Tibial Shaft Fractures

Boot Camp 2012

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Tibial Shaft Fractures

- Most common long bone fracture
- 492,000 fractures yearly
- Average 7.4 day hospital stay

Broad Range of Injuries

- Low energy:
  - Non-displaced
  - Simple patterns
  - Heal reliably with simple immobilization

High Energy Fx's

- Open fractures
- Closed soft tissue injuries
- Bony comminution

High Energy Fx's

- Problems obtaining union
- Tibia is subcutaneous, with a relatively poor blood supply

History & Physical: Low Energy

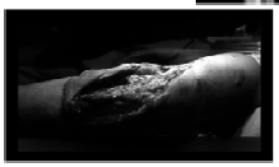
Minimal soft-tissue injury

- Less complicated fracture pattern
  - 76.5% closed
  - 53.5% mild soft-tissue energy

History & Physical: High Energy

High incidence of neurovascular injury and open wounds

High suspicion for compartment syndrome



Radiographic Evaluation

- Full length AP and lateral Views
- Include/check joint above & below

Associated Injuries

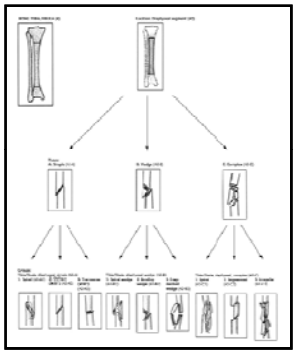
- 30% of patients will have other injuries
  - Ipsilateral Fibula Fracture
  - Foot & Ankle injury
  - Ligamentous knee injuries

Classification

- By location:
- Proximal 1/3
- Middle 1/3
- Distal 1/3

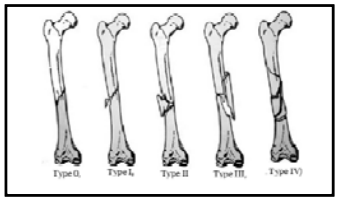
- By fracture pattern:
  - Transverse, oblique, spiral
  - Butterfly
  - Comminuted

AO/OTA Classification



Hansen Winquist Classification: Degree of Comminution

- 1: minimal comminution
- 2: <50%
- 3: >50%
- 4: 100% or a segmental fracture
- 5: segmental bone loss

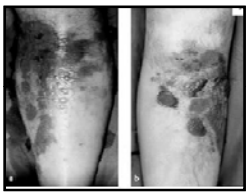


Absolute Operative Indications

- Open fractures
- Vascular injury
- Compartment syndrome

Relative Operative Indications

Floating knee
Intact fibula
Segmental fracture
Severe closed soft tissue injuries
Multiple injuries
Ipsilateral limb injuries
Intra-articular extension
Bilateral tibia fractures

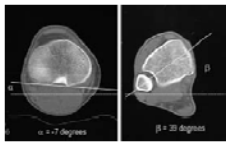


Acceptable Alignment

- Defined as:
- <1 cm of shortening
- angulation < 5-7 degrees
- rotational deformity <10 degrees
- Based on minimal functional outcome data

Rotational Malalignment Tibial IMN's

- 22 patients/CT scans
- 5/22 (22%) were off by more than 10 degrees
  - 3 were off by >= 15 degrees



Puloski et al JOT 18(7), 2004

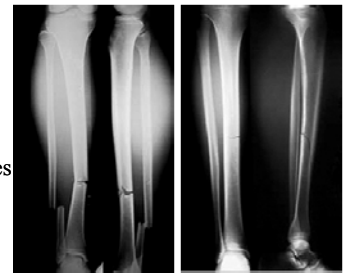
Closed Tibia Fractures

Closed Fractures

- "Standard" treatment for "stable" closed tibia fractures:
  - closed reduction
  - long leg casting
  - functional brace at about 3-6 weeks
  - with early weight bearing

Cast bracing indications: "Stable" Fractures

- Closed transverse fractures that can reduced
- Spiral, oblique, or comminuted fractures with < 12 mm of initial shortening



Functional Bracing Relative Contra-Indications

- Intact fibula
  - varus deformity > 5 degrees likely
- Comminuted fractures
  - take longer to heal

Sarmiento JBJS '84

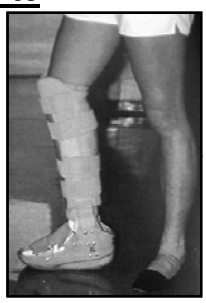
- Closed Functional Treatment
  - 1,000 Tibial Fractures
  - 60% Lost to F/U
- Fracture Characteristics
  - All < 1.5cm shortening
  - None with intact fibula
  - Only 5% more than 8° varus

Sarmiento JBJS '84

- Treatment Course
  - Average 3.7 wks in long leg cast
  - Transition to functional fracture brace
  - Early WBAT
  - Stable patterns!

Sarmiento

- Union Rate
  - 98.5%
- Time to Union
  - 18.1 weeks
- Shortening
  - <1.4%



- Initial Shortening = Final Shortening

20 YO Walked into a cement plantar

Injury

Post Cast

Post Casting

Unstable Fracture Patterns

- In general "unstable" fractures need operative stabilization
- High-energy fractures:
  - higher incidence of delayed union
- Severe closed soft tissue injury
- Articular surface involvement

Definition: Unstable Fracture Patterns

- 100% displacement of the fracture on the initial film
- >50% comminution of the cortex
- Fibula fracture at the same level as the tibia fracture

IMN vs. Closed Treatment of Isolated, closed, "unstable" fractures Literature Summary

Treatment with an IMN vs closed rx:

Shorter time to healing with IMN

Higher union rate with IMN

Functional scores, general health status all favor IMN

IMN vs. Closed Treatment of Isolated, closed, "unstable" fractures

Closed treatment:

- Increased disability
- 15% had hindfoot stiffness
- 22% of those initially treated closed had an operative procedure when reduction could not be maintained

IM Nails – Bone et.al.

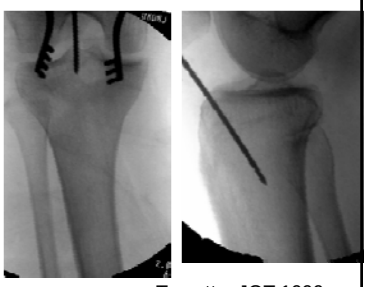
Retrospective review 99 patients

	Cast	Nail
Time to union	26 wks	18 wks
SF-36	74	85
Knee score	89	96
Ankle score	84	97

Bone JBJS '97

Starting Hole

- AP: Canal is just lateral to midline
- Lateral :Anterior corner of the joint



Tornetta, JOT 1999

Intramedullary Nailing (IMN)

- Reamed interlocked nails:
  - High union rates
  - Low malunion rates
  - Low infection rates
- Primary indication:
- diaphyseal fractures
  - distal fractures within 4 cm of the ankle joint

Ream or Not?

	Reamed	Non-Reamed
# pts.	73	63
Nonunion	4%	11%
Malunion	4%	3%
Broken Bolts	3%	16%
Time to Union	16.7 wks	25.7 wks

Larsen JOT '04

CLOSED Fractures: Reamed vs. Unreamed Nails

- Prospective randomized studies
- Nonreamed nails:
  - Increased time to union
  - Increased locking screw breakage (old nails)

Knee pain and compartment syndrome rates were similar

Reamed vs Unreamed: SPRINT

- Possible benefit of reamed IM nails for closed fractures
- No difference for open fractures
- Delaying reoperation for nonunion for at least 6 months significantly lowers the need for reoperation

Bhandari M, et al ***JBJS,* 2008**

Knee pain s/p IMN

- Occurs in 10- 60% of patients
- No difference in knee pain if a patellar tendon splitting approach is used vs. a parapatellar incision
- Usually activity related and made worse by kneeling

Knee pain s/p IMN

- In one study there was no correlation between nail protrusion and knee pain
- 80% of patients had total or partial pain relief with nail removal
- Cause is unknown

Standard ORIF: Tibial Shaft

- Open reduction with wide exposures is usually avoided because of infection and soft tissue complications.
- MIPPO techniques:
  - Distal and proximal 1/3 fractures

"MIPO" ORIF

- Relative plating indications:
  - Fractures with extension into the ankle or knee joint
  - Arterial injuries requiring repair (exposure may already be done)
  - Proximal and distal 1/3 fractures (increased incidence of deformity with IMN's)

External Fixation

- Minimizes further disruption of the soft tissue and blood supply of fracture fragments
- Current indications:
  - Initial rx high grade open fractures with massive contamination
  - Damage control orthopedics:
    - "Sick" patients
    - "Sick limb"

External Fixation

- Complications:
  - Malunion
  - Delayed and nonunion
  - Pin tract infections
- ***Higher rate of malunion compared with IMN

Open Tibial Shaft Fractures

Mechanism of Injury

Lower energy, torsional type injury (e.g., skiing)

More common with higher energy direct force (e.g. car bumper)

Priorities

- ABC'S
- Assoc Injuries
- Tetanus
- Antibiotics
- Soft Tissue Management/ Fixation
- Long term issues

Physical Examination

- Given subcutaneous nature of tibia, deformity and open wound usually readily apparent
- Circumferential inspection of soft tissue envelope, noting any lacerations, ecchymosis, swelling, and tissue turgidity

Physical Exam

Neurologic and vascular exam of extremity including ABI's if indicated

Wounds assessed once in ER, then covered with sterile gauze dressing until treated in OR- digital camera / cell phone

Wound classification after surgical debridement

Classification of Open Tibia Fractures

Table 2 Gustilo Classification of Open Fractures[6]

Type	Description
I	Clean wound <1 cm in length
II	Clean wound >1 cm in length without extensive soft-tissue damage, flaps, or avulsions
IIIA	Adequate soft-tissue coverage despite extensive soft-tissue damage, flaps, or high-energy trauma irrespective of the wound size
IIIB	Inadequate soft-tissue coverage with periosteal stripping, often associated with massive contamination
IIIC	Arterial injury requiring repair

- Gustilo and Anderson open fracture classification first published in 1976 and later modified in 1984
- In one study interobserver agreement on classification only 60%

Limb Salvage

- Over all assessment of the limb and the patient
  - Associated injuries
  - Age/ pre-existing medical conditions
  - Degree of muscle damage
  - Bony injury
  - Vascular injury
  - Plantar sensation
    - Anatomic disruption!!!!!!!!!!!!

LEAP Data

- Outcome at 2 and 7 years was the same for amputees and salvaged limbs
- All patients were severely disabled
- Salvage has a higher incidence of complications, more operations, and more hospitalizations

Limb salvage scoring systems

- Low sensitivity
- High specificity
- About 20% of amputations occur at scores below the cutoff value
- Do not use scoring systems alone to determine amputation vs. salvage

Open Fractures

- Infection incidence depends on:
  - *Degree of soft tissue and bone injury
  - *Extent of contamination
  - Timing/ use of antibiotics
  - Adequacy of debridment
    - *not under surgeon control

Open Fracture Treatment

Surgical emergency

ER wound care:

cover with a sterile dressing

Debride wound and stabilize fracture in OR

Re-debride every 48-72 hours until the wound is healthy, if needed

Antibiotics

- Closed, grade 1, grade II, grade IIIA open fractures:
  - Cephalosporin for 24-48 hours
- Grade IIIB and IIIC injuries:
  - add amino glycoside
- Anaerobic contamination (barnyard injury):
  - add penicillin

Open Fracture Treatment

- Antibiotics: 24-72 hours initially
- 24 hours after subsequent debridments
- Soft tissue coverage should be obtained as early as possible

Treatment of Soft Tissue Injury

- Careful planning of skin incisions
- Essential to fully explore wound as even Type 1 fractures can pull dirt/debris back into wound and on fracture ends
- All foreign material, necrotic muscle, unattached bone fragments, exposed fat and fascia are debrided

Large Fragments: What to do?

Infection Rates if retained - 21%

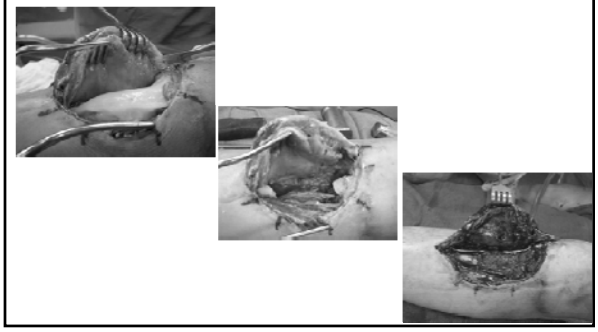
- Infection Rates if removed- 9%
  - **Edwards CC, *CORR*, 1998**
- Use to assist in determining length, rotation and alignment

Bone Defects

- PMMA –aminoglycoside +/- vancomycin
- Bead pouch
- Solid spacer


Bone Defects: PMMA Spacer

Masquelet AC, Reconstruction of the long bones by the induced membrane and spongy autograft [French]. *Ann Chir Plast Esthet 2000*



Soft Tissue Coverage

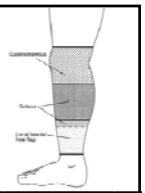
- Definitive coverage should be performed within 7-10 days if possible
- Most type 1 wounds will heal by secondary intent or can be closed primarily Hohmann E, Comparison of delayed and primary wound closure in the treatment of **open tibial fractures.** ***Arch Orthop Trauma Surg 2007***
- Delayed primary closure usually feasible for type 2 and type 3a fractures

Soft Tissue Coverage

- Type 3b fractures require either local advancement or rotation flap, split-thickness skin graft, or free flap
- STSG suitable for coverage of large defects with underlying viable muscle

Soft Tissue Coverage

- Proximal third tibia fractures can be covered with gastrocnemius rotation flap
- Middle third tibia fractures can be covered with soleus rotation flap
- Distal third fractures usually require free flap for coverage



Stabilization of Open Tibia Fractures

Options depending on fracture pattern and soft tissue injury:

- IM nail- reamed vs. unreamed
- External fixation
- ORIF

■ REVIEW ARTICLE

A review of the management of open fractures of the tibia and femur

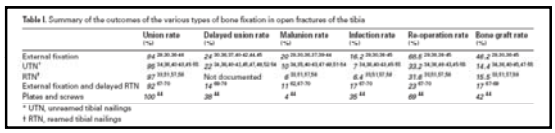


Table I. Summary of the outcomes of the various types of bone fixation in open fractures of the tibia

	Union rate (%)	Delayed union rate (%)	Malunion rate (%)	Infection rate (%)	Re-operation rate (%)	Bone graft rate (%)
External fixation	84	24	20	16.2	66.5	46.2
UTN*	88	22	10	2.74	33.3	14.4
RTN†	87	Not documented	6	6.4	21.8	15.5
External fixation and delayed RTN	82	14	13	17	23	17
Plates and screws	100	38	4	26	69	42

* UTN, unreamed tibial nailings
† RTN, reamed tibial nailings

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Unreamed IMN + Open Fractures

Combined with aggressive debridment

- Pooled data
- Grade 1: < 3% infection
- Grade II: 4%
- Grade IIIA: 7%
- Grade IIIB: 17%
- Infection probably more related to degree of injury rather than implant

Reamed vs Unreamed: SPRINT

- Possible benefit of reamed IM nails for closed fractures
- No difference for open fractures
- Delaying reoperation for nonunion for at least 6 months significantly lowers the need for reoperation

BMPs

- BMP-2 (Infuse) FDA approval in subset of open tibia fractures BESTT study group JBJS 84, 2002
- Significant reduction in the incidence of secondary procedures
- Accelerated healing
- Lower infections

Compartment Syndrome

Compartment Syndrome

- 1-9% of tibia fractures
- Open and closed fractures
- Sports injuries!!!!!
- Diagnosis:
  - Clinical diagnosis in awake alert patients
  - Use pressure measurements for patients with altered mental status

Compartment Syndrome: Symptoms

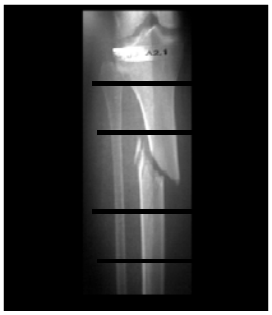
- Pain out of proportion to injury:
  - Patient was comfortable and no longer is
  - Escalating doses of pain meds
- Pain with passive stretch
- Paresthesias (nerve ischemia)
- Pallor (too late)
- Paralysis (too late)

Compartment Syndrome

- Pressure measurements:
- Especially useful:
  - Unresponsive patients
  - those who's clinical symptoms are unclear
- Use a side port needle
  - Pressured measured with a simple needle are 15-20 mm Hg higher.
- The highest pressures are adjacent to the fracture site.

Pressures Not Uniform

- Highest at Fracture Site
- Highest Pressures in:
  - Deep Posterior
  - Anterior
    - Heckman JBJS '76

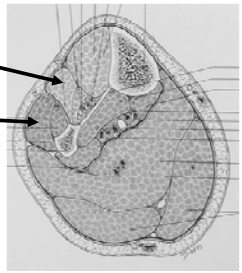


ICP **Threshold for Fasciotomy**

- Absolute pressure is unclear: 30- 45 mm Hg
- ΔP: DBP- ICP <30 mm Hgis less than 30mm Hg

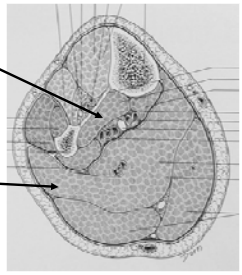
Tibial Compartments

- Anterior:
  - Deep peroneal nerve
  - Sensation to 1st web space
- Lateral:
  - Sup peroneal nerve
  - Sensation to dorsum of foot



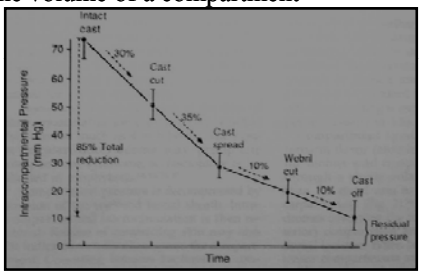
Tibial Compartments

- Deep posterior:
  - Tibial nerve
  - Sensation to sole of foot
- Superficial posterior:
  - Medial sural cutaneous nerve
  - No predictable sensation



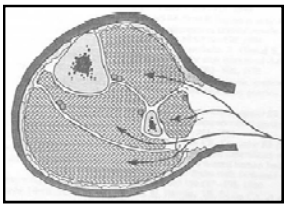
Management:#1- Split Casts and Bandages!

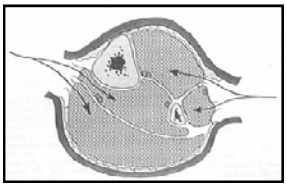
- Circumferential casts or dressing decrease the volume of a compartment



Management

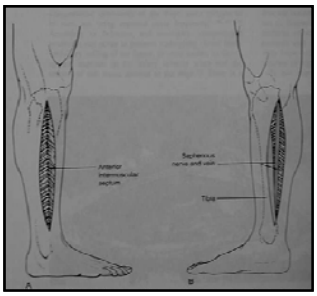
- 4-compartment fasciotomy
- One (lateral) or two (medial and lateral) incisions





Management

- **Long** skin and fascial incisions
- **Leave them open (vac)**
- Back to OR every 48 hours or so
- Closure vs. STSG



End