Tibial Shaft Fractures

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Any pictures not specifically referenced are from authors' personal file

Objectives:

- Describe the epidemiology and evaluation of tibia shaft fractures
- Compare treatment options
- Discuss outcomes and complications

Epidemiology

- Most common long bone fracture Lang GJ. *OKU Trauma* 2000.
- High incidence open fxs
  - 12-47% open fxs (institution dependent)
  - Subcutaneous location of bone Boulton CL*Rockwood and Green's Fractures* 2020
- Bimodal distribution
  - Young (<30 y.o.) - high-energy transverse and comminuted fxs
  - Older (>50 y.o.) - low-energy spiral fxs
- Vehicular trauma most common cause of high-energy fxs
  - Pedestrian struck by vehicle>motorcycle crash>motor vehicle crash

Evaluation

- History and Physical exam
- Radiographs
- Possible CT scan and/or Vascular studies

Evaluation – History

- History
  - Mechanism of injury High vs low energy
  - Isolated injury vs polytrauma
  - Patient demographics + PMH
    - Age/DM/Smoking/Substance abuse/Obesity/Immune Comprise

Evaluation –Physical Exam

- Open versus closed
- Pain Compartment syndrome
- Soft tissue injury
- Vascular exam
- Neurologic exam (motor and sensory)

Evaluation - Radiographs

- Trauma bay XRs
  - Quick tool to identify fxs, but usually poor quality
  - True orthogonal XRs of tibia/fibula optimal for evaluation
- Ankle and knee XRs
- Periarticular extension, especially distal tibia shaft
  - Distal fibula fxs
  - Syndesmotic ankle and proximal tibiofibular joint injuries

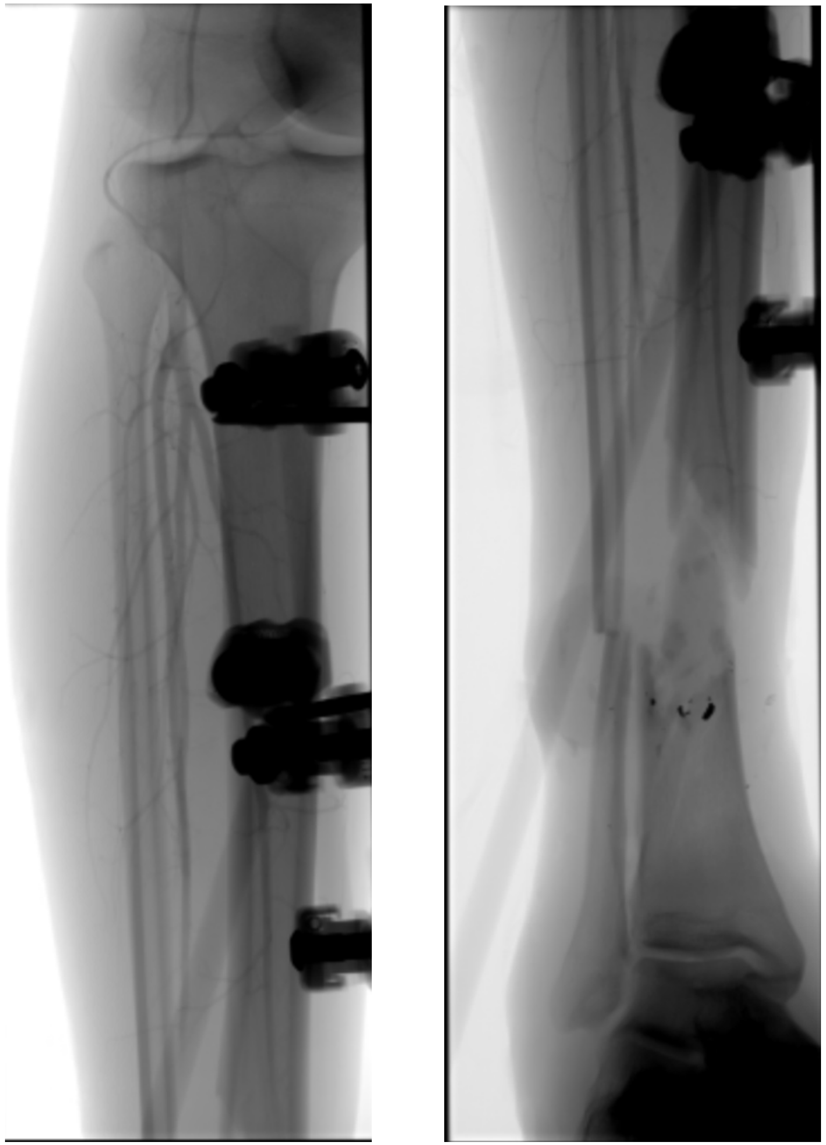
Evaluation: CT scan

- Evaluate for adjacent articular fx
- 8-9% have associated posterior malleolar fx
  - 25-39% with distal 1/3 spiral fxs Boulton CL, *Rockwood and Green's 2019*
  - Recommend CT scan for all distal 1/3 tibia fx
- Proximal 1/3 extension to plateau less common
- Articular fx must be part of surgical plan


Boulton CL, *Rockwood and Green's 2019*

Evaluation : Vascular

- Indicated if distal perfusion remains abnormal (asymmetrical) despite fracture realignment
  - Handheld Doppler
  - ABIs
  - CTA
  - Vascular consult
  - Angiogram



Angiogram showing arterial injury at the level of fracture

Evaluation: Compartment Syndrome

- More common with higher energy mechanism of injuries
- CLINICAL DIAGNOSIS in an awake patient
  - Pain out of proportion
  - Pallor
  - Paresthesia
  - Pulselessness (late finding)
  - Paralysis (late finding)
- Intubated/Obtunded diagnosis confirmed with compartment measures
- Compartment measures confirmatory in awake patient
- See Lecture General Part B3

Evaluation: Associated Injuries

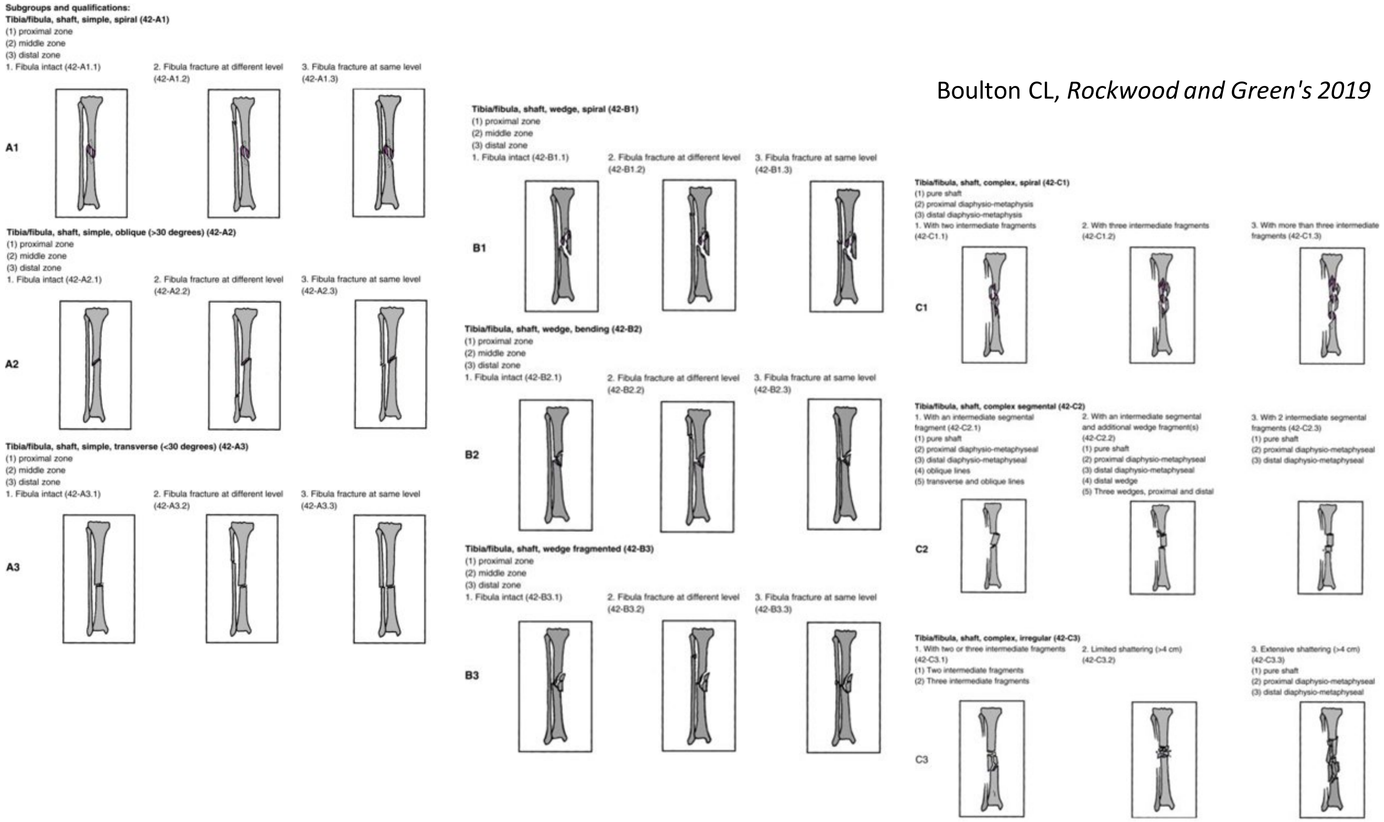
- Ankle Injuries
- Floating knee
- Ligamentous injury of the knee
- Proximal Tibiofibular Joint Dislocation

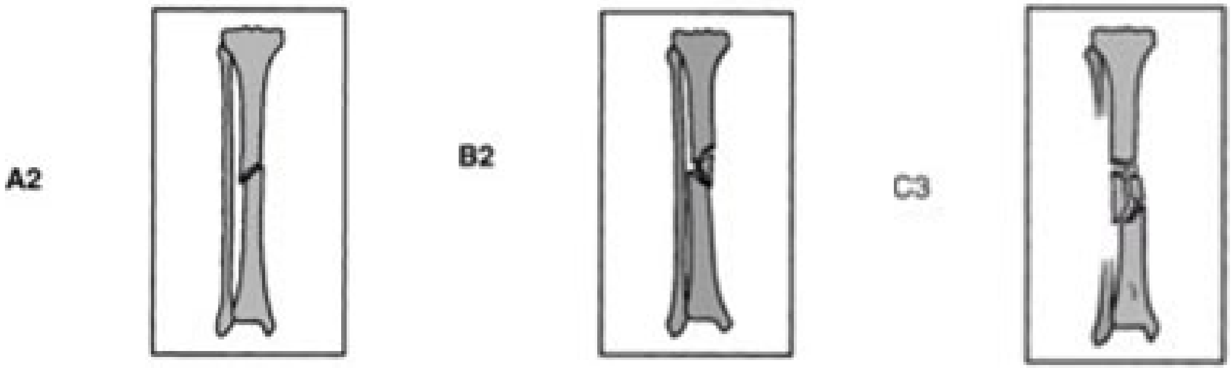
Radiograph with left tibia shaft fracture with retained ankle hardware, tibial plateau fracture, knee ligamentous injury and proximal tibiofibular disruption

Classification

- **AO/OTA Classification**
  - Based on fracture morphology
  - A, B, C clinically useful
    - A=Simple
    - B= Wedge
    - C= Complex/Comminuted,
  - Full detail primarily for research
  - No soft tissue injury assessment

Boulton CL, *Rockwood and Green's 2019*





Classification

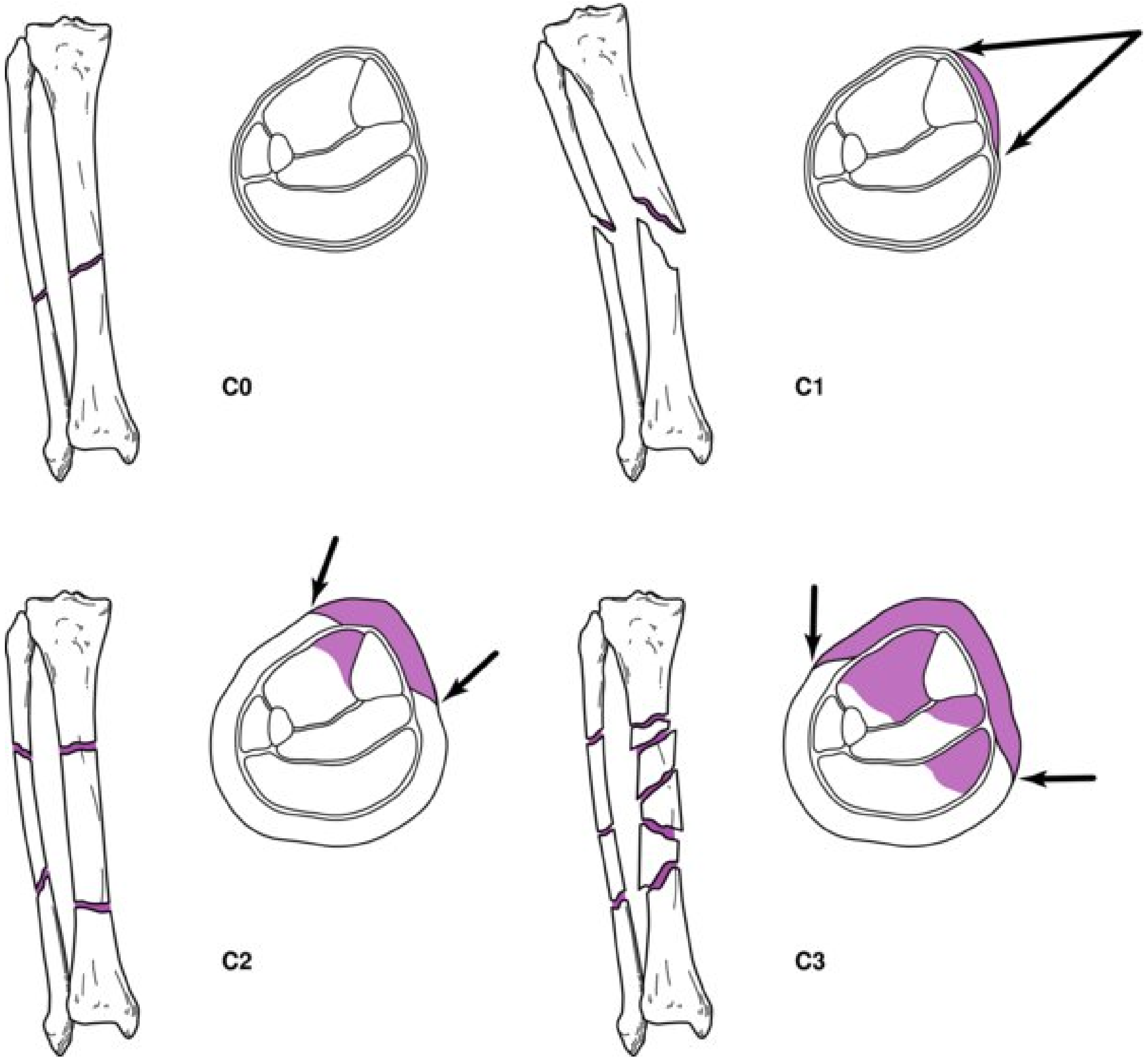
- Gustilo Classification
  - Used to grade severity of OPEN FRACTURES
  - Most commonly used
  - Type determined intra-operatively after debridement
  - Tibia shaft fxs are most common site to require flap coverage, 3B

Type	Description
• I	• Clean wound <1 cm in length • Low-energy fracture type
• II	• Wound size 1–10 cm in length without extensive soft tissue damage • Without high-energy fracture type
• IIIA	• Wound associated with more extensive soft tissue damage than type II regardless of wound length • Any wound >10 cm regardless of soft tissue stripping • High-energy fracture type (segmental) regardless of wound size • IIIA must have a skin defect that can be treated with closure or skin grafting
• IIIB	• Wound requires muscle or skin flap for coverage
• IIIC	• Vascular repair required to revascularize leg • Isolated vascular injury with a well-perfused foot (e.g., peroneal artery with other two arteries still patent) does not classify as IIIC even if the vessel is repaired

Boulton CL, *Rockwood and Green's 2019*

Classification

- **Tscherne Classification**
- Grades soft tissue injury in CLOSED FRACTURES
- ***C0,* little or no soft tissue injury, simple fx**
- ***C1,* superficial abrasions, mild to moderately severe fx**
- ***C2,* deep contamination with local skin or muscle contusion, moderately severe fx**
- ***C3,* extensive contusion or crushing of skin or destruction of muscle, severe fx**



Boulton CL, *Rockwood and Green's 2019*

Treatment Options:

- Non-operative
- IMN
- Plate fixation
- External fixation
- Special Techniques

  - Locked intramedullary nailing is the mainstay of treatment of tibial shaft fractures in adults Schmidt AH, *Instructional Course Lecture*. 2003.
  - Specific injury characteristics including severity and associated injuries may necessitate alternative treatment options




Treatment: Non-operative

- Relative indications for non-operative treatment
  - Adequate alignment and length in a splint or cast
  - Soft tissue can tolerate cast
  - Significant anesthetic risk
  - Patient refuses operative treatment

Alignment Parameter	Acceptable Malalignment
Varus	<5 degrees
Valgus	<5 degrees
Apex anterior/posterior	<5–10 degrees
Rotation	<0–10 degrees
Shortening	<10–12 mm

Boulton CL, *Rockwood and Green's 2019*

Treatment: Non-operative

- Traditional alignment parameters somewhat arbitrary and unreliable
- These malangulations rarely exist in isolation
  - Important to evaluate total deformity
- Shortening of this amount often no longer accepted

Alignment Parameter	Acceptable Malalignment
Varus	<5 degrees
Valgus	<5 degrees
Apex anterior/posterior	<5–10 degrees
Rotation	<0–10 degrees
Shortening	<10–12 mm

Boulton CL, *Rockwood and Green's 2019*

Treatment: Non-operative Protocol

Boulton CL, *Rockwood and Green's 2019*

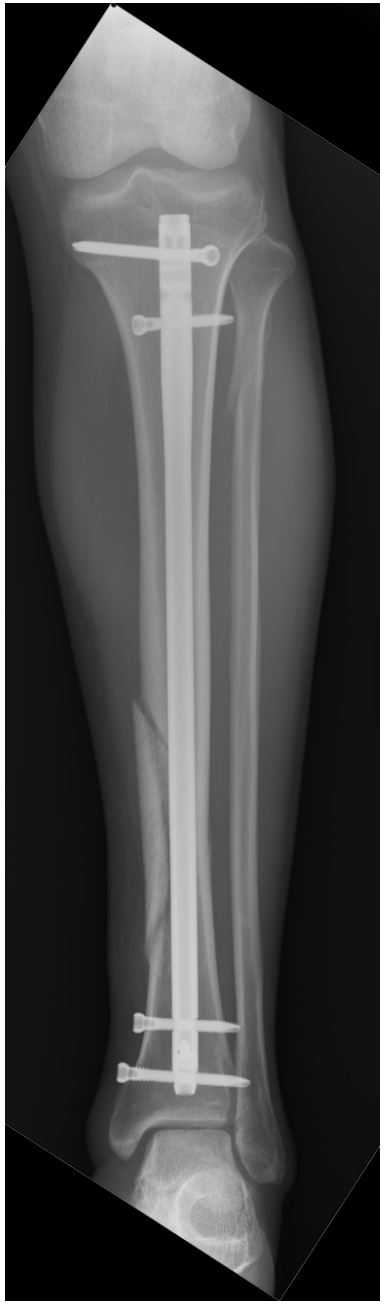
- Closed reduction with a well molded long leg splint or cast
  - Conscious sedation often required for best reduction
  - Be cautious of risk of compartment syndrome with circumferential cast at initial presentation
- Close follow-up for maintenance of alignment
  - Wedging of cast to adjust alignment if needed
  - Conversion to open treatment if unsuccessful
- Transition to patella bearing cast or brace at 2-4 weeks

Treatment: Non-operative

- Sarmiento reported retrospectively on 1000 closed tibial shaft fxs
  Sarmiento A, *Clin Orthop Relat Res*. 1995
  - Nonunion rate of 1.1%
  - 94% healing with ≤ 12 mm of shortening
  - 90% ≤ 6 degrees of angulation
  - Final shortening (4.3 mm) correlated strongly with initial shortening (2.5 mm)
- Sarmiento's results have been referenced for years, but have not been replicated
- More recent RCTs favor operative treatment with lower rates of nonunion, malunion, complications and return to work Coles CP, *Can J Surg*. 2000.

Treatment: Intramedullary nailing

- Surgical treatment indications:
  - Severe initial displacement
  - Failure to obtain adequate closed reduction
  - Open fracture
  - Vascular injury
  - Soft tissue envelope that precludes cast application
  - Patient unable to comply with closed treatment
  - Patient requires early return to activity



Treatment: Intramedullary nailing

- Operative treatment indicated for most tibia shaft fxs in adults
- 96% of surgeons prefer IMN for closed + type 1 open tibia shaft fxs (international survey) Bhandari M, *J Bone Joint Surg Am*. 2001
- IMN minimizes soft tissue stripping, allows immediate weight bearing compared to ORIF, but can be associated with knee pain

Treatment: Intramedullary Nailing

- 2 approaches:
  - Infrapatellar (A)
  - Suprapatellar (B)

A

B

Boulton CL, *Rockwood and Green's 2019*

Boulton CL, *Rockwood and Green's 2019*

Treatment: Intramedullary Nailing

- Infrapatellar approach
  - Traditional approach
  - Knee in hyperflexion to access start point
  - Knee hyperflexion can increase deforming forces in proximal third tibia fractures
  - XR can be difficult

Treatment: Intramedullary Nailing

- Suprapatellar approach
  - Semi-extended position
  - Start point accessed through knee
  - Reduces deforming forces, especially in proximal 1/3 tibia fxs
  - Need special instrumentation to protect knee

Boulton CL, *Rockwood and Green's 2019*

Treatment: Intramedullary Nailing

J Orthop Trauma. 2020 Jul 8. doi: 10.1097/BOT.0000000000001897. Online ahead of print.

Comparison of Infrapatellar and Suprapatellar Approaches for Intramedullary Nail Fixation of Tibia Fractures

Kathryn B Metcalf [1], Jerry Y Du [1], Isaac O Lapite [1], Robert J Wetzel [1], John K Sontich [1], Elizabeth R Dachenhaus [1], Jessica L Janes [1], George Ochenjele [1]

Affiliations + expand

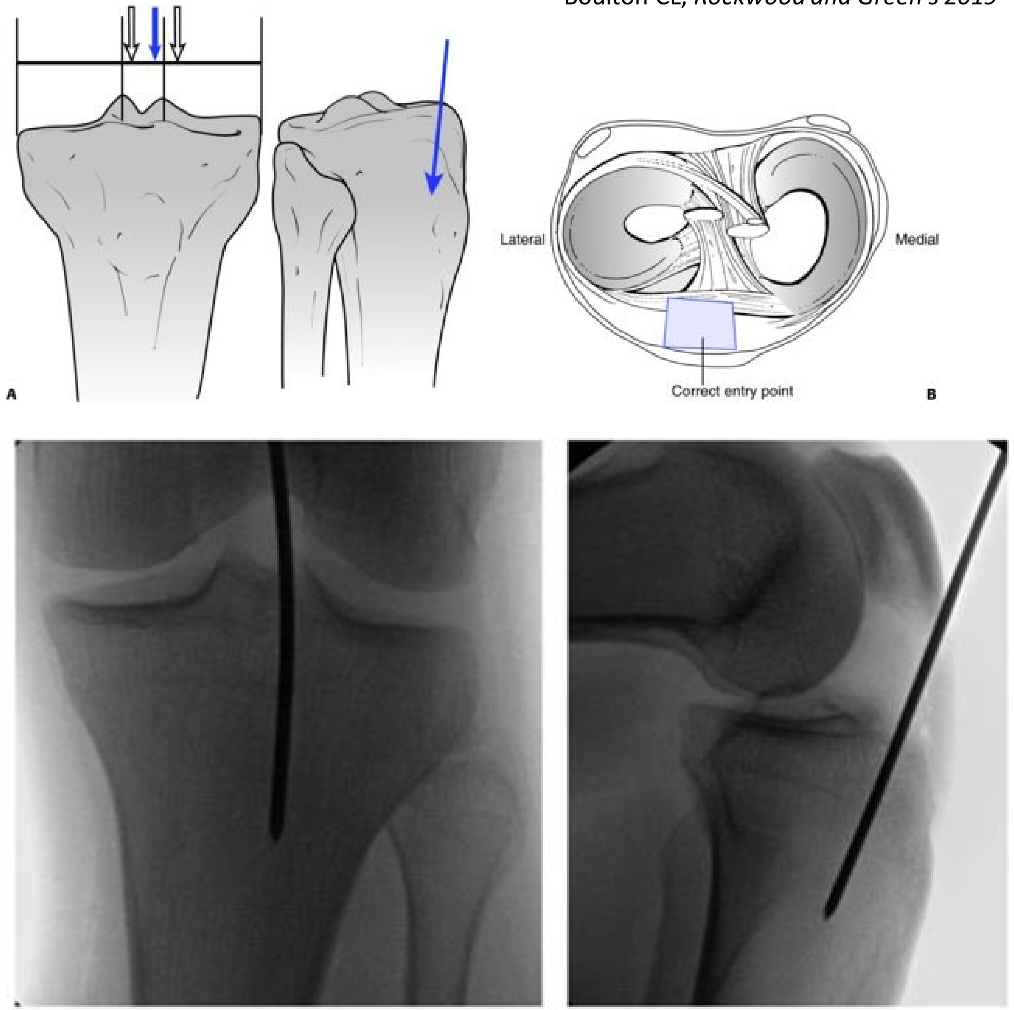
PMID: 32658019 DOI: 10.1097/BOT.0000000000001897

- Retrospective study comparing outcomes between infrapatellar and suprapatellar tibial IMN
- Suprapatellar nailing had decreased risk of malunion and decreased risk of post-operative knee pain
- No difference in rate of nonunion or PROMIS physical function or pain interference
- Consistent with other studies

Treatment: Intramedullary Nailing

Boulton CL, *Rockwood and Green's 2019*

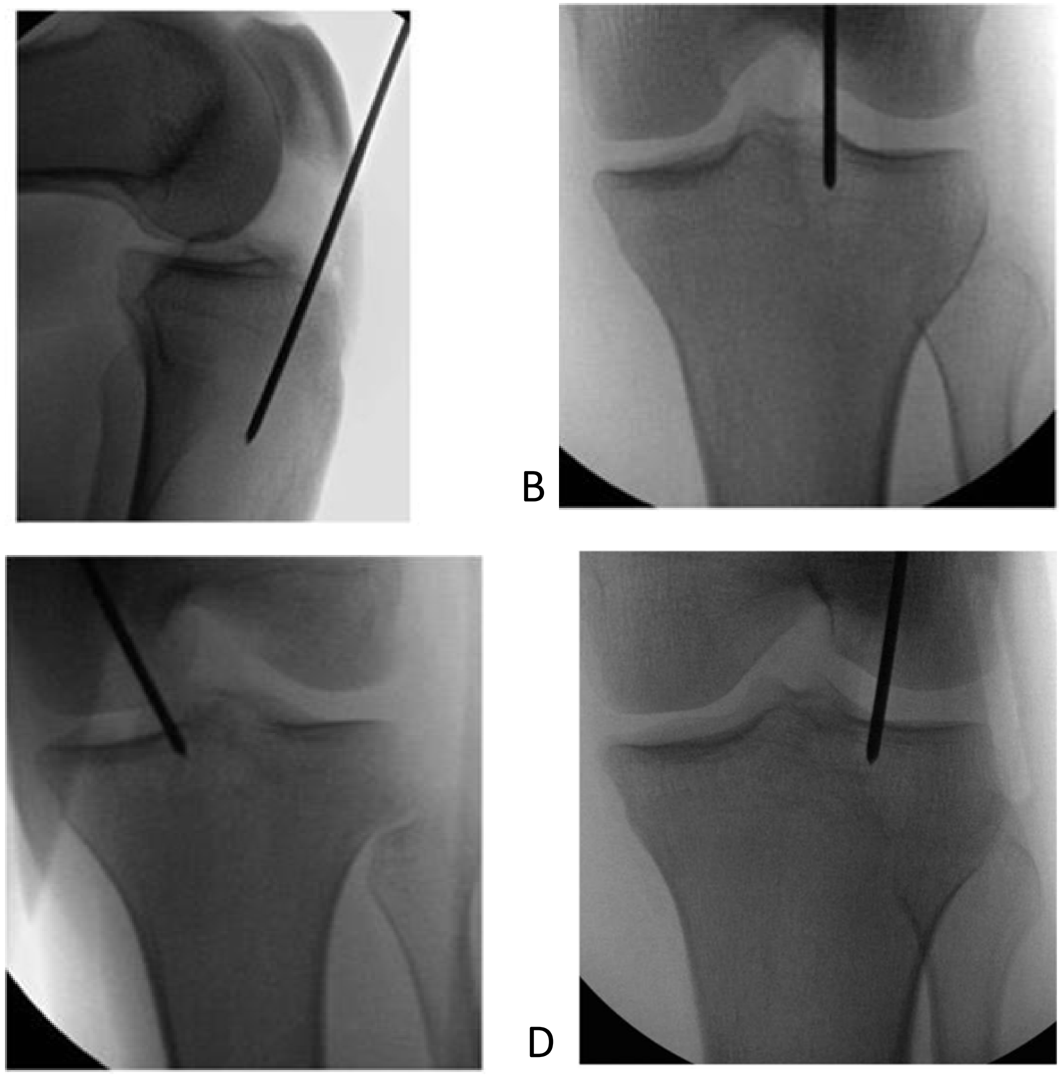
- Start point vitally important for alignment
- Ideal guide wire placement for average tibia:
  - Just medial to the lateral tibial spine on true AP knee XR
  - Just anterior to the articular surface and parallel the anterior tibia cortex on lateral knee XR



Treatment: Intramedullary Nailing

Boulton CL, *Rockwood and Green's 2019*

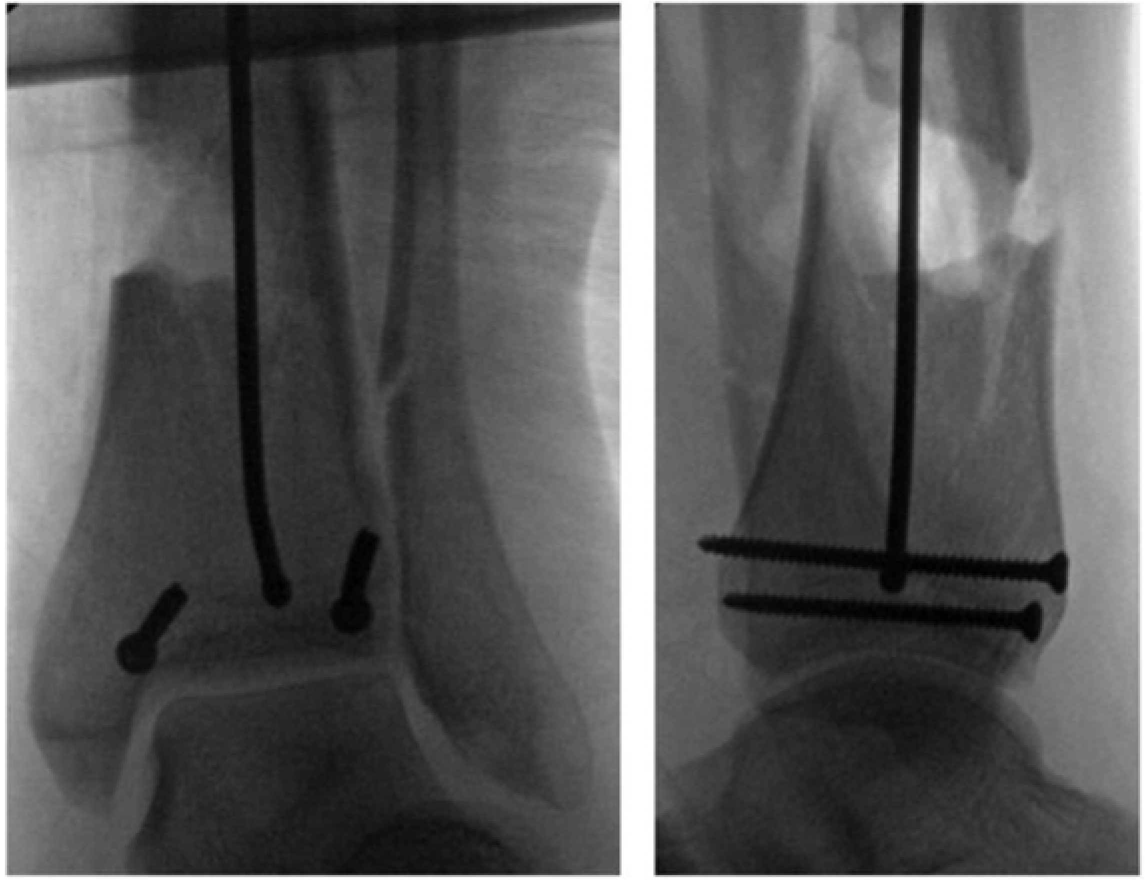
- Assuring true AP and lateral XRs with appropriate rotation is crucial to obtaining the start point
- True lateral has overlapping condyles (A)
- True AP knee XR is orthogonal to true lateral
  - Usually lateral tibial plateau edge bisects the fibula shaft (B)
- The fluoroscopic images show the same guide wire in the same position with changes in C- arm rotation (C and D)



A B C D

Treatment: Intramedullary Nailing

- After guide wire optimally positioned, it is over-reamed by entry reamer
- A ball tip guide wire placed into this pathway
- The ball tip wire is advanced across the fx to the physeal scar in the distal tibia



Boulton CL, *Rockwood and Green's 2019*

Treatment: Intramedullary Nailing

- End point for nail also key to optimal alignment Triantafillou K. J Orthop Trauma. 2017
    - Especially important for distal metaphyseal fxs
- End point should be at the center of the talus
    - This is very lateral within the distal tibial metaphysis
- The wire should be centered on the lateral view

Treatment: Intramedullary Nailing

- Reduction MUST be performed PRIOR to reaming and fixation
- The nail does not reduce fx, unless the canal is properly reamed
- Reduction techniques
  - Manual traction and reduction
  - Push-past technique
  - External fixation assistance
  - Clamps
  - Shantz pins
  - Plate assisted nailing

Treatment: Intramedullary Nailing

- Traction, bumps and manual reduction

Treatment: Intramedullary Nailing

- "Push Past" technique Gary JL. Orthopedics. 2014
- Reaming is performed up to and past the fx site, but not at the fx
- The reamer is "pushed" through the fx
- Preserves cortical edges at fx site that help optimize reduction when nail passed

Treatment: Intramedullary Nailing

- External fixator can hold length and reduction for reaming and nailing Nicolescu R. J Orthop Trauma. 2019
- Wires or pins must be outside nail path
- Especially helpful for metaphyseal fxs or with limited assistance

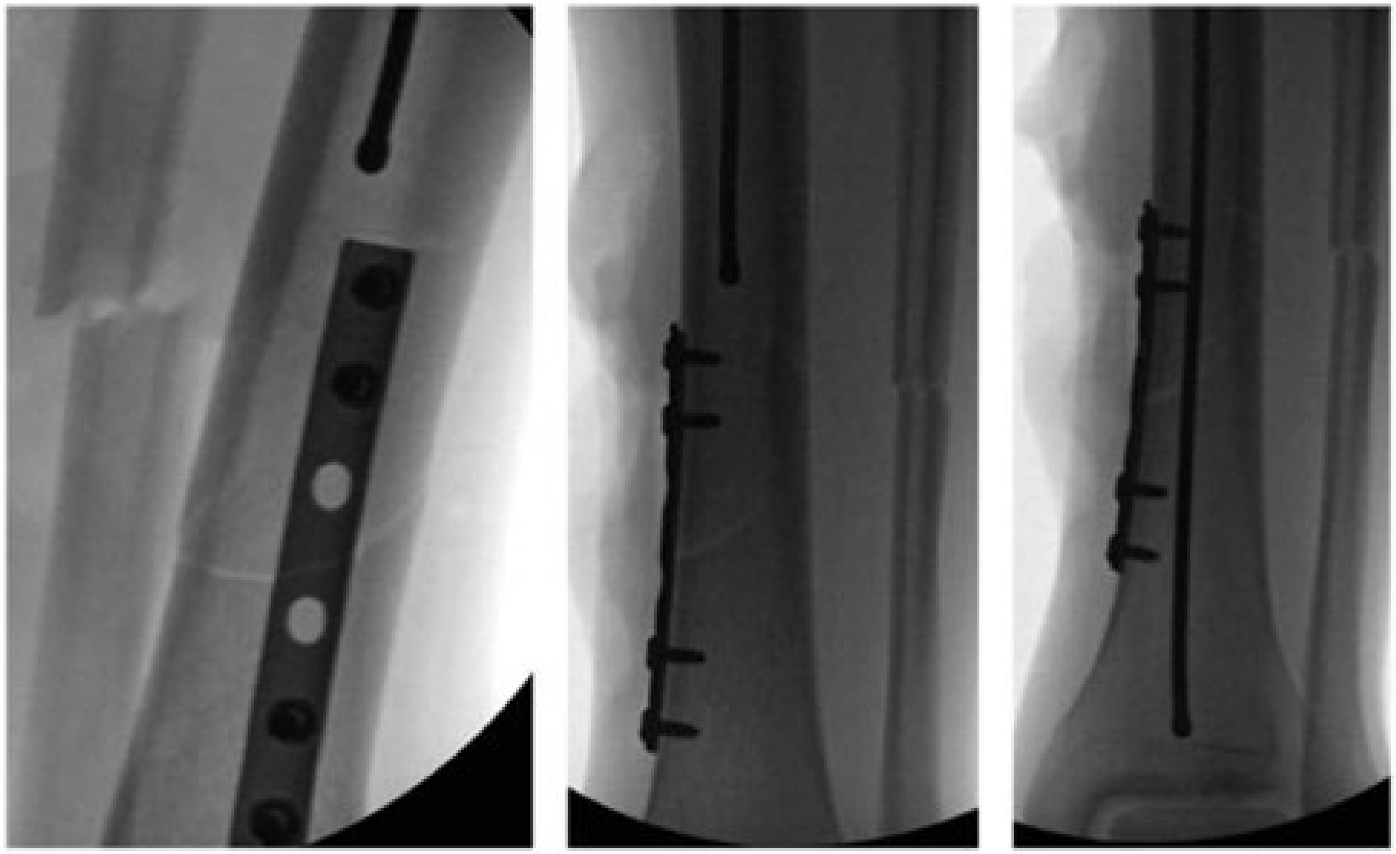
Treatment: Intramedullary Nailing

- Clamps
  - Placed percutaneously in closed fx
  - Placed through wound in open fx

Boulton CL, *Rockwood and Green's 2019*

Treatment: Intramedullary Nailing

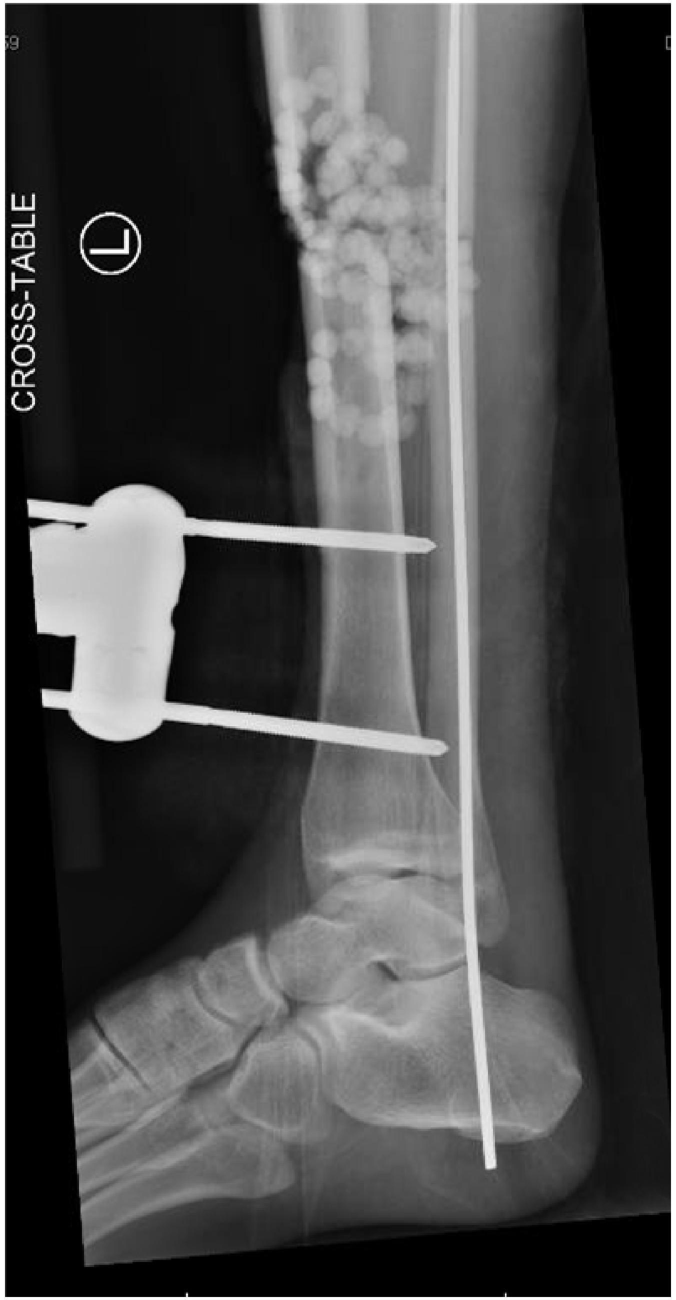
- Unicortical plate fixation
- Can be placed through open wound
- Sometimes helpful for segmental fractures
- Soft tissue stripping and loss of periosteal blood supply at fx site, so not optimal for routine use
- Plates can be left in place to provide additional mechanical stability of fixation



Boulton CL, *Rockwood and Green's 2019*

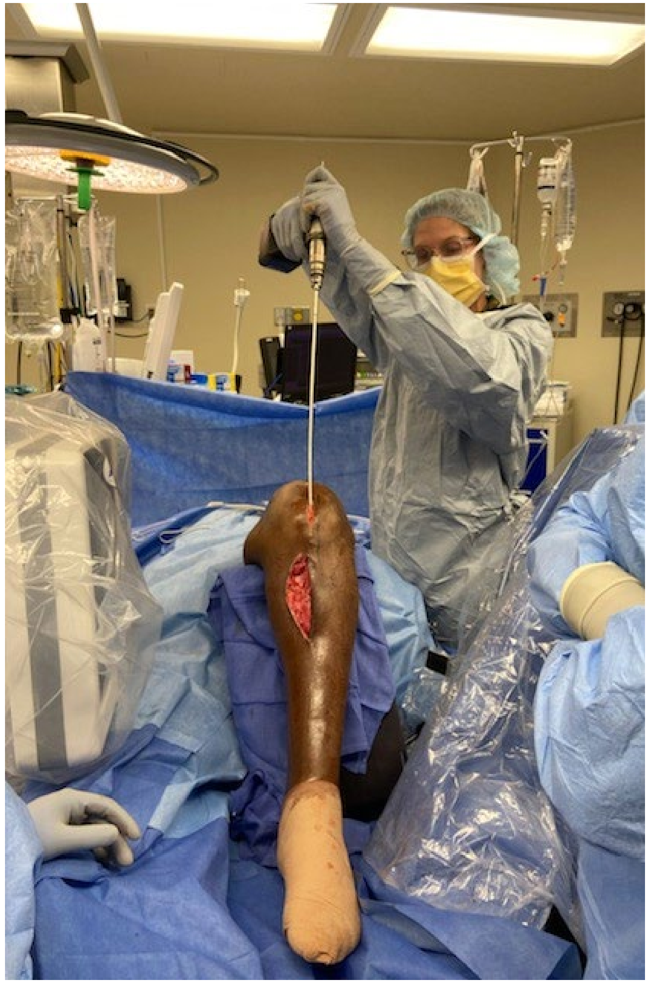
Treatment: Intramedullary Nailing

- Fibula fixation (ORIF versus intramedullary fixation)
- Helps establish length
- Some studies indicate intact or fixed fibula may cause higher rates of tibia delayed or nonunion Vallier HA. J Orthop Trauma. 2016



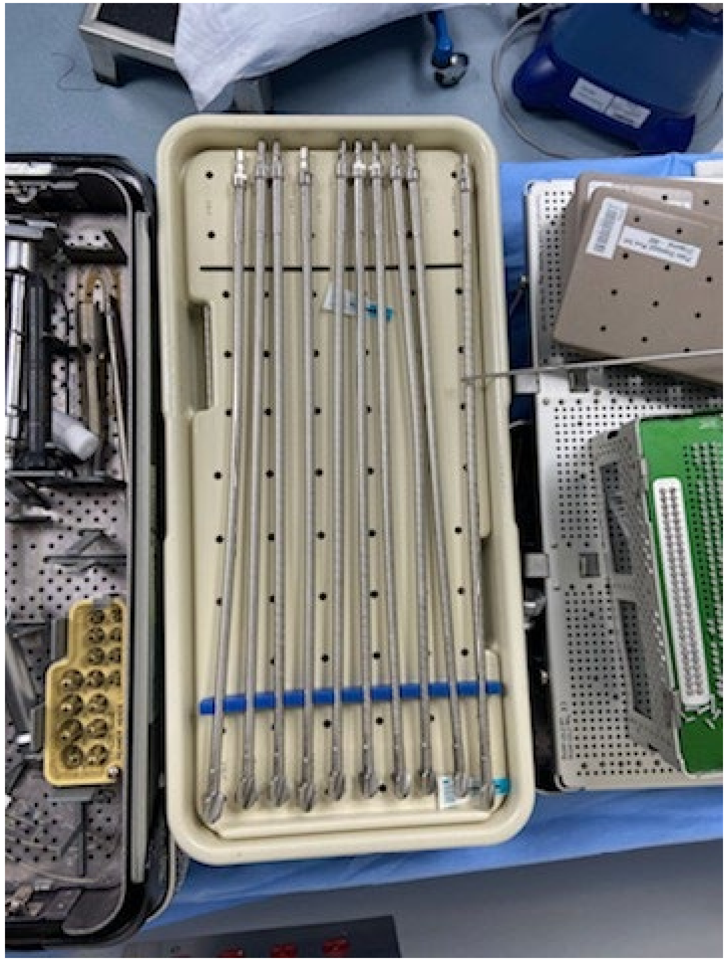
Treatment: Intramedullary Nailing

- Reaming creates an IMN path and allows for a larger diameter nail
- Reaming is performed over a guide wire
- It is critical to maintain fracture reduction during reaming
- Once chatter is noted, sequentially ream to 1-1.5 mm over desired nail diameter



Treatment: Intramedullary Nailing

- Reaming Debate:
  - Reamed nailing can be destructive to the endosteal blood supply, but the blood supply rebounds within 2 weeks
  - Unreamed nailing preserves the endosteal blood supply, but must use smaller nail
  - ….this has more or less been settled…



Treatment: Intramedullary Nailing

Randomized Trial of Reamed and Unreamed Intramedullary Nailing of Tibial Shaft Fractures

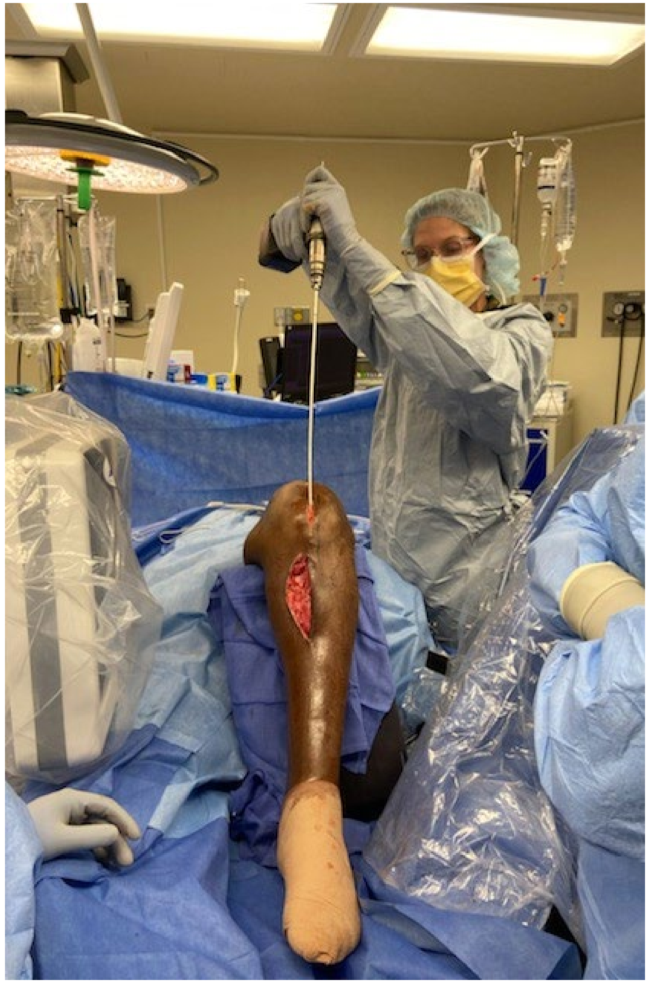
By the Study to Prospectively Evaluate Reamed Intramedullary Nails in Patients with Tibial Fractures (SPRINT) Investigators*

Investigation performed at McMaster University, Hamilton, Ontario, Canada

- Prospective randomized trial comparing reamed versus unreamed in tibia intramedullary nailing SPRINT. Bhandari M. J Bone Joint Surg Am. 2008
- Possible benefit with reaming in closed tibia shaft fractures
  - Highest failure rates noted in small unreamed nails (<9mm with smaller locking screws)
- No difference between reamed and unreamed nails in open fracture

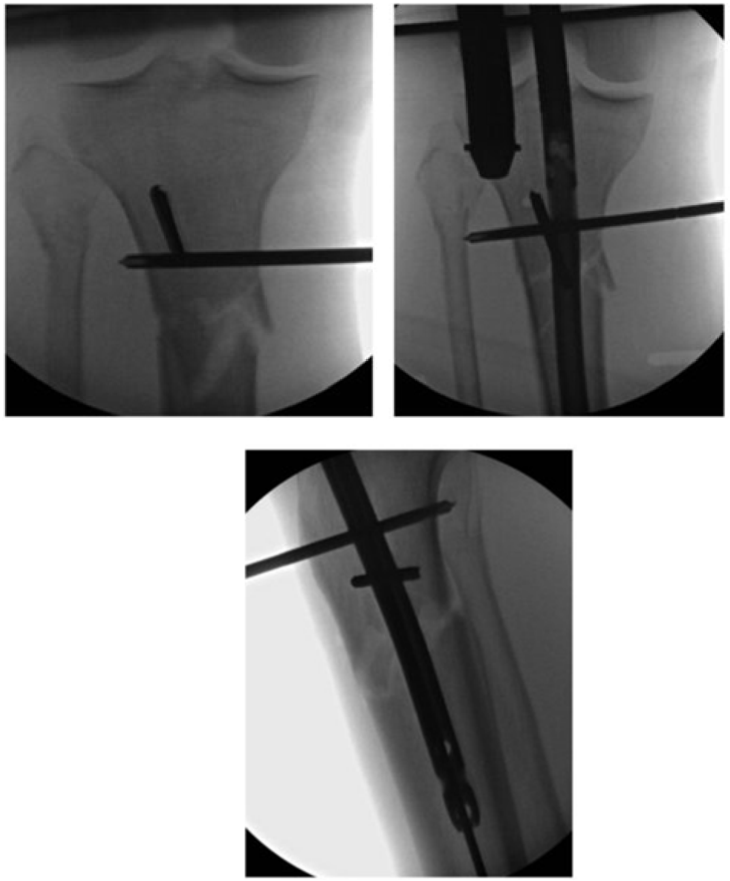
Treatment: Intramedullary Nailing

- Key points:
  - Both reamed and unreamed acceptable
  - Avoid small unreamed nails (ideally not smaller than 9mm)
  - Most common nail diameter = 10 mm
  - Once adequate size nail possible, further aggressive reaming is discouraged
  - DO NOT REAM WITH TOURNIQUET ELEVATED



Treatment: Intramedullary Nailing

- Proximal + distal metaphyseal fxs prone to angular malalignment
  - Proximal fxs tend to deform into valgus and apex anterior
  - Distal fxs tend to valgus
- Blocking (Poller) screws can prevent or correct angular deformity
- Blocking screws are placed on the concave side of the deformity
  - Aka, screws are placed where you don’t want the nail to go



Boulton CL, *Rockwood and Green's 2019*

Treatment: ORIF

- ORIF NOT generally preferred for tibia shaft fxs, but is an option in certain circumstances:
  - Proximal and distal metaphyseal fxs
  - Articular extension proximal or distal
  - Previous implants (total knee arthroplasty) or deformity that preclude IMN

Boulton CL, *Rockwood and Green's 2019*

Treatment: ORIF

- Fracture pattern often dictates fixation mode
  - Simple fx = direct reduction + absolute stability (A)
  - Comminuted fx = bridge plating + relative stability with secondary bone healing (B)

A 

B 

Boulton CL, *Rockwood and Green's 2019*

Treatment: ORIF

- Minimally invasive plate osteosynthesis (MIPO), modern anatomic implants, and fluoroscopy for distal tibial shaft fxs can have <9% deep infection and wound dehiscence Vallier HA. J Orthop Trauma. 2016
- Small incisions do not necessarily confer minimally invasive osteosynthesis
  - Avoid significant periosteal stripping and creating unnecessary surgical planes
  - Careful handling of soft tissues and using as much sharp dissection as possible

Treatment: ORIF

- Tibia has relatively poor soft tissue coverage and vascularity
- Trauma + surgical dissection can devascularize bone with very high risk of catastrophic infection
- If plating is to be performed for a shaft fx, it must be MIPO
- The surgical insult seen here MUST BE AVOIDED under all circumstances!

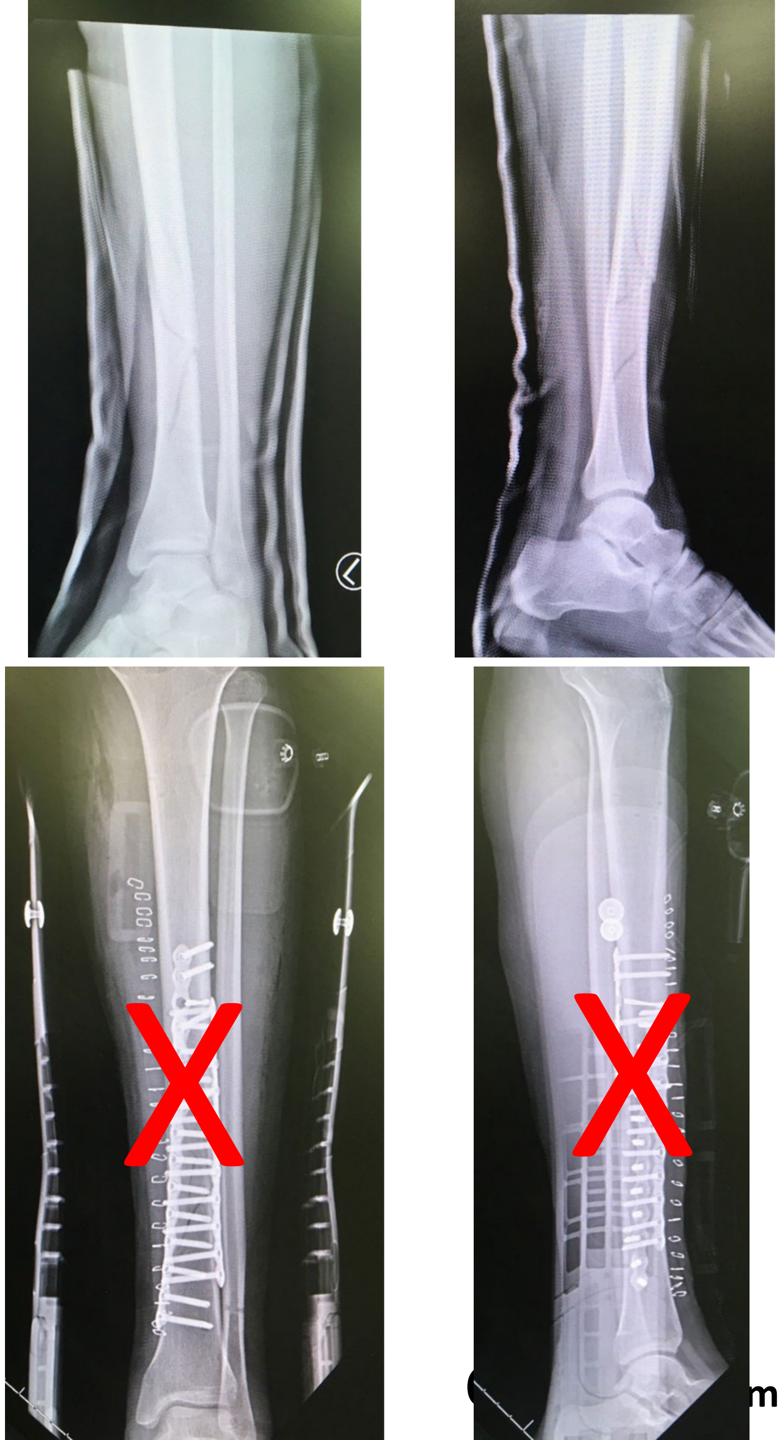
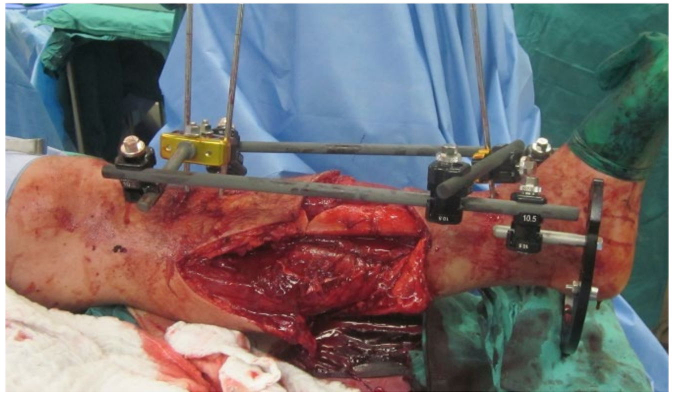


Plate vs. Nail

- Existing literature indicates less angular malalignment with ORIF when compared to infrapatellar nailing, especially in metaphyseal fxs Coles CP. *Can J Surg*. 2000.
- Newer studies show improved alignment in metaphyseal fx nailing with suprapatellar approach + external fixation assistance and/or blocking screws Nork SE. *J Orthop Trauma*. 2006.
  - Alignment may not be different between plates and nails with modern nailing methods
- Nails allow earlier return to WBAT and in some studies improved functional outcomes

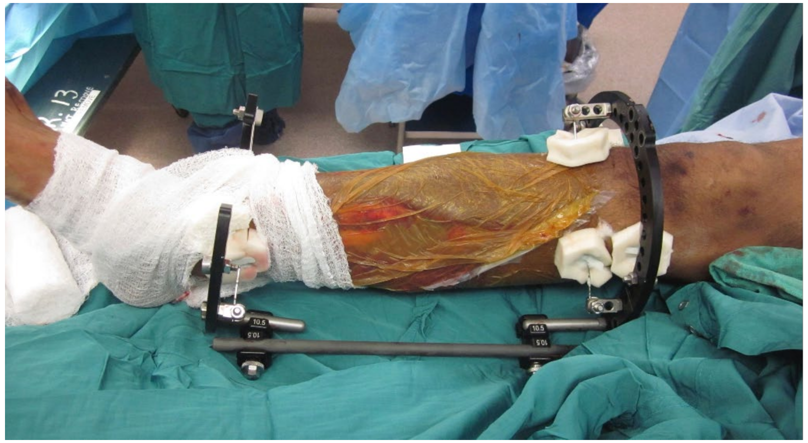
Treatment: External fixation

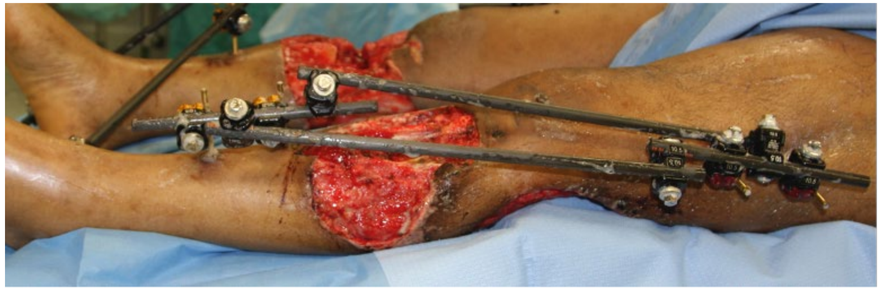
- Provisional stabilization or definitive treatment
- Provisional stabilization used for soft tissue injury or for polytrauma damage control
  - Allows soft tissue rest, decrease in swelling, wound care of soft tissue injury
  - Gives time for planning definitive fixation + soft tissue coverage if needed
- Uniplanar or delta frame external fixators are commonly used for temporary stabilization
- Hybrid fixator excellent alternative for severe soft tissue injury



Treatment: External fixation

- Ex-fix can be coupled with soft tissue treatments
  - Negative pressure wound therapy (NPWT)/Wound vac
    - NPWT can lower the need for free flap in open tibia fxs with soft tissue loss Dedmond BT, J Orthop Trauma. 2007
    - NPWT does not lower infection rate for Type IIIB open fxs Bhattacharyya T. Plast Reconstr Surg. 2008
  - Antibiotic beads/Spacer
    - Placement of antibiotic cement within the wound can provide local antibiosis and optimize soft tissues for staged bone graft or transport
  - Return to OR for serial debridements
    - Required with severe open fractures to address tissue viability and contamination control





Treatment: External fixation

- Definitive ex-fix indications:
  - severe soft tissue injury
  - bone loss
  - high infection risk
- Pin-to-bar constructs less stable than ring fixators and are prone to malunion/nonunion
  - Uniplanar ex-fix malunion rates 39-48% Court-Brown CM, *J Orthop Trauma*. 1998
- Ring fixators Ilizarov or hexapod are best for definitive management (96% union open fxs)
- Hexapod fixators allow for post-op adjustment or alignment and length if needed

Ilizarov

Taylor Spatial Frame with adjustable struts

Treatment: External fixation

- Theoretical increased risk of infection with primary external fixation and conversion to definitive internal fixation, but exact rates in relation to time in external fixator is unknown
- Many surgeons aim for conversion to definitive fixation before 2 weeks

Treatment: Amputation

- Although current trends are toward limb salvage, amputation remains a viable option
- Amputation performed when limb salvage
  - Poses significant risk to patient survival
  - Irreparable vascular injury
  - Warm ischemic time > 6 hours
  - Functional result will be better with a prosthesis (relative indication)
  - Patient prefers amputation to course of treatment for salvage (relative indication)
- Numerous scoring systems available, but all have limited clinical validity and no correlation with long-term outcome

Open and high energy tibia fractures

- Initial Care
  - Early antibiotics
  - Thorough debridement of foreign material and devitalized tissues
- Low –grade open tibia fxs in stable patient
  - One stage debridement + IMN preferred
  - 3% infection, 89% union without further surgery
    Kakar S, *J Orthop Trauma*. 2007
- High-grade open tibia fxs
  - Temporary ex-fix with staged debridement before definitive care
- Types III A,B, & C
  - Best definitive care remains controversial
  - High complication rates with all treatments

Open and high energy tibia fractures

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

A

B

C

Segina DN, OTA Core Curriculum, 2010.

Open and high energy tibia fractures

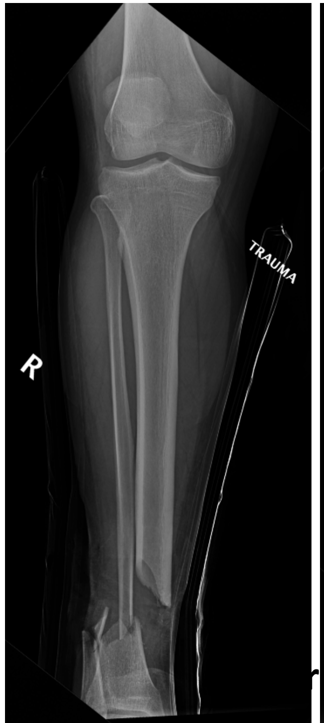
- Soft tissue coverage should be achieved as soon as feasible.
  - Ideally within 5-7 days.
  - Longer time to coverage =⬆ infection
- Concomitant definitive soft tissue coverage + fixation decreases infection vs staged fixation and coverage Mathews JA, Injury. 2015
  - 4.2% infection when definitive fixation + coverage in single procedure
  - 34.6% infection when definitive fixation and coverage in separate procedures

Bone Loss

- Significant bone loss in ~ 10 % of open fxs
  - ~2/3 occurring in the tibia Southam BR, J Orthop Trauma. 2017
- Can occur at time of injury or as a result of debridement
- Various treatment options for bone loss
  - Acute shortening
  - Bone grafting (autograft/allograft)/Induced membrane bone grafting
  - Bone transport (distraction osteogenesis)
  - Vascularized fibula graft
  - Osteocutaneous flap

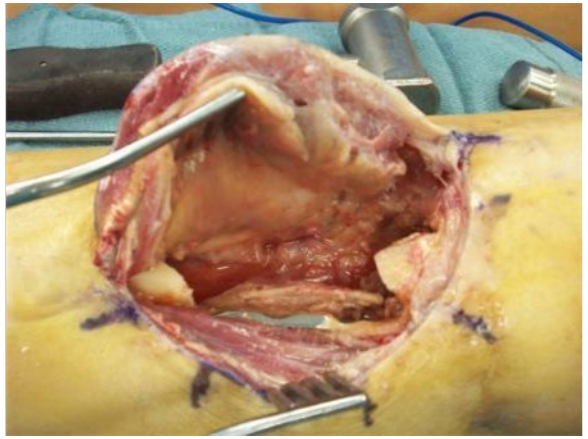
Bone Loss

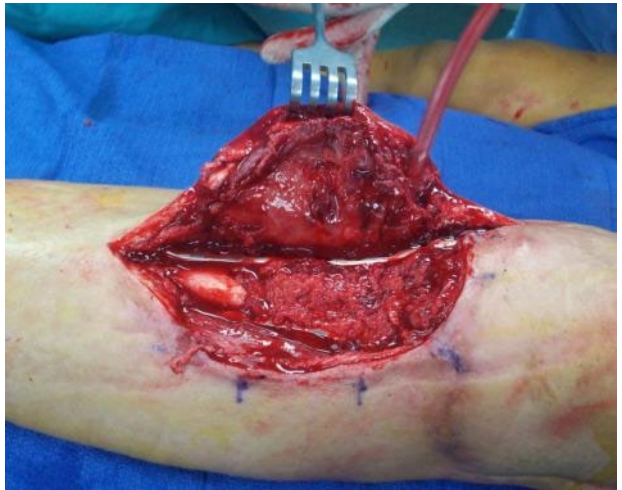
- Treatment strategy may affect debridement
- Bone grafting methods (such as Masquelet)
  - Bone spikes are left to maximize bone volume preserved
- Bone transport (Distraction osteogenesis)
  - Potentially devitalized bone spikes removed
  - Optimizes bone contact and mechanics at docking
- Trade off – greater bone loss vs. more thorough debridement
- Difference in ease of creating/incorporating new bone between methods major reason for different strategies



Treatment: Bone Loss

- Induced membrane bone grafting (Masquelet) Masquelet AC, Ann Chir Plast Esthet. 2000
  - PMMA spacer to prepare grafting site
  - Creates pro-osteogenic membrane
  - Provides space for bone graft
- Simplest treatment requiring least follow-up and compliance
- Higher risk of infection and failure in tibia than other locations due to poor soft tissue envelope

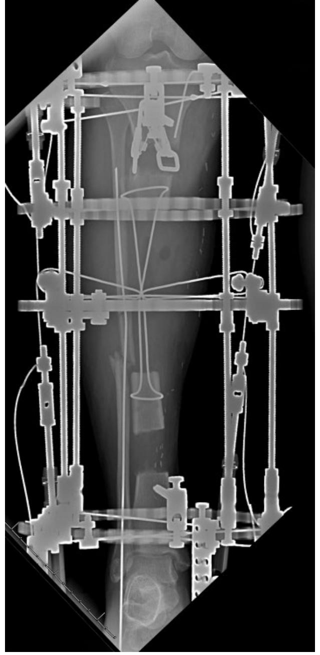




Segina DN, OTA Core Curriculum 2010.

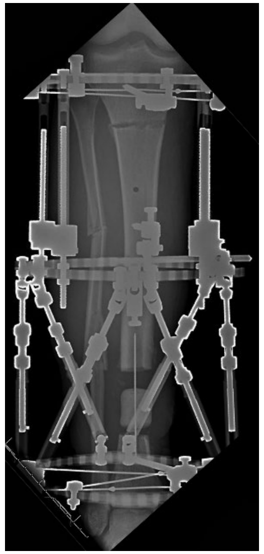
Treatment: Bone Loss

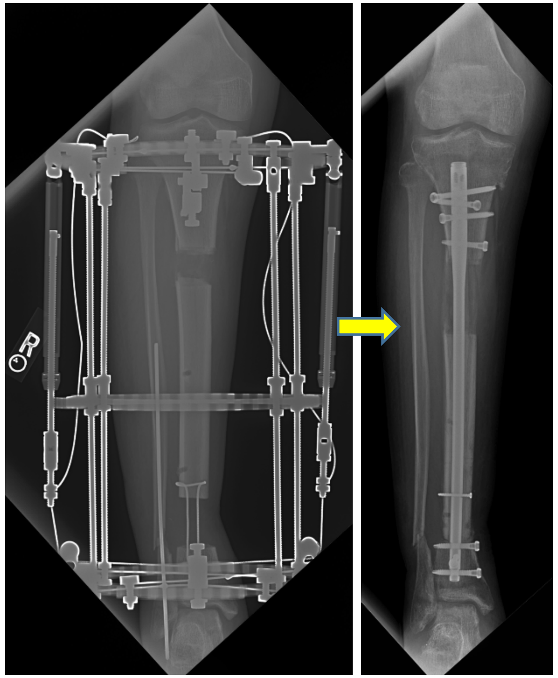
- Bone Transport
  - Uses distraction osteogenesis to gradually pull apart osteotomy and bring bone segment across defect
  - Reliably creates high quality new bone that recapitulates normal bone anatomy and biology
  - Gradual process requires patient compliance and takes time



Treatment: Bone Loss

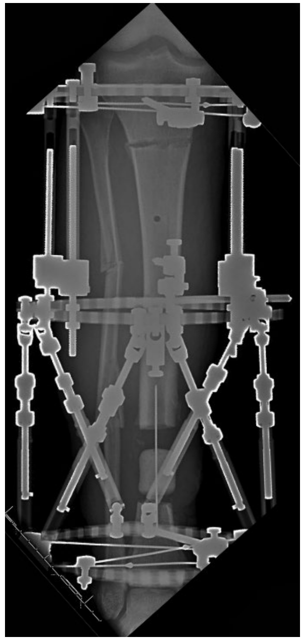
- Bone Transport Techniques:
    - External fixation
        - Ilizarov
        - Bifocal frame
        - Monolateral frame
        - Cable transport
    - Integrated
        - Cable transport and then nailing
        - Transport over nail
    - All internal
        - Bone transport nail

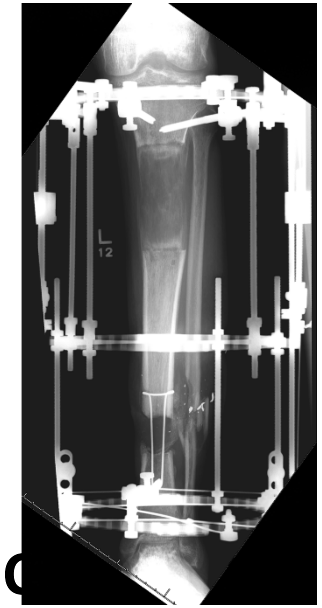




Treatment: Bone Loss

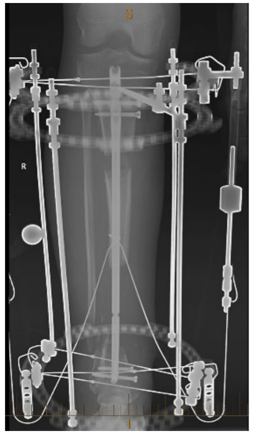
- Bone Transport with Ex-Fix:
  - Ilizarov motors transport segment with ring moving down threaded rods and is the original method for bone transport
  - Bifocal allows additional lengthening after transport
  - Hexapod allows adjustment of alignment and docking site
  - Monolateral rail minimizes footprint of ex-fix (helpful for femur) but mechanically inferior
  - Internal cables decrease pain, scarring, and pin problems during transport and facilitate safe conversion to IM fixation

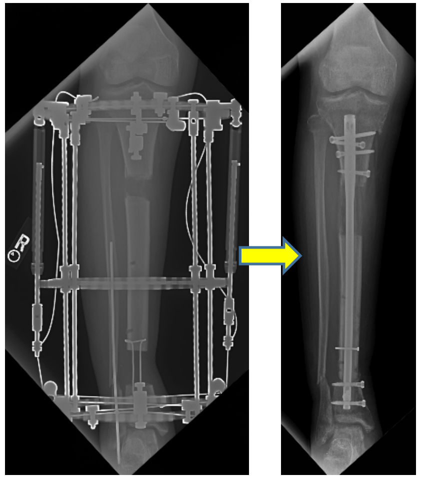


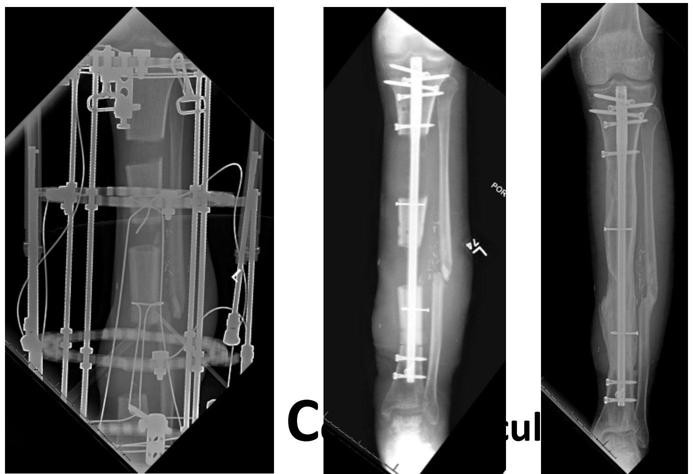


Treatment: Bone Loss

- Bone Transport with Integrated Methods:
  - Integrated methods greatly decrease ex-fix time and some decrease healing time
    - Transport over a nail
      - Nail helps guide transport
      - Risk of infection from pins near nail
        - May be less when done with cable
    - Balanced Cable Transport and Then Nailing Quinnan SM. J Orthop Trauma. 2017
      - Fastest consolidation and docking site healing time of any transport method
      - Facilitates multifocal transport

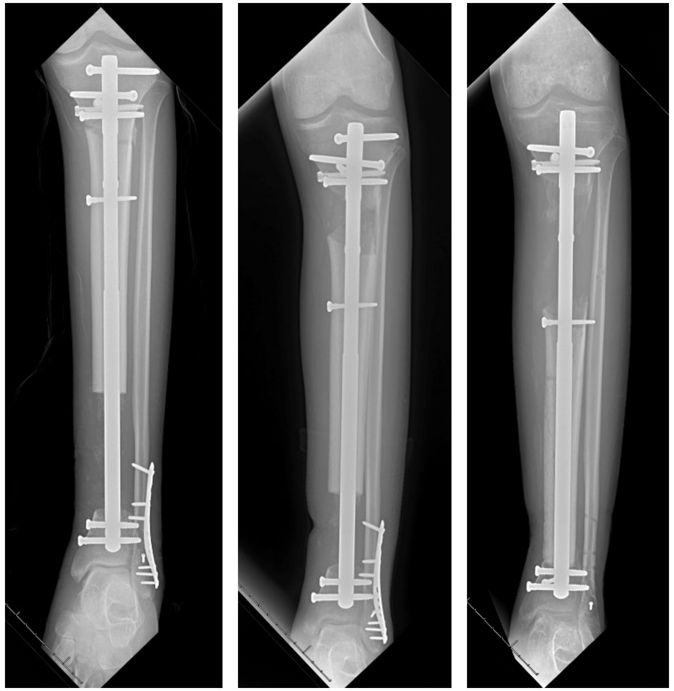






Treatment: Bone Loss

- Bone Transport with All Internal Methods:
  - Bone Transport Nail
    - Optimal control of alignment
    - Similar healing time to Ilizarov
    - 11.5 or greater size nails can WBAT
  - PABST (Plate assisted bone segment transport) Olesen UK. J Am Acad Orthop Surg Glob Res Rev. 2019.
    - First all-internal method
    - Large amount of hardware under poor soft tissue coverage in tibia problematic for infection
    - Alignment control and docking management can be difficult
  - Early results of BTN for open fxs are promising, but no long-term follow-up available



Outcomes

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TRAUMA

Outcome at 12 to 22 years of 1502 tibial shaft fractures

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- Largest long-term(12- 22 years) follow up 568 patients with tibia shaft fracture
- 90.7% union rate
- 46% were pain free
- 75 % returned to pre-injury work level
- 9% returned to less physically demanding job
- 20.1% were unable to return to work due to disability
- Mechanism of injury correlated with outcome, higher mechanism of injury resulted in worse long-term function

Complications

- Deep Infection
- Non-union
- Malunion
- Anterior Knee Pain/ Symptomatic hardware

Complications: Deep Infection

- Infectious complications closely linked to severity of soft tissue injury
  - Closed + Type 1 open tibia shaft fractures ~1.8%
  - Type III open fracture 14.3 - 60% O'Toole RV, JOT 2017
- Staphylococcus aureus is most common organism ~64% of deep infections Zych GA, *Clin Orthop Relat Res*. 1995
- Treatment can be complex and depends upon
  - Stage of bone and soft tissue healing
  - Acute or chronic infection

Complications: Non-union

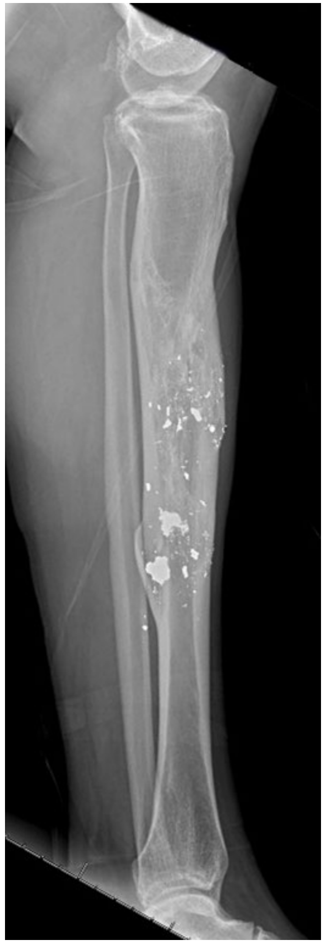
- Defining delayed union and/or non-union can be difficult
- Mean time to tibia shaft union is 15.7 to 35.8 weeks
  Boulton CL, *Rockwood and Green's Fractures* 2020.
  - Longer than the 3 months for most other fxs
- Non-union of tibia shaft fx typically defined
  - lack of complete healing
  - pain with weight bearing
  - absence of visible callus or failure of consolidation after 6 months
- However, this definition should not delay treatment if healing is clearly failing to progress before 6 months

Complications: Non-union

- Nonunion rates for fxs treated operatively Boulton CL, *Rockwood and Green's Fractures* 2020
  - Closed tibia shaft fxs 1- 8%
  - Open tibia shaft fxs 5.3-24%
- Risks factor for non-union include open fx, deep infection, post-op fracture gap, distal fx and smoking

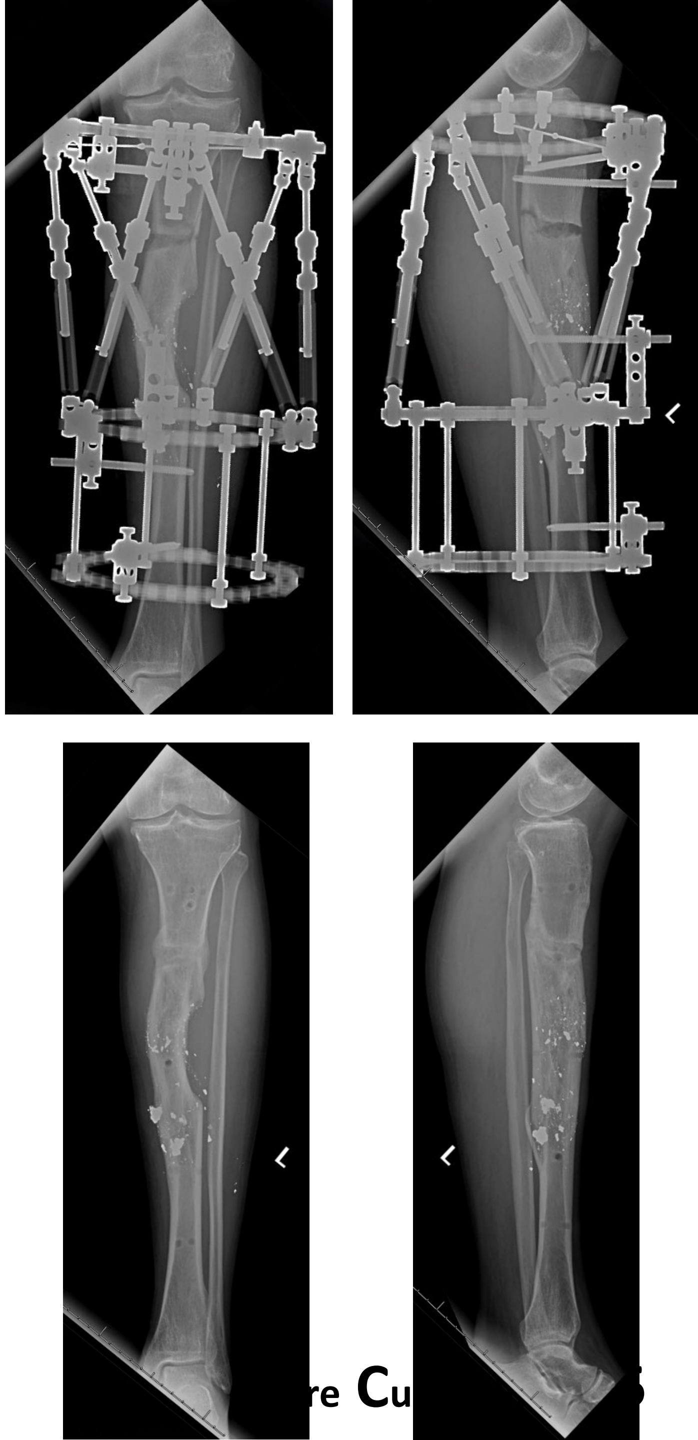
Complications: Malunion

- No clear definition
- Commonly cited *acceptable* numbers
  - Varus/valgus <5-10 degrees
  - Recurvatum/procurvatum <5-10 degrees
  - Rotation of 0-10 degrees
  - Shortening of 1-2 cm
- Malalignment results in abnormal joint forces at the knee and ankle, but above cutoffs are not clinically validated and oversimplify deformity



Complications: Malunion

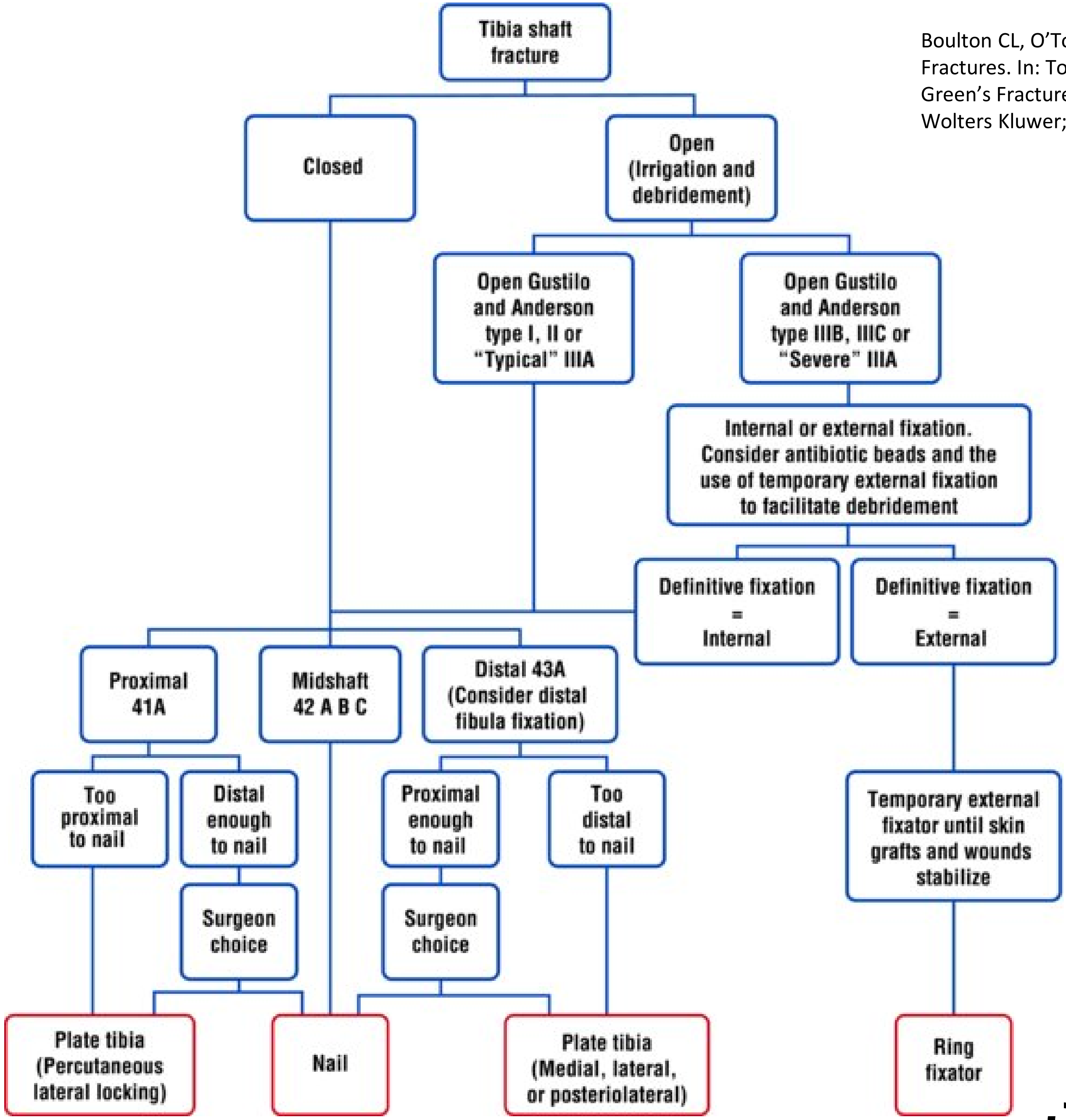
- Every malunion potentially has components of deformity in six axes that should be evaluated as a whole
  - Varus/Valgus
  - Apex Anterior/Posterior
  - Internal/External Rotation
  - Shortening/Overlengthening
  - Medial/Lateral Translation
  - Anterior/Posterior Translation
- Correction of symptomatic malunion involves an osteotomy and often multiplanar correction



Complications: Anterior Knee Pain/ Symptomatic Hardware

- Anterior knee pain is common with both infrapatellar and suprapatellar nailing, 19%- 73% Boulton CL, *Rockwood and Green's,* 2020, but lower for suprapatellar approach MacDonald DRW, Bone Joint J. 2019
- Exact etiology is unknown and likely multifactorial
  - Infra-patellar nerve damage
  - Proximal interlock screw pain
  - Prominent nail proximally
  - Post-op changes to patellar tendon (infrapatellar)
  - Fat pad scarring/adhesions
- Symptomatic hardware can exist in both IMN and ORIF
  - Long or subcutaneous interlocks, prominent nail in IMN
  - Subcutaneous plates/screws in ORIF
- Hardware removal frequently resolved symptoms related to prominent hardware, but not always knee pain Williams BR, J Am Acad Orthop Surg Glob Res Rev. 2020.

Proposed Algorithm From Rockwood and Greens



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Summary

- Common fx with bimodal distribution
- IMN is gold standard for most closed and low-grade open tibia shaft fxs
- ORIF can be used for very distal or proximal metaphyseal fxs, especially if there is articular extension
  - Pay special attention to soft tissue handling during ORIF
- Open and high energy tibia shaft fxs have high complication rates
  - Require timely soft tissue coverage
  - Definitive care with IMN vs Ex-Fix

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