Segmental, proximal and distal tibial shaft fractures

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Assistant Professor, Patras University Hospital
Objectives

General principles

Epidemiology & anatomy

Classifications

Pearls of reduction and fixation

Best implant choice

Results and evidence based outcome
Introduction

Tibial shaft fractures:
commonest long bone fractures
often open, RTA
slow to heal
frequently cause sequelae
related to both injury and treatment
Wide spectrum of injury patterns
Epidemiology

are **declining** in incidence

Sweden: 18.7/10^5 (1998)
         48% fall, 21% RTA


Mechanism of injury
1988-1990: 37.5% **RTA**, 30.9% sports, 17.8% fall
2007-2008: 20.5% RTA, 27.4% sports, **32.8% fall**
Epidemiology

↓ young males, ↑ old females

av. age 37.1 → 44.6

av. age 48.9 → 56.0
Important factors in overall management

**Injury characteristics**
- Soft tissue injury: open/closed
- Type: transverse, spiral, oblique
- Degree of comminution
- Mechanical stability

**Surgeon factors**
- Skills and training
- Familiarity with implants

**Patient factors**
- Comorbidity
- Associated injuries
- Functional requirements
- Likely compliance

**Other factors**
- Full range of implants
- Anaesthetist and theatre staff
- Radiograph facilities
- Follow-up facilities
Relevant anatomy
Current management of tibial shaft fractures
A survey of 450 Canadian orthopedic trauma surgeons

Jason W Busse¹, Emily Morton², Christina Lacchetti¹, Gordon H Guyatt¹, and Mohit Bhandari¹

**closed fractures**
87% IM, 8% plates and 2% non-op

**open fractures**
83% IM, 7% plates and 7% Ex-Fix
17 y old, RTA
6 m pop
Full WB
Full ankle & knee motion
Prognostic Factors for Predicting Outcomes After Intramedullary Nailing of the Tibia

Study to Prospectively Evaluate Reamed Intramedullary Nails in Patients with Tibial Fractures (SPRINT) Investigators*

Investigation performed at McMaster University, Hamilton, Ontario, Canada

Large (1226 pt), multicenter trial of reamed & unreamed IM

Higher risk of a **poor outcome**
- high-energy injuries,
- need for soft-tissue reconstruction,
- fracture gap (< 1 cm)
- open fractures with reamed nails
- full weight bearing postop

**Severity of injury** plays the most important role
Segmental tibial fractures

Incidence between 3% and 12%

Usually severe soft tissue injuries
- impaired fracture healing (up to 50%),
- compartment syndrome (up to 50%), and
- septic complications (up to 35%)

↓ blood supply of intermediate fragment

Difficulties in reduction and alignment

Very short proximal or distal segments are notoriously difficult to control
# Melis classification

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>The fracture lines are situated proximally, so that the proximal fracture lies in the upper third of the shaft and the distal fracture lies in the middle third</td>
</tr>
<tr>
<td>Type II</td>
<td>The fracture lines are situated distally, so that the proximal fracture lies in the middle third of the shaft and the distal fracture lies in the lower third</td>
</tr>
<tr>
<td>Type III</td>
<td>The fracture lines are at the extremes of the shaft and there is a long intermediate fragment</td>
</tr>
<tr>
<td>Type IV</td>
<td>The fracture lines are close to one another and there is a short intermediate fragment in the middle third of the shaft</td>
</tr>
</tbody>
</table>

![Type I](image1.png)  ![Type II](image2.png)  ![Type III](image3.png)  ![Type IV](image4.png)
Treatment options

Conservative

Plate fixation

External fixation

Intramedullary nailing
Segmental wedge-fracture pattern

1. difficulty in placing the guide wire
2. more displacement on rod insertion
3. cerclage wires or unicortical plate
47 pt, closed fractures
inclusion criteria
- initial shortening <12 mm,
- angulation corrected to <7°

Mean healing time 15.2 weeks

All fractures united

No complications
23 **open** segmental fractures
20 temporarily fixed with ex-fix
4 grade IIIA,
16 grade IIIB
3 grade IIIC

3 compartment syndrome
Dermatofasciotomy in 13 cases
5 cases palsy of EHL
20/23 healed (mean 19 weeks)
Segmental fractures of the tibia treated by circular external fixation

multilevel stabilization
minimal disruption of soft-tissue
small biological bone ‘footprint’
ability for early ambulation

Pin track infection
Tolerance of the patient

20 pt, 21.7 weeks to union
2 nonunions, 2 reop
Primary union 46/51 patients (91%). Average time to union was 5 months.

Unreamed nailing
Semi-extended technique (50%) back-tapping
mild shortening to obtain cortical contact early weightbearing (within 2 months)
Tibial Unreamed Intramedullary Nailing
Using Schanz Screws in Displaced Diaphyseal Segmental Fractures

Kyung Cheon Kim, MD; June Kyu Lee, MD; Deuk Soo Hwang, MD; Jun Young Yang, MD; Young Mo Kim, MD

Orthopedics
November 2007 - Volume 30 - Issue 11

Report of 4 cases
1 delayed union
Technical note

Maintaining reduction during unreamed nailing of a segmental tibial fracture: the use of a Farabeuf clamp

A. Robertson, P.V. Giannoudis, S.J. Matthews

Clinical Outcomes of the Tibia Segmental Fractures Treated by Intramedullary Nail Using Various Reduction Techniques

Oog-Jin Shon, M.D., Ji-Hoon Shin, M.D., Chul-Wung Ha, M.D.
Department of Orthopaedic Surgery, Yeungnam University Medical Center, Yeungnam University College of Medicine, Daegu, Korea

Table 2. Complications

<table>
<thead>
<tr>
<th>Complication</th>
<th>Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delayed union</td>
<td>3/18 (16.6)</td>
</tr>
<tr>
<td>Coronal malalignment</td>
<td>1/18 (5.5)</td>
</tr>
<tr>
<td>Sagittal angulation</td>
<td>1/18 (5.5)</td>
</tr>
<tr>
<td>Local infection</td>
<td>2/18 (11.1)</td>
</tr>
</tbody>
</table>
Proximal non-articular tibia fractures

5% to 12% of all tibial shaft fractures

high-velocity injury

usually severe soft tissue damage

metaphyseal comminution

7% infection & compartment syndrome

**malalignment** 44% to 84% (IMN)
Classification

Type A2.1 (lateral oblique)
Type A2.1 (medial oblique)
Type A2.2 (anterior oblique)
Type A2.3 (transverse)

Type A3.1 (intact wedge)
Type A3.2 (fragmented wedge)
Type A3.3 (complex comminution)
Treatment options

Conservative

Plate fixation

External fixation - Ilizarov

Intramedullary nailing?
Biomechanical evaluation of various fixation methods for proximal extra-articular tibial fractures

Wei Feng, MD, Li Fu, MD, Jianguo Liu, MD, Xin Qi, MD, Dongsong Li, MD, and Chen Yang, MD

In compression testing the highest degree of axial stiffness was found in the IMN group.

In three-point bending test the DCP demonstrated the highest bending stiffness.

The Ex-Fix had the lowest level of stiffness in both tests.

IM in clinical application should be assisted with a plate.
Clinical and radiological outcome of percutaneous plating in extra-articular proximal tibia fractures: A prospective study
Monappa A. Naik, Gaurav Arora, Sujit Kumar Tripathy*, Premjit Suji, Sharath K. Rao

47 pt / 49 fractures
29 closed / 20 open
4 infections (reop-debridement)
3/4 ended up with nonunion
20 w union in type I open
25 w in type II & III
10 malunions (20.14%)
no difference to knee motion
Intrafocal lever-type KW manipulation
Temporary distraction with Ex-Fix and intraoperative assessment of alignment
Staged external and internal less-invasive stabilisation system plating for open proximal tibial fractures

Ching-Hou Ma, Chin-Hsien Wu, Shang-Won Yu, Cheng-Yo Yen, Yuan-Kun Tu

First stage

Control infection
(Radical debridement)
Fractures reduction
(Open reduction)
Provisional external fixation
(Locked plate)
Soft tissue reconstruction
(Repair or flap)
Rehabilitation
(CPM)

OPD follow-up
(Rehabilitation)

Second stage

Definite internal fixation
(MIPO technique)
Why IM usually fails?

1. anatomy of intramedullary canal
   - central axis of is slightly lateral to the midline
   - anteroposterior width is narrower medially

2. apex anterior angulation
   - Patellar tendon extends the proximal fragment
   - Hamstring tendons flex the fracture

3. valgus deformity
   - Deforming forces of pes anserinus
   - Pull of the anterior muscles
Surgical Options

- Extended/semi-extended nailing
  - Median parapatellar
  - Suprapatellar/retropatellar
  - Extra-articular
- Femoral distractor/external fixation
- Poller/blocking screws
- Supplemental plate fixation
Tricks and Pearls for IM

proper starting point

insertion angle

Semi-extended positioning
Intramedullary nailing of proximal tibia fractures—An anatomical study comparing three lateral starting points for nail insertion

Patrick Weninger\textsuperscript{a,*}, Manfred Tschabitscher\textsuperscript{b}, Hannes Traxler\textsuperscript{b}, Veronika Pfafl\textsuperscript{b}, Harald Hertz\textsuperscript{c}


<table>
<thead>
<tr>
<th>Entry point</th>
<th>Sample #</th>
<th>Varus (°)</th>
<th>Valgus (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral third</td>
<td>1</td>
<td>15</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>21</td>
<td>–</td>
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<tr>
<td></td>
<td>3</td>
<td>14</td>
<td>–</td>
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<td>4</td>
<td>17</td>
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<td></td>
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<td></td>
<td>6</td>
<td>13</td>
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<td>Middle third</td>
<td>1</td>
<td>10</td>
<td>–</td>
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<tr>
<td></td>
<td>2</td>
<td>11</td>
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<td>–</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>11</td>
<td>–</td>
</tr>
<tr>
<td>Medial third</td>
<td>1</td>
<td>5</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>7</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>–</td>
<td>4</td>
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<td></td>
<td>6</td>
<td>4</td>
<td>–</td>
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</tbody>
</table>
Malreduction rate (0 to 15.5%), with an average of 8.2%
Distal tibial fractures

8% of all tibial shaft fractures

high-velocity injury, soft tissue damage

fibula fixation?

residual varus, valgus, recurvatum, (IM)

difficult reduction and distal locking (IM) in small metaphyseal fragments
Classification
Treatment options

Conservative?

Plate fixation

Intramedullary nailing

External fixation (temporary)

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

Wang Cheng · Ying Li · Wang Manyi

30 cases (15 pairs of ORIF and MIPO) MIPO not superior to ORIF

<table>
<thead>
<tr>
<th>Group / statistic</th>
<th>Interval from injury to surgery (days)</th>
<th>Duration of surgery (min)</th>
<th>Drainage volume (ml)</th>
<th>Hospital stay (days)</th>
<th>Healing time (weeks)</th>
<th>Time of recovery to work (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORIF</td>
<td>7.1±4.9</td>
<td>87±25.7</td>
<td>175±96.9</td>
<td>12.1±3.8</td>
<td>19.2±23.5</td>
<td>27.7±28.2</td>
</tr>
<tr>
<td>MIPO</td>
<td>6.5±3.6</td>
<td>113.3±38.3</td>
<td>104.3±81.4</td>
<td>12.1±3.7</td>
<td>16.8±10.4</td>
<td>21.1±10.5</td>
</tr>
<tr>
<td>$t$ value</td>
<td>0.443</td>
<td>−1.942</td>
<td>1.782</td>
<td>−0.134</td>
<td>−0.134</td>
<td>0.909</td>
</tr>
<tr>
<td>$P$ value</td>
<td>0.664</td>
<td>0.073</td>
<td>0.096</td>
<td>0.896</td>
<td>0.737</td>
<td>0.379</td>
</tr>
</tbody>
</table>
No significant difference in healing time Type A and Type B Type C fractures, had shorter healing time in the closed group
41 patients, 30 extra-articular fractures. 13/30 extra-articular fractures were treated with interfragmentary screws. 11 had shorter time to full WB and heal. Callus index was significantly lesser.
How to facilitate reduction?

**Plates**
- frame & distraction
- percutaneous forceps
- fracture table
- at least 5 holes above fracture

locking screws should alternate with an empty hole in order to provide a better stress distribution
42/51 cases at 1 year
union rate 97.6%
mean 15.7 weeks.
14 valgus deviations >5°
4 dynamizations
2 infections

unfixed fibula was the only risk factor for initial axial deviation and fracture instability
How to facilitate reduction?

Nails

- distraction-fracture table
- not ream distal part
- blocking screws
- distal tibial joystick
- fix same level fibula fracture
- distal interlocking with 2-3 screws at right angles
60 patients with 42 AO shaft fracture
Group I (n = 26) fibula fixed
Group II (n = 34) fibula left

no evidence in favour of fibular fixation

higher tendency to develop a non-union:
- fractures at the same level
- bridging plate in the tibia
No statistical significant difference in functional outcome scores between locking-plate and IM nail.

<table>
<thead>
<tr>
<th>Complication</th>
<th>Treatment group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nail (n = 12)</td>
</tr>
<tr>
<td>Delayed union (&gt; 24 weeks)</td>
<td>1</td>
</tr>
<tr>
<td>Removal of metalwork</td>
<td>1</td>
</tr>
<tr>
<td>Delayed wound healing/superficial infection</td>
<td>3</td>
</tr>
<tr>
<td>Deep infection requiring surgical debridement</td>
<td>0</td>
</tr>
<tr>
<td>Buckled plate</td>
<td>0</td>
</tr>
<tr>
<td>Compartment syndrome</td>
<td>1</td>
</tr>
</tbody>
</table>
141 studies evaluated
2 prospective randomized controlled trials
3 retrospective comparative studies
relatively higher rate of infection in plating
malalignment more common with IMN
Conclusions

Tibial shaft fractures can be treated with a one or two-stage surgical treatment.

Prognosis correlates with injury severity, extent of soft tissue damage and further injuries.

Modern plating and IM techniques should be applied in order to achieve adequate reduction and stability.

Intramedullary nailing will remain a treatment of choice for diaphyseal fractures but it does seem likely that plating techniques will prove more common for proximal and tibial fractures.