© Med Sci Monit, 2011; 17(11): CR640-645
PMID: 22037743

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Clinical Research

Received: 2010.12.08
Accepted: 2011.05.31
Published: 2011.11.01

Adult tibial shaft fractures – different patterns, various treatments and complications

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
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Source of support: Departmental sources

Summary

Background: Tibial Fractures constitute a large number of emergency operations in most trauma centers. There are different approaches for tibial fractures. To our knowledge, there is insufficient evidence to consider post-operative complications in relation to both surgical methods and the types of fractures. Our purpose is to report our experience regarding the efficacy and complications associated with diverse surgical methods of different patterns of tibial shaft fractures in adults.

Material/Methods: We studied 387 adult patients. The patients' information was registered from the charts and after examination. The methods used were intramedullary interlocking nails, simple intramedullary rods, plating and external fixation. Early and late complications were recorded and by applying the DELPHI method different treatments were compared. Finally, the safest mode of treatment is proposed.

Results: In the intramedullary interlocking nails method the most noticeable complication was delayed union and the highest rate of complications was seen in open oblique fractures. In the simple intramedullary rods method the most frequent complication was pain, and in the with butterfly fractures the complications were the most. In the plating method the most frequent complication was pain, and most of the complications were seen in open comminuted fractures. Finally, in the external fixation method the most frequent complication was non-union and complications were the highest in the patients with oblique, comminuted and segmented fractures.

Conclusions: The proposed method to treat transverse, oblique and butterfly fractures is simple intramedullary rods; whereas intramedullary interlocking nails is the better method for comminuted, segmented and spiral fractures.

key words: **tibia fracture • adult • patterns • treatment • complications**

Full-text PDF: http://www.medscimonit.com/fulltxt.php?ICID=882049
Word count: 2403
Tables: 4
Figures: –
References: 31

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Background

Fractures of long bones constitute the majority of emergency operating room procedures in most trauma centers. Of these long bone injuries, tibial fractures are the most common. The National Center for Health Statistics (NCHS) reports an annual incidence of 492,000 fractures of the tibia and fibula per year in the United States [1]. Patients with tibial fractures remain in hospital for a total of 569,000 hospital days and incur 825,000 physician visits per year in the United States [1].

Tibial fractures are prone to complications [2,3]. The lack of a circumferential soft tissue envelope around the bone makes the bone ends more likely to fail unit (nonunion). Approximately 50,000 North Americans suffer from these nonunion complications each year [4]. Other complications include infection, malunion, malalignment, etc that sometimes necessitate additional operations. Management strategies to best minimize these frequent complications and resulting re-operations have proved controversial.

Over the last 20 years, surgeons have used 4 management approaches for tibial fractures: intramedullary nail fixation (interlocking intramedullary nails and simple intramedullary rods) [5], plate fixation [6], external fixation [7] and casting or functional bracing [8].

While it may be preferable to cast a closed tibial shaft fracture, most surgeons agree that in certain unstable fracture patterns, casts will not maintain adequate fracture alignment [9]. In recent years surgeons have moved away from plates and external fixators in favor of intramedullary nails in the operative treatment of both closed and open tibial fractures [10].

Given the published clinical data, intermedullary (IM) nailing techniques were developed to minimize surgical insult to the fracture and adjoining soft tissues [10,11]. It has become standard care for the majority of displaced tibial shaft fractures, but it has also been associated with some complications in these patients [12,13]; therefore, some orthopaedic surgeons prefer plate fixation for tibial shaft fractures [14–18]. Minimally invasive plating techniques reduce surgical trauma and maintain a more biologically favorable environment for fracture healing [19].

To the best of our knowledge, there is insufficient evidence from previous studies to consider post-operative complications in relation to both surgical methods and the types of fractures; there is also no data establishing how the characteristics of the patients and the quality of their fractures should be considered in choosing an appropriate mode of treatment. The purpose of this study is to report our experience with the efficacy and complications associated with diverse surgical methods of different patterns of tibial shaft fractures in adults.

Material and Methods

In this retrospective observational study we reviewed all charts of patients with tibial fractures which have been admitted to our center between January 2003 and December 2006 in a census method. Those aged 14 years and over, with at least 1 fracture in the shaft of the tibia, who had comprehensive personal and medical background, and at least a 1-year follow-up after treatment were invited by telephone or mail to visit our center. Out of 457 eligible patients, 387 patients who accepted our invitation were included in our study. Those candidates with articular fractures and extra-articular fractures within 5cm of the proximal or distal end of the tibia were excluded from the study. Charts were reviewed for demographic information, sites, types and patterns of fractures, follow-up care, complications and other clinical data. All the patients were examined by 1 orthopaedic surgeon, and the results including knee and ankle range of motion (ROM), infection, malalignment, non-union, delayed union, pain, sensory-motor loss, limb shortening, etc. were registered. The previous radiographies were reviewed and a new one was ordered for the fracture location, then these were compared with each other and the results were recorded.

Table 1. Complications and their related scores in tibial shaft fractures after operation.

Complications	Scores
Osteomyelitis and infected nonunion	89
Neurovascular disorders	88
Nonunion	63
Refractures, device failure	62
Deep infection	50
Shortening of limb	41
Delayed union	34
Compartment syndrome	33
Need to open reduction and big incision	32
Additional operations	32
Malalignment	31
Limitation in knee ROM	21
Wound dehiscence	20
Limitation in ankle ROM	19
Pain in afflicted limb	17
Cellulites	14

Four different surgical methods had been used in these patients: intramedullary interlocking nails (INT), simple intramedullary rods (IMR), plating (PLT) and external fixation (EF).

The outcome of different surgical methods is demonstrated by studying the complications during the first month after the operation (early complications) and those during a period of at least 1 year after the surgery (late complications).

In a later stage, by applying DELPHI method [20,21] and consulting with 16 orthopaedic surgeons in our educational center, the complications were listed alphabetically. Next, the same surgeons were asked to give a score to each of the complications according to its importance. The means of the scores are given in the Table 1.

Table 2. Demographic information and frequencies of different patterns of tibial shaft fractures.

	Comminuted	Oblique	Segmented	Spiral	Transverse	With butterfly	Total
Gender							
Male	107	58	39	39	65	40	348
Female	12	6	2	13	5	1	39
Fracture Types							
Open	64	30	26	6	32	18	176
Closed	55	34	15	46	38	23	211

Table 3. Early and Late complications in different surgical methods of tibial shaft fractures.

Treatment methods	INT	IMR	PLT	EF	Total
Early complications					
Infection	8.8%	0.0%	12.1%	37.5%	58.4%
Wound dehiscence	1.4%	0.0%	0.8%	0.0%	2.2%
Cellulitis	0.7%	0.0%	0.8%	0.0%	1.5%
Others	1.4%	0.0%	1.5%	4.2%	7.1%
Late complications					
Delayed union	25.9%	5.7%	4.5%	18.8%	54.9%
Nonunion	18.4%	9.4%	9.8%	45.8%	83.4%
Pain	21.1%	18.9%	13.6%	16.7%	70.3%
Ankle ROM	6.8%	1.9%	5.3%	16.7%	30.7%
Knee ROM	4.1%	9.4%	3.8%	6.3%	23.6%
Malalignment	4.1%	1.9%	5.3%	12.5%	23.8%
Sensory-Motor loss	4.1%	0.0%	<1%	8.3%	13.4%
Shortening	<4.0%	0.0%	0.0%	0.0%	<4.0%
Osteomyelitis	<4.0%	0.0%	3.0%	<2%	<6.0%
Others	<4.0%	3.8%	4.5%	4.2%	16.5%
Fracture types					
Open	59	29	43	43	174
Closed	88	24	89	5	206
Patients frequency	147	53	132	48	380

INT – Interlocking intramedullary nailing; IMR – Intramedullary rods; PLT – plate and screws; EF – External fixation.

The patients were classified according to the particular method of surgery. In order to compare different methods, we multiplied the frequency of complications in each group by the mean scores. Based on these results, the safest method of treatment is proposed.

Results

In our survey, out of all the reviewed charts, 387 patients (348 men and 39 women) were included into our study. The average ±SD age at admission was 31.3±12 years (16–76 years). About 45% of fractures were open, and the most frequent fracture was comminuted with the incidence rate of 31%. Table 2 shows demographic information of the patients in different patterns of fractures.

Among 387 patients, 57.8% (227 patients) had undergone open reduction and 41.3% (160 patients) closed reduction. One-hundred forty-seven patients were treated with intramedullary interlocking nailing (INT) method, 132 with plating (PLT), 53 with intramedullary rod (IMR), 48 with external fixation, and 7 with screws. Table 3 shows

Table 4. The proposed methods of treatment in different patterns of tibial shaft fractures.

Fractures	First choice	Second choice	Third choice
Closed			
With butterfly	IMR	–	–
Comminuted	PLT	INT	–
Oblique	IMR	INT	PLT
Segmented	INT	–	–
Spiral	INT	PLT	–
Transverse	IMR	PLT	INT
Open			
With butterfly	IMR	INT	–
Comminuted	INT	IMR	PLT
Oblique	IMR	PLT	INT
Segmented	INT	EF	PLT
Spiral	–	–	–
Transverse	IMR	INT	PLT

INT – Interlocking intramedullary nailing; IMR – Intramedullary rods; PLT – plate and screws; EF – external fixation.

statistical information of complications in different surgical methods.

In these patients the rates of fractures were 12.4% in proximal part, 39.8% in middle, 38% in distal, and 9.8% in more than 1 part.

In the INT method the most noticeable complications were delayed union (26%), pain (21%), nonunion (18%) and infection (9%). No vascular disorder was noticed, neurological disorders were less than 4.1% and device failure was approximately 2%. The complication rates of this method for treatment of fractures in upper, middle and the lower third of the tibia were 54%, 51% and 57%, respectively, and the rate for segmented fracture was 33%. According to the Delphi method the complication rates in the INT method were, in descending order, open oblique, closed segmented, open segmented, open comminuted and closed oblique fractures. Table 4 shows the proposed methods of treatment according to complications in different patterns of fractures.

In the simple intramedullary rods without locking method (IMR) the most frequent complications were pain in the proximal and distal ends of the nails and fracture site, nonunion and limitation in knee range of motion (ROM), with frequencies of 19%, 9% and 9%, respectively. The complication rates of this method in treatment of upper, middle and lower third fractures of the tibia were 0%, 41% and 16%, respectively, and the most frequent complications were seen in butterfly, comminuted and transverse fractures, particularly in open type ones.

In the plating method (PLT) the most noticeable complications were pain, infection, nonunion and malalignment, with frequencies of 14%, 12%, 10% and 5%, respectively. The complication rates for treatment of fractures in the proximal, middle and distal third of tibia were 37%, 31% and 37%, respectively, and this rate for segmented fracture was 60%. The complications in this procedure are open comminuted, closed spiral and closed oblique, in descending order.

Finally, in the external fixation method (EF) the most frequent complications were nonunion, infection, delayed union and limitation in ankle ROM, with the rates of 46%, 38%, 19%, and 17% percent, respectively. Malalignment was seen in about 13% of patients, and the most frequent complications were seen in the patients with oblique, comminuted and segmented fractures.

Discussion

The most noticeable complications after INT method were delayed union, pain, nonunion and infection. The neurological disorders were less than 4.1%, no vascular disorder was seen, and device failure was around 2%; these complications were highest in the open oblique fractures. In the IMR method the most frequent complications were pain in the proximal and distal ends of the nails and fracture site, non-union, and limitation in knee-ROM; these complications were highest in butterfly fractures. In the PLT method the most common complications, in descending order, were pain, infection, nonunion, and malalignment. These complications were superior in the open comminuted fractures. Finally, in EF technique the most considerable complications were nonunion, infection, delayed union and limitation in ankle ROM. These complications were more in the oblique, comminuted and segmented fractures.

Christine et al [22] compared external fixation (EF) versus intramedullary rod fixation (IMR) in Gustilo grade IIIB tibial fractures that required microvascular free flaps. They studied 38 patients, of whom 18 underwent external fixation and 20

had intramedullary rodding. The intramedullary rod group had higher incidences of non-union, wound infection and osteomyelitis (40%, 25% and 25%, respectively) than the external fixation group (17%, 6%, and 11%, respectively).

The study was confined to just 2 methods of treatment and 1 type of fracture, and their results differ with ours. In our research, the rates of complications such as non-union, infection and osteomyelitis were greater than in the EF method (45.8%, 37.5% and <3%, respectively) than in IMR (9.4%, 0% and 0%, respectively).

Phinit et al. [23] assessed complications of locking plate fixation (PLT) in complex proximal tibia injuries. The study was limited to just 1 method of treatment in tibia fractures. They evaluated 37 patients with complex proximal tibia fractures that were treated with locking plates in a retrospective case series study. Twelve fractures (32%) healed without any complications, 8 patients (22%) developed deep infections, 8 cases (22%) had postoperative malalignment, 3 cases (8%) had loss of alignment into varus during healing, and the rest had other complications. The report showed that the complication rates, particularly infection, were higher than in previous reports. Other complications such as hardware prominence, malalignment, and loss of alignment were similar to those of historical controls. We found the 12.1% infection rate after plating to be the highest complication rate after pain (13.6%).

Huang et al. [24] evaluated the effect of tibial shaft fracture treatment with plate-screw (PLT) versus intramedullary interlocking nail (INT). They treated 35 fractures with intramedullary interlocking nail and 45 fractures with plate-screw system. Operation time, range of motion, time of bone union, and complications after a mean follow up of 13 months (range 8 to 26 months) were evaluated. They concluded that PLT osteosynthesis could attain satisfactory results in uncomminuted tibial shaft fractures, and that INT is more appropriate in comminuted fractures.

In our study the results showed that for comminuted fractures INT is better than PLT, but the best choice is IMR, and for the other types of fractures (uncomminuted) INT and IMR were better methods than PLT, and only in transverse fractures was PLT better than INT.

Fernandez et al. [25] conducted a prospective, randomized study to compare patients with closed, multi-fragmented (comminuted) tibial diaphyseal fractures that were treated with nonreamed interlocking intramedullary nails or bridging plates. They compared similar groups and reported that the clinical and radiological parameters (articular function, deformities, infection, and pseudarthrosis) were similar in both groups. Healing time was the only significant difference, and was earlier in patients receiving bridging plates compared with patients who were treated with nonreamed interlocking intramedullary nails. They only assessed the comminuted fractures with 2 different surgical methods, thus their study was more limited than ours. We did not evaluate healing time in our study. However, in other aspects that we considered, the PLT method was better than the INT method in the closed multi-fragmented (comminuted) fracture.

In the literature, the most important complication following the INT method is pain, with a prevalence of 52% [26], but in our study the most important complication was delayed union, and pain was second most important complication.

Although previous studies have mentioned neurovascular disorders subsequent to the interlocking method ranges from 2% to 30% [27], we had no vascular disorders, and the neurological complication rate was less than 4.1%.

Furthermore, we had much less device failure (2%) in comparison with the 4% to 20% frequency that is reported by others [28]. According to our observations the most noticeable complications of the PLT method were pain, infection, nonunion and malalignment, with frequencies of 14%, 12%, 10% and 5%, respectively, but in 1 other study the highest percentages were joint stiffness (11%) and infection (10%) [29].

For the EF technique our results showed the most frequent complications were nonunion, infection, delayed union and limitation in ankle ROM, with rates of 46%, 38%, 19%, and 17%, respectively. Malalignment was seen in about 13% of patients, but those which have been reported in some previous studies include malalignment, infection and nonunion, with the incidence rates of 0–50%, 20% and 6–41%, respectively [30].

Overall, in our study IMR was the treatment of choice because it causes fewer complications, and INT was the better choice only for segmented and spiral fractures. Our conclusions differ from some of the other studies that state the INT method is the treatment of choice in tibial diaphyseal fractures [31].

To our knowledge there is no comprehensive study that considers all types of fractures and different surgical method complications, and we could only find some studies that had compared just 1 or 2 specific fractures with different methods of treatment.

Lack of enough samples in some types of fractures and poor cooperation of some patients were some of the problems that we faced in this study

Conclusions

Our results showed that the best method to treat oblique fractures is IMR and the next best choice is PLT. Due to the highest numbers of complications and adverse effects, INT cannot be suggested as a preferred treatment for oblique fractures (especially at the proximal 3rd of tibia). For butterfly fractures, IMR can be a minimally invasive method; if IMR is not possible, the other choices are INT and PLT. To treat spiral fractures, INT is a good candidate, but PLT is not recommended as a first choice. The preferred treatments for transverse fractures are IMR, PLT and INT methods. EF is the best choice when the others are contraindicated or not available.

The treatment of tibial fractures remains controversial. Identifying treatment alternatives that reduce the risk of need for a subsequent operation, as well as costs to the health care system, will be a significant contribution to the practice of orthopaedics.

Acknowledgements

The authors wish to thank Mrs. Masoomeh Sadeghian, RN; Mrs. Roshanak Razavi, student of nursing and Mrs.

Mobashereh Bagheri, Clinical Manager for their help in preparing the data of the patients, inviting the patients for follow-up and providing some necessary references.

Conflict of interest

The authors declare that they have no relevant financial interests in this manuscript.

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