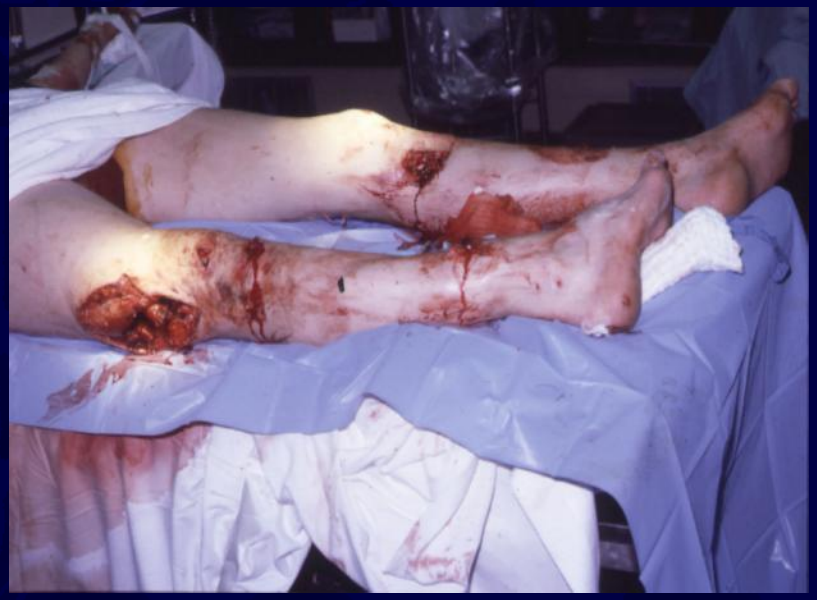
Open Fractures of the Tibial Diaphysis

Daniel N. Segina, MD
Robert V. Cantu, MD
David Templeman, MD

Created March 2004
Updated May 2010

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

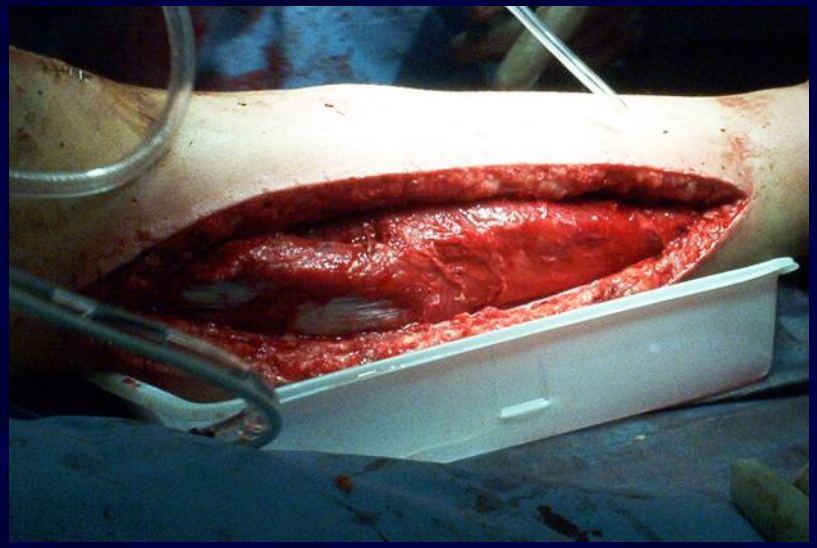
- Full length AP and lateral views from knee to ankle required for all tibia fractures
- Ankle views suggested to examine mortise
- Arteriography indicated if vascular compromise present after reduction

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

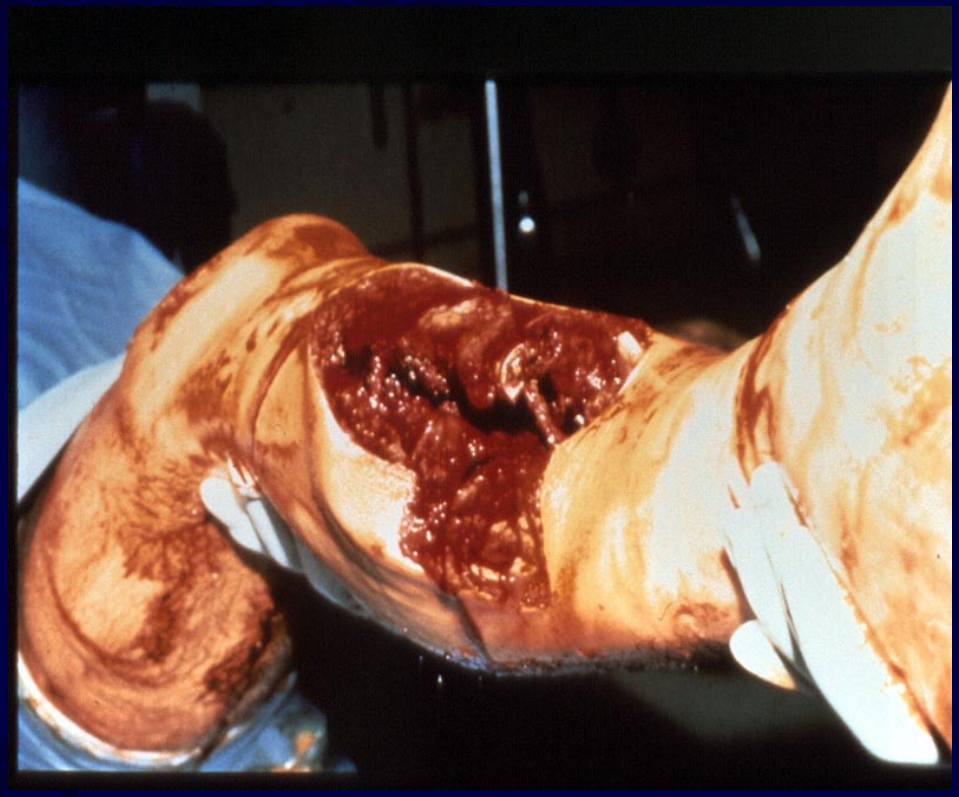
Table 2 Gustilo Classification of Open Fractures[6]

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

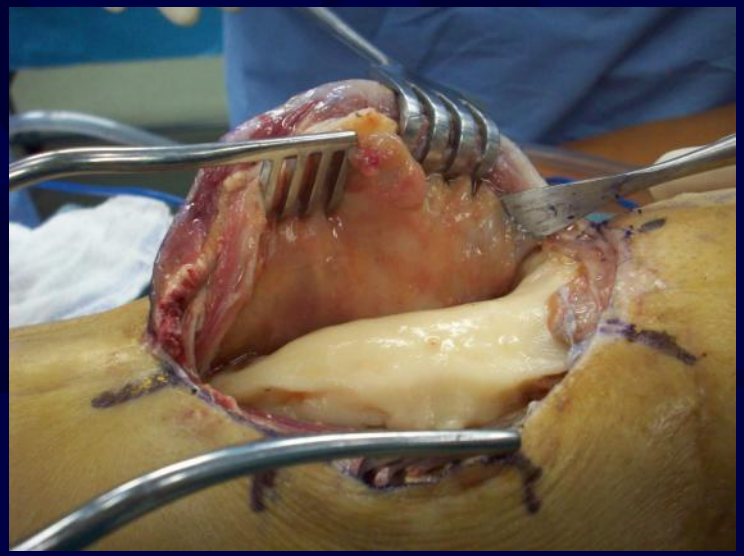
- Saline +/- surfactants (soap) Anglen J, Removal of surface bacteria by irrigation. *J Orthop Res 1996*
- Pressure – avoid high pressure / pulse lavage Polzin B, Removal of surface bacteria by irrigation. *J Orthop Res 1996*
- Timing > 6 hrs Crowley DJ, Debridement and wound closure of **open fractures: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

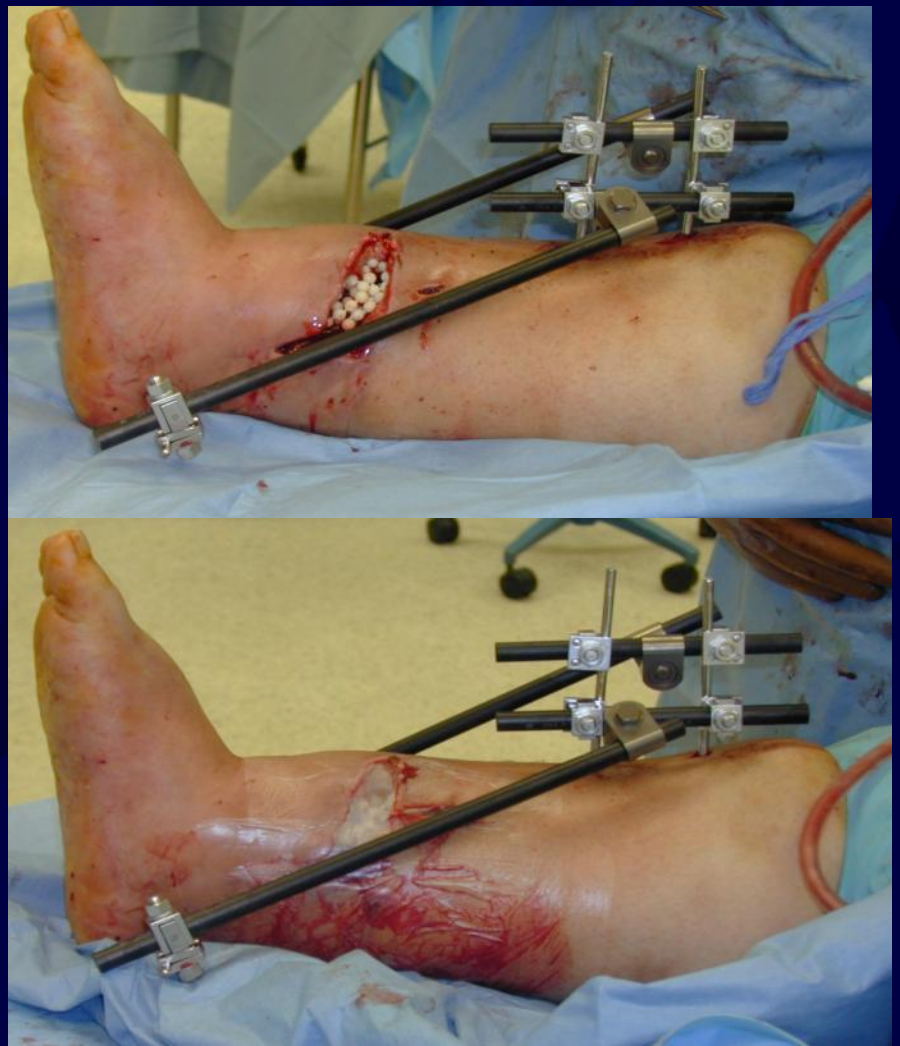
Bone Defects

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



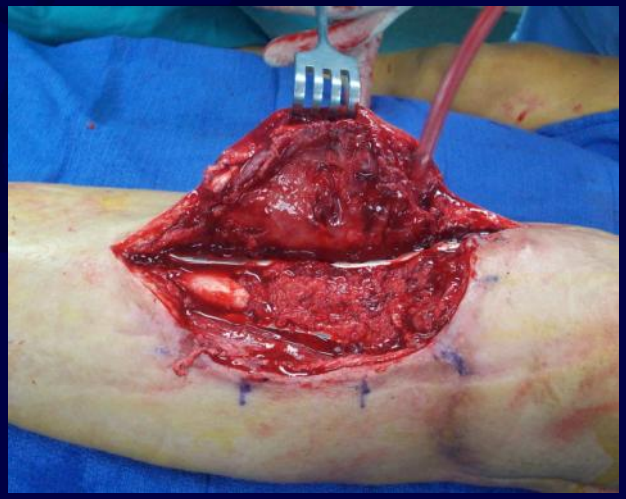
Bone Defects: Bead Pouch

Ostermann PA, Local antibiotic therapy for severe **open fractures: A review of 1085 consecutive cases.** ***J Bone Joint Surg Br 1995***



Bone Defects: PMMA Spacer

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



Large Fragments: What to do?

- Infection Rates with retained - 21%
- Infection Rates with removed- 9%

Edwards CC, Severe open tibial fractures. Results treating 202 injuries with external fixation. *CORR*, 1998

- Use to assist in determining length, rotation and alignment

Soft Tissue Coverage

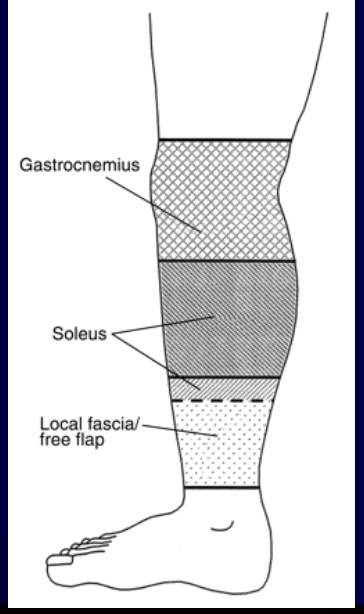
- Definitive coverage should be performed within 7-10 days if possible
- Most type 1 wounds will heal by secondary intent or can be closed primarily Hohmann E, Comparison of delayed and primary wound closure in the treatment of **open tibial fractures.** ***Arch Orthop Trauma Surg 2007***
- Delayed primary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

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

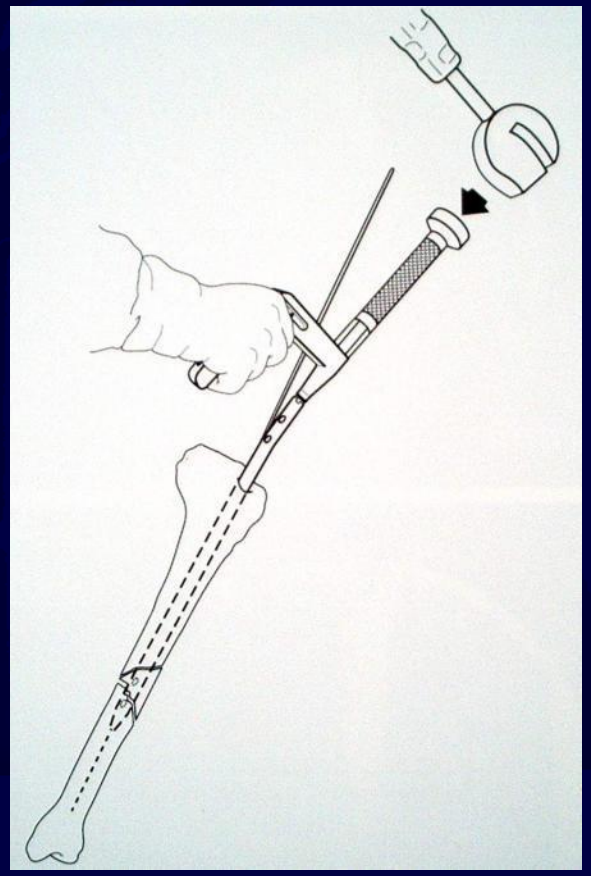
  IM nail- reamed vs. unreamed

  External fixation

  ORIF

IM Nail

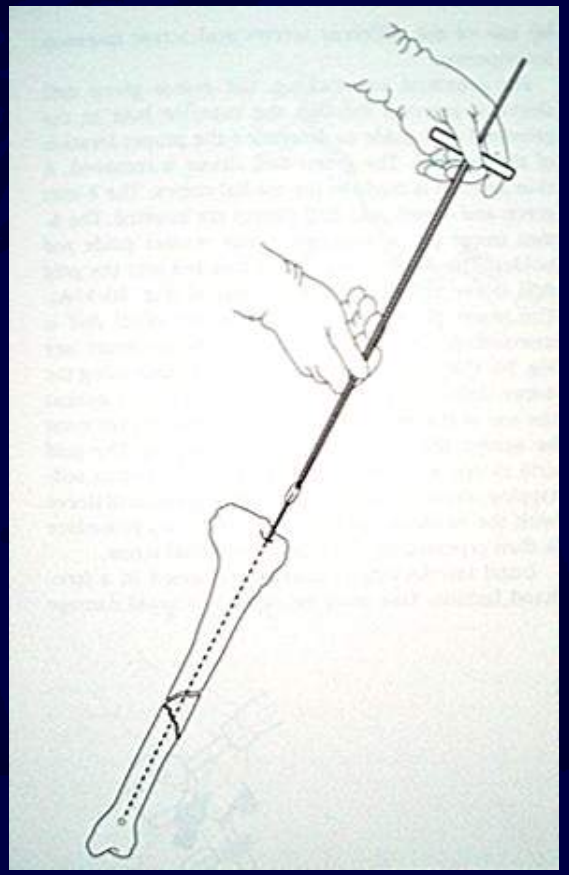
- Excellent results with type 1 open fractures



Unreamed IM Nail

- Time to union with unreamed nails can be prolonged- in one study of 143 open tibia fractures 53% were united at 6 months

- Vast majority of fractures united, but 11% required at least one secondary procedure to achieve union*



*Tornetta and McConnell 16th annual OTA 2000

Reamed Tibial Nailing

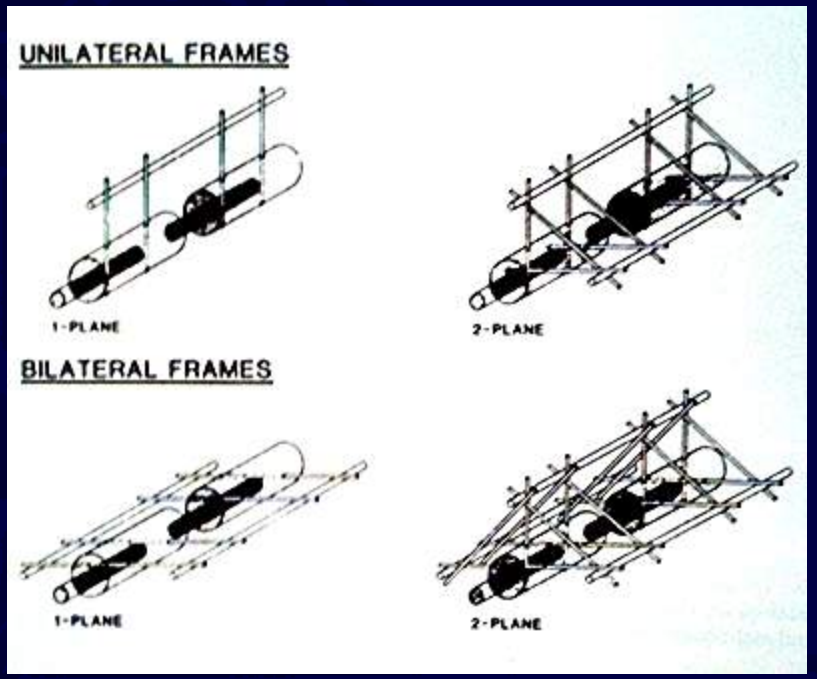
- In one study of type 2 and type 3a fractures good results- average time to union 24 and 27 weeks respectively; deep infection rate 3.5%*

- Complications increased with type 3b fractures- average time to union was 50 weeks and infection rate 23%*

*Court-Brown JBJS 1991

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

Mangled Extremity Severity Score

- An attempt to help guide between primary amputation vs. limb salvage
- In one study a score of 7 or higher was predictive of amputation*

Component	Points
A. Skeletal and soft tissue injury	
Low energy (stab; simple fracture; "civilian gunshot wound")	1
Medium energy (open or multiplex fractures, dislocation)	2
High energy (close-range shotgun or "military" gunshot wound, crush injury)	3
Very high energy (same as above plus gross contamination, soft tissue avulsion)	4
B. Limb ischemia (score is doubled for ischemia >6 hours)	
Pulse reduced or absent but perfusion normal	1
Pulseless; paresthesias, diminished capillary refill	2
Cool, paralyzed, insensate, numb	3
C. Shock	
Systolic blood pressure always >90 mm Hg	0
Hypotensive transiently	1
Persistent hypotension	2
D. Age (yr)	
<30	0
30–50	1
>50	2

*Johansen et al. J Trauma 1991

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

LEAP Study

Bosse MJ, A prospective evaluation of the clinical utility of the lower-extremity injury-severity scores. *J Bone Joint Surg Am 2001*

	Scoring Systems*				
	MESS	LSI	PSI	NISSSA	HFS-97
Age	X			X	
Shock	X			X	X
Warm ischemia time	X	X	X	X	X
Bone injury		X	X		X
Muscle injury		X	X		
Skin injury		X			X
Nerve injury		X		X	X
Deep-vein injury		X			
Skeletal/soft-tissue injury	X			X	
Contamination				X	X
Time to treatment			X		

*MESS = Mangled Extremity Severity Score; LSI = Limb Salvage Index; PSI = Predictive Salvage Index; NISSSA = Nerve Injury, Ischemia, Soft-Tissue Injury, Skeletal Injury, Shock, and Age of Patient Score; and HFS-97 = Hannover Fracture Scale (1997 version).

LEAP Study

- Plantar sensation not prognostic
  - Scoring systems do not work
    - Predictors of outcome
- Salvage vs Amputation about equal

Table 1 Predictors of a Poor Sickness Impact Profile Score at 2 and 7 Years Following Lower Extremity Injury

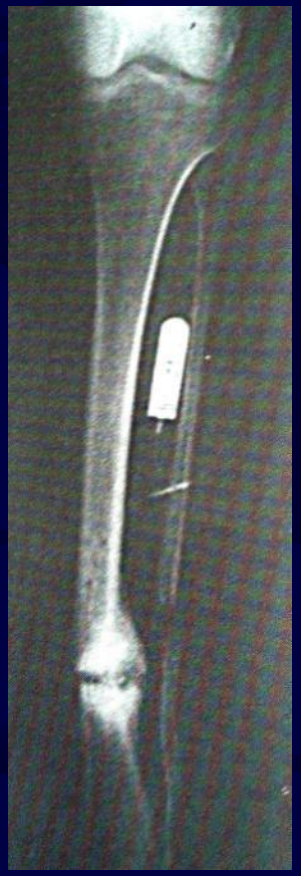
2-year Patient Predictors
Rehospitalization for a major complication
Low education level
Nonwhite race
Poverty
Lack of private health insurance
Poor social support network
Low self-efficacy
Smoking
Involvement in disability compensation litigation
7-year Patient Predictors
Older age
Female sex
Nonwhite race
Lower education level
Living in a poor household
Current or previous smoking
Low self-efficacy
Poor self-reported health status before injury
Involvement in disability compensation litigation

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

Deep Infection

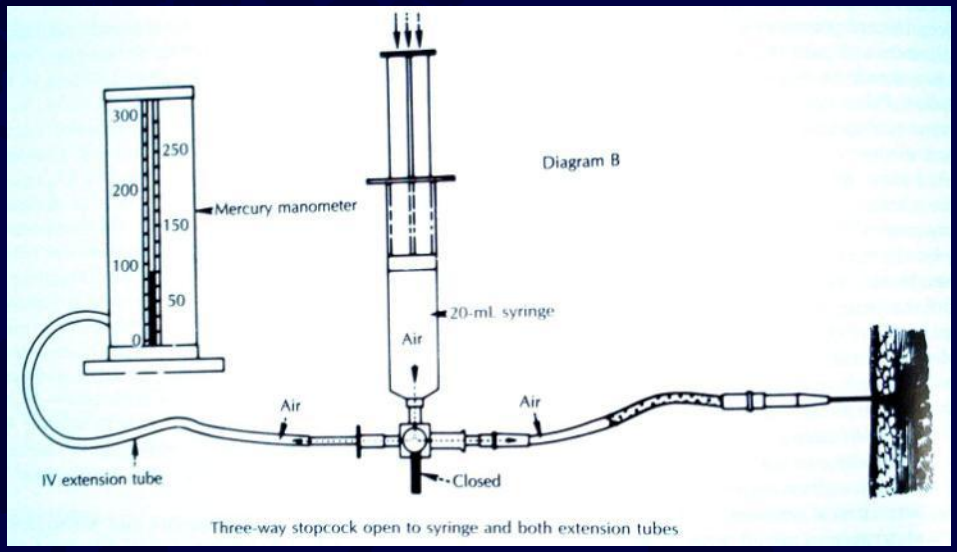
- Not the Implant but the Management of the Soft Tissues
- If IM nail already in place, reamed exchange nail with appropriate antibiotics may prove adequate treatment
- Staged reconstruction with the used of PMMA + antibiotics

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



Reamed vs Unreamed: SPRINT Trial

Bhandari M, **Randomized trial of reamed and unreamed intramedullary nailing of tibial shaft fractures *JBJS*, 2008**

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

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

Negative Pressure Would Therapy (NPWT)

- Can lower need for free flaps Dedmond BT, The use of negative-pressure wound therapy (NPWT) in the temporary treatment of soft-tissue injuries associated with high-energy **open tibial shaft fractures.** ***J Orthop Trauma 2007***
- Cannot lower infection rates for Type IIIB open fractures Bhattacharyya T, Routine use of wound vacuum-assisted closure does not allow coverage delay for **open tibia fractures.** ***Plast Reconstr Surg 2008***

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

Outcomes

- Outcome most affected by severity of soft tissue and neurovascular injury
- Most studies show major change in results between type 3a and 3b/c fractures
- In one study of reamed nailing, the deep infection rate was 3.5% for type 2 and 3a fractures, but 23% for type 3b fractures*

*Court-Brown JBJS 1991

Outcomes

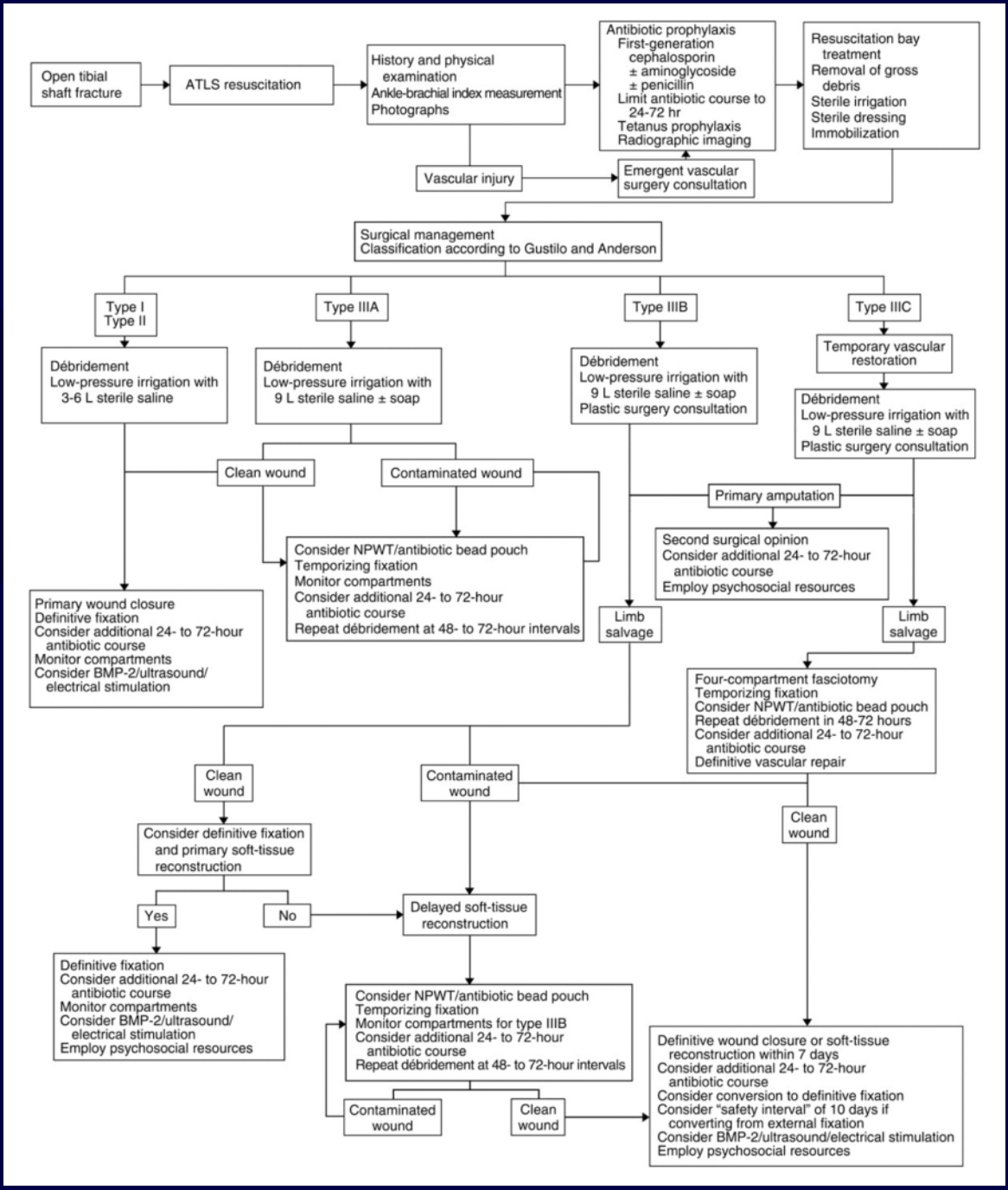
- For type 3b and 3c fractures early soft tissue coverage gives best results

- In one study of 84 type 3b and 3c fractures, results with single stage procedure involving fixation with immediate flap coverage better than when coverage delayed more than 72 hours (deep infection 3% vs. 19%)*

*Gopal et al. JBJS[Br] 2000

Suggested treatment algorithm

Melvin JS, **Open Tibial Shaft Fractures: I and II, *JAAOS*, Jan-Feb 2010**



Summary

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

If you would like to volunteer as an author for the Resident Slide Project or recommend updates to any of the following slides, please send an e-mail to ota@ota.org

Return to Lower Extremity Index

Return to index