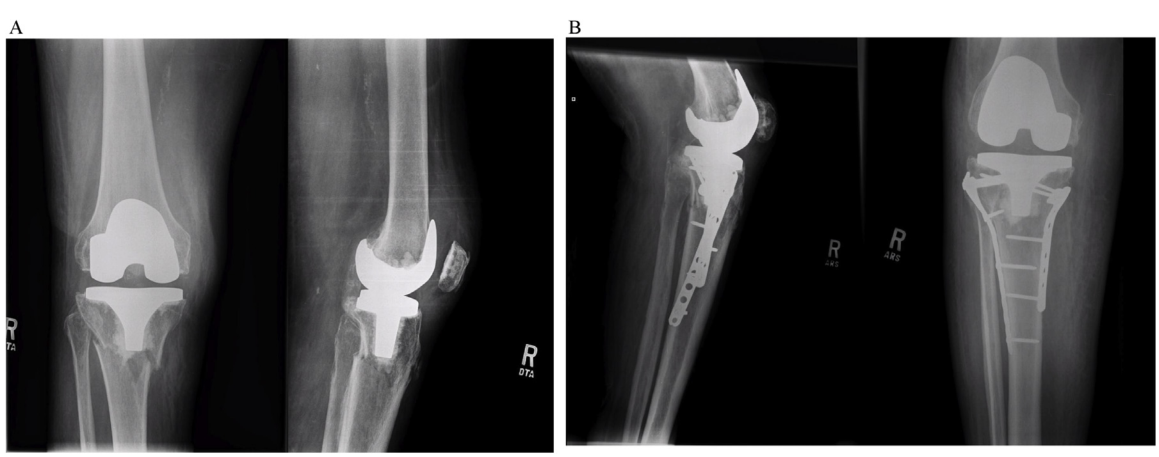

Fig. 2. A: Felix 2A injury films. B: Felix 2A, clinically and radiographically united at 3 months.

Fig. 3. A: Felix 3A injury films. B: Felix 3A, clinically and radiographically united at 3 months.

The authors of this meta-analysis illustrated 27 (18.75%) subtype A fractures (adjacent to tibial stem with a well-fixed prosthesis), with 6 being managed surgically with an intramedullary (IM) nail, 2 treated with extension immobilization and screw fixation, and 19 managed nonsurgically with casting or restricted weight bearing. Similarly, a recent review article on periprosthetic tibia fractures had limited recommendations on treatment for these difficult fractures [11]. After completing their review, the authors suggested that “major fracture displacement or angulation, tibial component loosening, and alteration of tibial component alignment are all relative indications for surgical intervention.”

Limitations of our study include multiple fracture types and fixation methods, multiple surgeons, no patient reported outcome scores, and small sample size. The post-hoc power analysis demonstrated a β of 0.38, i.e. a 38% chance of committing a type 2 error. However, these are uncommon injuries with a projected

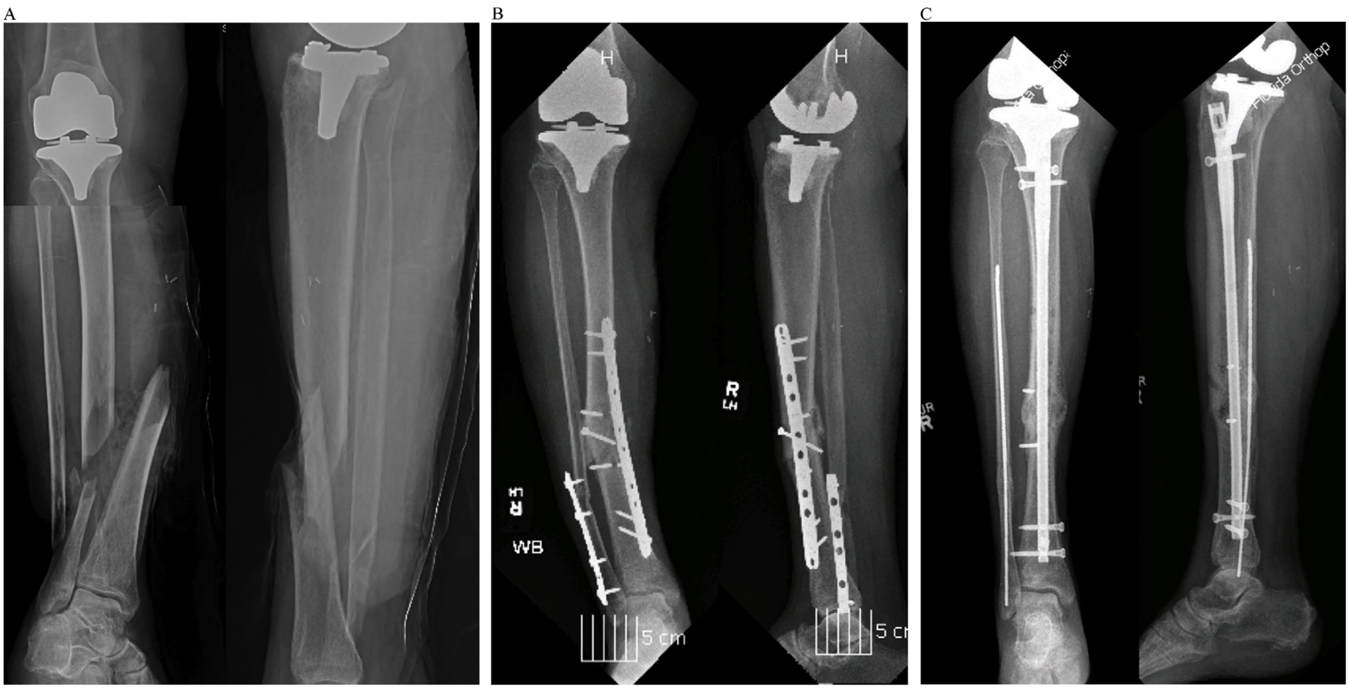

Fig. 4. Felix 3A injury X-rays. B: Non-union of midshaft Felix 3A fracture. C: Revision fixation with IMN, clinically and radiographically united at 4 months.

increase in incidence and we achieved our main objective of describing the treatment and outcomes for these patients.

Conclusions

Periprosthetic tibia fractures present a challenging clinical scenario. Our study represents the largest cohort reported to date of non-intraoperative periprosthetic tibia fractures treated with operative fixation. These injuries have a high risk of nonunion (23.7%) and reoperation (31.6%) even with modern fixation techniques. Most patients, however, can be treated to union with operative fixation (76.7%) and do not require revision arthroplasty if well-fixed at time of injury (37/38, 97.4% implant survival). We recommend dual plating for fractures in the proximal third, and either single plating or nailing for fractures in the middle and distal thirds depending on bone quality, implant positioning, and fracture morphology.

Acknowledgements

There was no outside sources of funding for this study. The authors would like to acknowledge Krista Howard, PhD., for her help with statistical analysis.

References

[1] Inacio MCS, et al. Projected increase in total knee arthroplasty in the United States - an alternative projection model. Osteoarthr Cartil 2017.
[2] Kim HJ, et al. Successful outcome with minimally invasive plate osteosynthesis for periprosthetic tibial fracture after total knee arthroplasty. Orthop Traumatol Surg Res 2017;103(2):263–8.
[3] Platzer P, et al. Management and outcome of periprosthetic fractures after total knee arthroplasty. J Trauma 2010;68(6):1464–70.
[4] Ebraheim NA, et al. Systematic review of periprosthetic tibia fracture after total knee arthroplasties. World J Orthop 2015;6(8):649–54.
[5] Agarwal S, Sharma RK, Jain JK. Periprosthetic fractures after total knee arthroplasty. J Orthop Surg (Hong Kong) 2014;22(1):24–9.
[6] Felix NA, Stuart MJ, Hanssen AD. Periprosthetic fractures of the tibia associated with total knee arthroplasty. Clin Orthop Relat Res 1997;(345):113–24.
[7] Kuzyk PRT, Watts E, Backstein D. Revision total knee arthroplasty for the management of periprosthetic fractures. J Am Acad Orthop Surg 2017;25(9):624–33.
[8] Yoo JD, Kim NK. Periprosthetic fractures following total knee arthroplasty. Knee Surg Relat Res 2015;27(1):1–9.
[9] Nagwadia H, Joshi P. Outcome of osteosynthesis for periprosthetic fractures after total knee arthroplasty: a retrospective study. Eur J Orthop Surg Traumatol 2018.
[10] Haller JM, et al. Intramedullary nailing of tibial shaft fractures distal to total knee arthroplasty. J Orthop Trauma 2014;28(12):e296–300.
[11] Born CT, Gil JA, Johnson JP. Periprosthetic tibial fractures. J Am Acad Orthop Surg 2018.