Open Fractures of the Tibial Diaphysis

Ezekiel Oburu

Incidence

- Open fractures of the tibia are more common than in any other long bone

- Rate of tibial diaphysis fractures reported from 2 per 1000 population to 2 per 10,000 and of these approximately one fourth are open tibia fractures*

*Court-Brown; McBirnie JBJS 1995

Mechanism of Injury

- Can occur in 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 Johansen K, *J Trauma* April 1991
- Wounds should be assessed once in ER, then covered with sterile gauze dressing until treated in OR- digital camera / cell phone
- True classification of wound best done after surgical debridement completed

Radiographic Evaluation

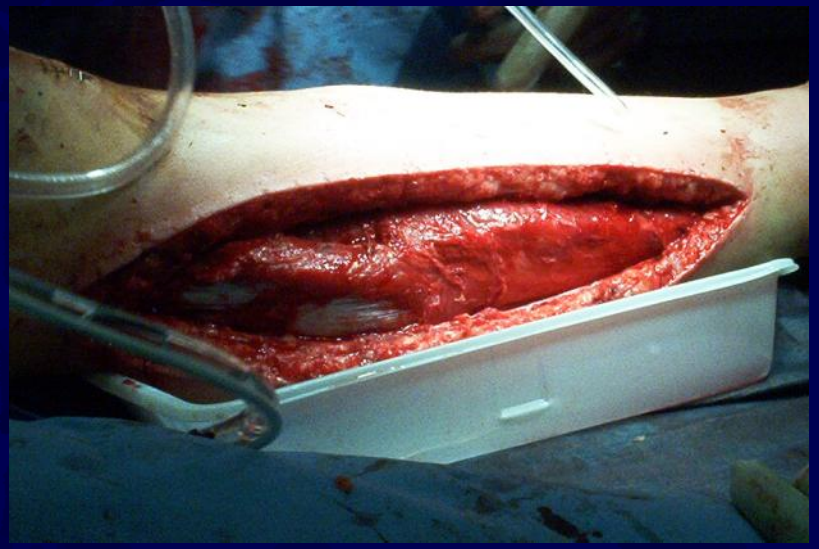
- Full length AP and lateral views from knee to ankle required for all tibia fractures
- Ankle views suggested to examine mortise
- Arteriography indicated if vascular compromise present after reduction

Associated Injuries

- Approximately 30% of patients have multiple injuries
- Fibula commonly fractured and its degree of comminution correlates with severity of injury
- Proximal or distal tib-fib joints may be disrupted
- Ligamentous knee injury and/or ipsilateral femur ('floating knee') more common in high energy fractures

Associated Injuries

- Neurovascular structures require repeated assessment
- Foot fractures also common
- Compartment syndrome must be looked for



Antibiotics

Surgical Infection Society guideline: prophylactic antibiotic use in open fractures: an evidence-based guideline. Hauser CJ, *Surg Infect*, Aug 2006

- First Generation Cephalosporin
- +/- Aminoglycoside
- +/- Pen G or Clindamycin if Pen allergic
- No Cipro alone Patzakis MJ, *J Orthop Trauma* Nov 2000
- 24-72hr course

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%

Objectives of Surgical Treatment

- Prevent Sepsis
- Achieve Union
- Restore Function

Treatment of Soft Tissue Injury

- After initial evaluation wound covered with sterile dressing and leg splinted
- Appropriate tetanus prophylaxis and antibiotics begun
- Thorough debridement and irrigation undertaken in OR within 6 hours if possible
- Photo documentation

Treatment of Soft Tissue Injury

- Careful planning of skin incisions
- Longitudinal incisions / “Z” plasty
- 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

Irrigation

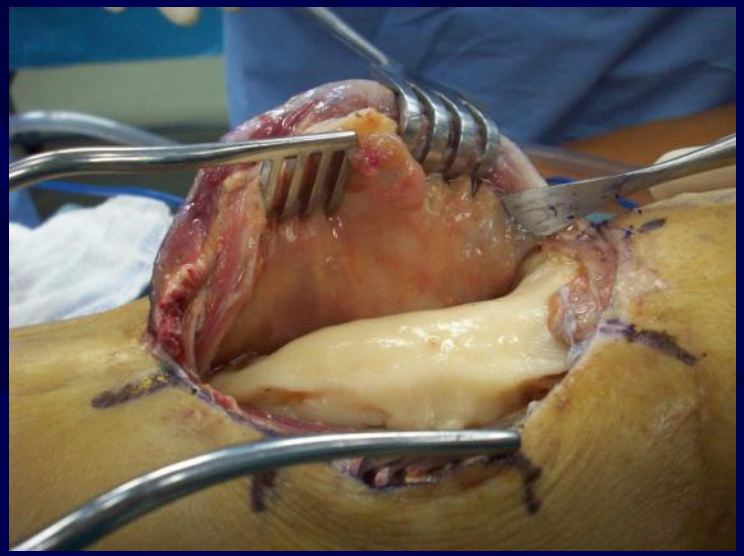
- Saline +/- surfactants (soap) Anglen J, Removal of surface bacteria by irrigation. *J Orthop Res 1996*
- Pressure – avoid high pressure / pulse lavage Polzin B, Removal of surface bacteria by irrigation. *J Orthop Res 1996*
- Timing > 6 hrs Crowley DJ, Debridement and wound closure of **open fractures: The impact of the time factor on infection rates.** ***Injury 2007***

Treatment of Soft Tissue Injury

- After debridement thorough irrigation with Ringer's lactate or normal saline
- Fasciotomies performed if indicated even in open fractures
- After I+D new gowns, gloves, drapes and sterile instruments used for fracture fixation

Bone Defects

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



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***

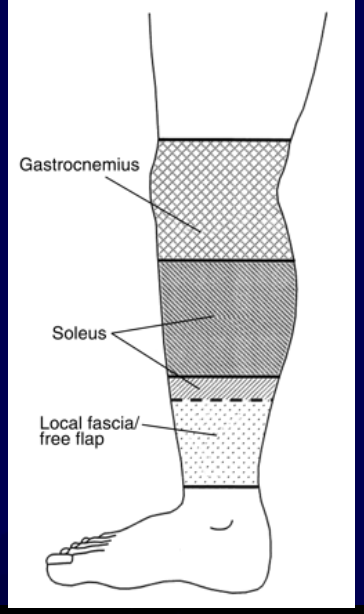
- Delayed primary closure usually feasible for type 2 and type 3a fractures

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 usuall require free flap for coverage

Stabilization of Open Tibia Fractures

- Multiple options depending on fracture pattern and soft tissue injury:

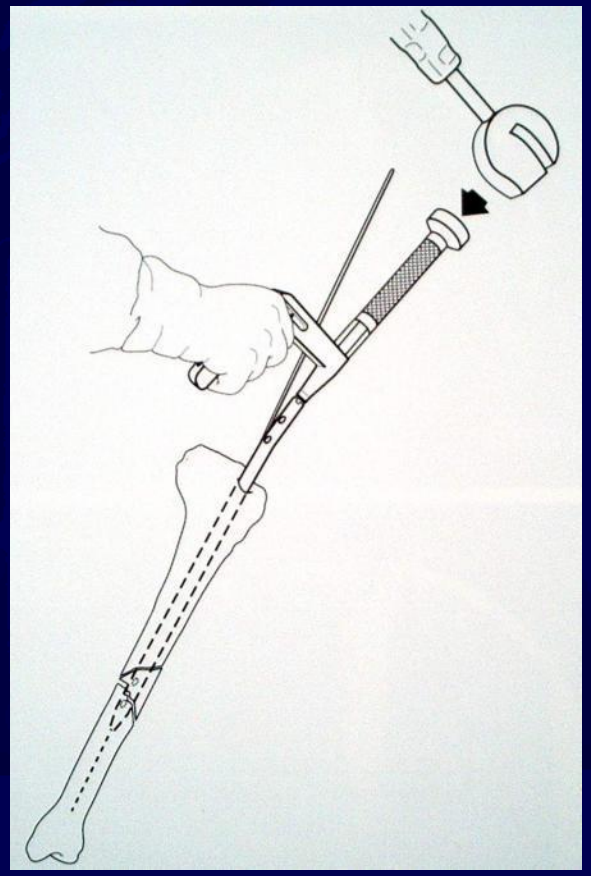
  IM nail- reamed vs. unreamed

  External fixation

  ORIF

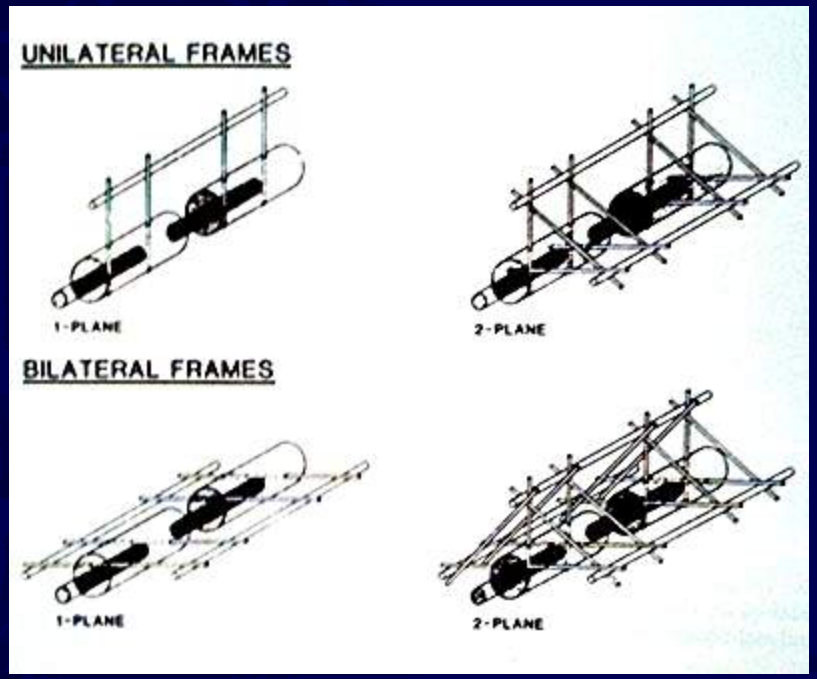
IM Nail

- Excellent results with type 1 open fractures



External Fixation

- Compared to IM nails, increased rate of malunion and need for secondary procedures
- Most common complication with ex-fix is pin track infection (21% in one study)*



*Tornetta JBJS 1994

Conversion from Ex-Fix to IM Nail

Bhandari M, Intramedullary nailing following external fixation in femoral and **tibial shaft fractures.** ***J Orthop Trauma 2005***

- Conversion between ex-fix and IM nail
- 9% infection 90%union
- Infection rates decreased with shorter duration of ex-fix time

Plate Fixation

- Traditional plating technique with extensive soft tissue dissection and devitalization has generally fallen out of favor for open tibia fractures
- Increased incidence of superficial and deep infections compared to other techniques
- In one study 13% patients developed osteomyelitis after plating compared to 3% of patients after ex-fix*

*Bach and Handsen, Clin Orthop 1989

Percutaneous Plate Fixation

- Newer percutaneous plating techniques using indirect reduction may be a more beneficial alternative

- Large prospective studies yet to be evaluated

Gunshot Wounds

- Tibia fractures due to low energy missiles rarely require debridement and can often be treated like closed injuries

- Fractures due to high energy missiles (e.g. assault rifle or close range shot gun) treated as standard open injuries

Amputation

- In general amputation performed when limb salvage poses significant risk to patient survival, when functional result would be better with a prosthesis, and when duration and course of treatment would cause intolerable psychological disturbance

Amputation

- Lange proposed two absolute indications for amputation of tibia fractures with arterial injury: crush injury with warm ischemia greater than 6 hours, and anatomic division of the tibial nerve*

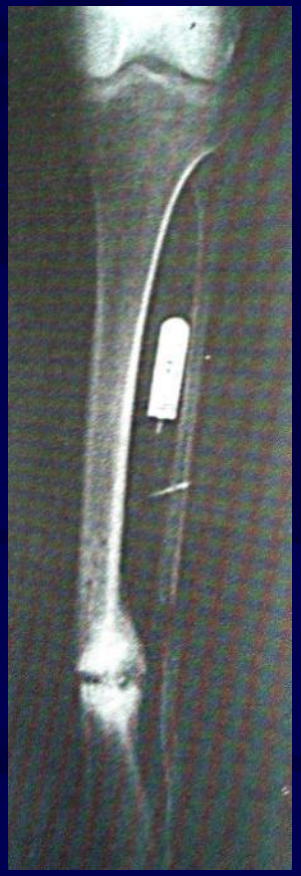
*Lange et al. J Trauma 1985

Complications

- Nonunion
- Malunion
- Infection- deep and superficial
- Compartment syndrome
- Fatigue fractures
- Hardware failure

Nonunion

- Time limits vary from 6 months to one year
- Fracture shows no radiologic progress toward union over 3 month period
- Important to rule out infection
- Treatment options for uninfected nonunions include onlay bone grafts, free vascularized bone grafts, reamed nailing, compression plating, or ring fixator



Malunion

- In general varus malunion more of a problem than valgus
- In one study deformity up to 15 degrees did not produce ankle complications*
- For symptomatic patients with significant deformity treatment is osteotomy

*Kristensen et al. Acta Orthop Scand 1989

Deep Infection

- Often presents with increasing pain, wound drainage, or sinus formation
- Treatment involves debridement, stabilization (often with ex-fix), coverage with healthy tissue including muscle flap if needed, IV antibiotics, delayed bone graft of defect if needed

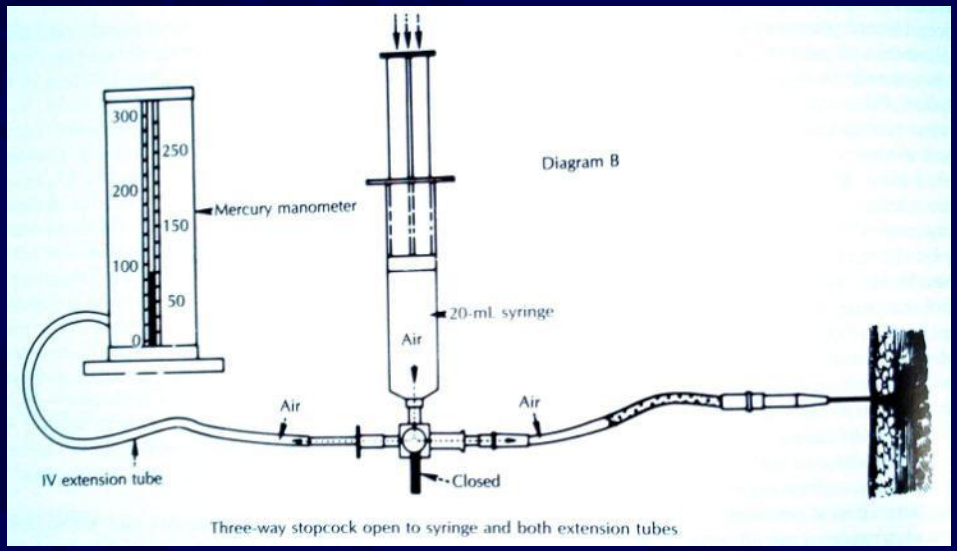
Superficial Infection

- Most superficial infections respond to elevation of extremity and appropriate antibiotics (typically gram + cocci coverage)

- If uncertain whether infection extends deeper and/ or it fails to respond to antibiotic treatment , then surgical debridement with tissue cultures necessary

Compartment Syndrome

- Diagnosis same as in closed tibial fractures
- Common with high energy tibia fractures
- Release ALL 4 compartments



Hardware Failure

- Usually due to delayed union or nonunion
- Important to rule out infection as cause of delayed healing
- Treatment depends on type of failure- plate or nail breakage requires revision, whereas breakage of locking screw in nail may not require operative intervention

Summary

- Different injury in young and old
- Important injury in both young and old
- Understand goals of treatment
- Maximize outcome with least iatrogenic risk

Closed Fractures of the Tibial Diaphysis

Tibia Fractures

- Most common long bone fracture
- 492,000 fractures yearly
- Average 7.4 day hospital stay
- 100,000 non-unions per year

History & Physical

- Low Energy
  - Minimal soft-tissue injury
  - Less complicated fracture pattern and management decisions
    - 76.5% closed
    - 53.5% mild soft-tissue energy

History & Physical

- High Energy
  - High incidence of neurovascular energy and open injury
  - Low threshold for compartment syndrome
  - Complete soft-tissue injury may not declare itself for several days

Radiographic Evaluation

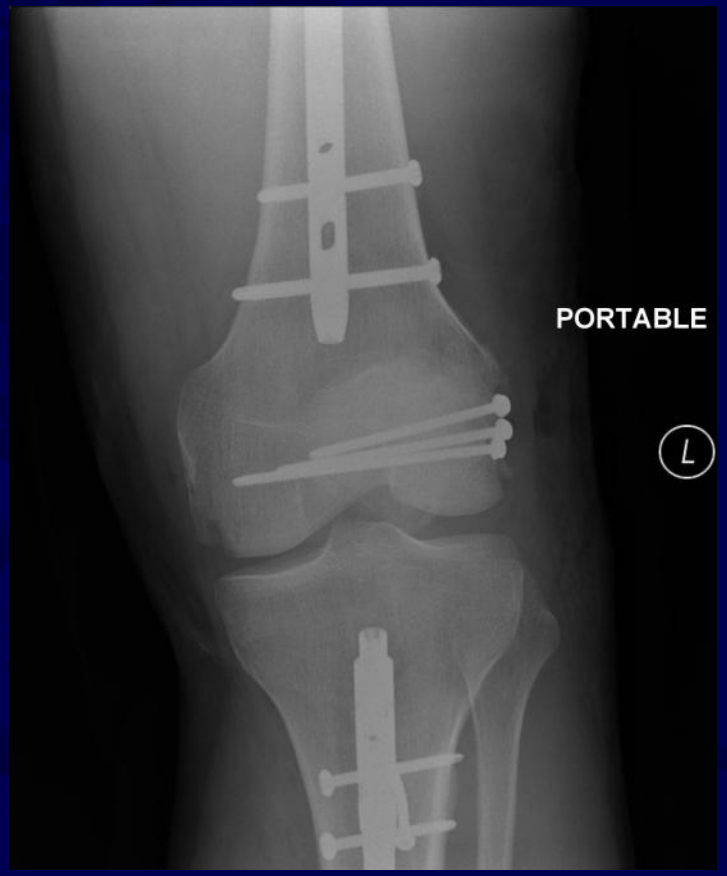
- Full length AP and Lateral Views
  - Check joint above & below
- Oblique views may be helpful in follow-up to assess healing

Injuries Associated

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

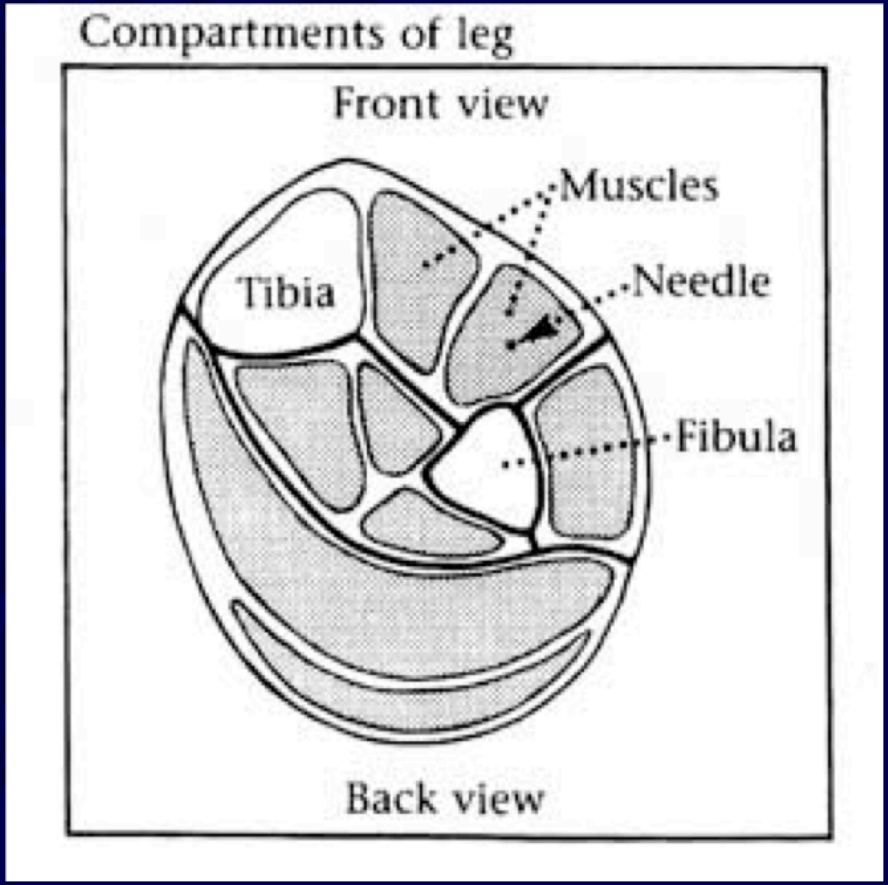
Injuries Associated

- Ipsilateral Femur Fx
  - "Floating Knee"
- Neurovascular Injury
  - More Common In:
    - High Energy
    - Proximal Fracture
    - Floating Knee
    - Knee Dislocation



Compartment Syndrome

- Incidence:
  - 5-15%
- History
  - High-Energy
  - Crush
- Exam
  - 4 Compartments
  - 6 P's
    - Pain
    - Pain with passive stretch
    - Parasthesias
    - Pulsless
    - Pallor
    - Paralysis



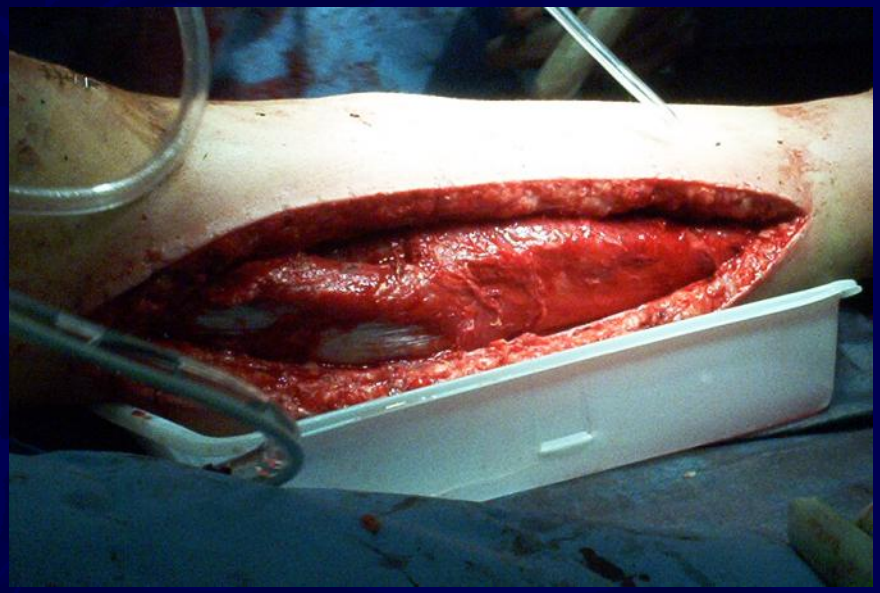
Compartment Syndrome Remains a Clinical Diagnosis

Pressure Measurements

- May be helpful in borderline cases
  - Basic Science
    - Muscle ischemia present at 20 mmHg below DBP and 30 mmHg below MAP
- Various Thresholds
  - P = 30 mmHg
  - P = 45 mmHg
  - Whiteside's Theory
    - Δ P = DBP – CP = < 30 mmHg

Clinical Monitoring

- Close Observation
  - Repeat Exams
  - Repeat Pressure Measurements
- Indwelling Monitors
  - Reserved for intubated patient with high suspicion



Goals of Fasciotomy

- Decompress the compartment
  - Minimize further soft-tissue damage
- Single vs. Two incisions
  - Go long
    - No increased morbidity
    - No difference in long-term outcome
- Plan for fracture fixation
- Plan for wound closure
- Coordinate with location of future incisions and/or internal fixation

Closed Tibial Shaft Fracture

- Broad Spectrum of Injures w/ many treatments

- Closed Management
- Intramedullary Nails
- Plates
- External Fixation

Non-Operative Treatment Indications

- Minimal soft tissue damage
- Non-intact fibula
  - Higher rate of nonunion & varus with intact fibula
- Stable fracture pattern
  - < 5° varus/valgus
  - < 10° pro/recurvatum
  - < 1 cm shortening
- Ability to bear weight in cast or fx brace
  - Requires frequent follow-up

Fracture Brace

- Closed Functional Treatment
  - 1,000 Tibial Fractures
  - 60% Lost to F/U
- Fracture Characteristics
  - All < 1.5cm shortening
  - Non with intact fibula
  - Only 5% more than 8° varus
- Treatment Course
  - Average 3.7 wks in long leg cast
  - Transition to Function Fracture Brace

- Sarmiento JBJS '84

Sarmiento

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

- Initial Shortening = Fina

Natural History

- Long-term angular deformities
  - Well tolerated without associated knee or ankle arthrosis

  - Kristensen 22 pt F/U: 20-29 yrs
    - All patients >10 degree deformity
    - No radiographic Ankle arthrosis

  - Merchant & Dietz 37 pt F/U: 29 yrs
    - 76% of Ankles had G/E radiographic results
    - 92% of Knees had G/E radiographic results

Post Tibia Fracture Ankle Motion

- 25% Post Tibia Fracture will lose 25% of Ankle ROM

Surgical Indications

- Patient Characteristics
  - Obesity
  - Poor compliance with non-operative management
  - Need for early mobility
- Injury Characteristics
  - High Energy
  - Moderate soft-tissue injury
  - Open Fracture
  - Compartment Syndrome
  - Ipsilateral Femur Fx
  - Vascular Injury
- Fracture Characteristics
  - Meta-Diaphyseal location
  - Oblique fracture pattern
  - Coronal Angulation > 5°
  - Sagittal Angulation > 10°
  - Rotation > 5°
  - Shortening > 1cm
  - Comminution > 50% cortical circumference
  - Intact fibula

Surgical Options

- Intramedullary Nail
- ORIF with Plate
- External Fixation
- Combination of fixation

Advantage of IM Nail

- Less malunion
- Early weight-bearing
- Early motion
- Early WB (load sharing)
- Patient satisfaction
  - L Bone, JBJS
- Cost
  - Less expensive to society when compared to casting
    - Busse Acta Ortho ‘05

Disadvantages of IM Nail

- Anterior knee pain
  - 2/3, improve w/in year
- Risk of infection
- Increased hardware failure with unreamed nails
- Thermal Necrosis
- Medial HW prominence

Complications

- Infection 1-5%
- Union >90%
- Knee Pain 56%
  - w/ kneeling 90%
  - w/ running 56%
  - at rest 33%

Court-Brown JOT ‘96

Post Tibia Fracture Ankle Motion

- 25% Post Tibia Fracture will lose 25% of Ankle ROM

Plating of Tibial Fractures

- 3.5 mm or Narrow 4.5mm DCP plate can be used for shaft fractures
- Newer periarticular plates available for metaphyseal fractures

Subcutaneous Tibial Plating

- Newer alternative is use of limited incisions and subcutaneous plating- requires indirect reduction of fracture and hybrid screw fixation options

External Fixation

- Generally reserved for open tibia fractures or periarticular fractures