

Updates on Tibial Shaft Fractures

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Objectives

- Evaluation of the patient with tibial shaft fracture
- Nonoperative and Operative Management
- Outcomes after tibia shaft fracture
- Complication of tibia shaft fracture



Epidemiology

- Most common long bone fracture
- Most commonly OPEN long bone fracture in adults
 - ~18%¹
 - Subcutaneous nature of bone
- Bimodal distribution
 - Young (<30 yo) – high energy, ie vehicular trauma
 - Older (>50 yo) – low energy, ie twist and fall, spiral fractures



Evaluation

- History:
 - Mechanism of Injury
 - High vs Low Energy
 - Patient demographics & Past Medical History
 - Age
 - Diabetes
 - Smoking
 - Substance abuse
 - Obesity
 - Immune compromise



Evaluation

- History:
 - Isolated injury vs polytrauma?
 - Need for ATLS activation?
 - Associated musculoskeletal injuries?



Evaluation

- Physical Exam:
 - Open vs closed? Soft tissue injury?
 - Pain response? → Compartment Syndrome?
- Vascular Exam
 - Pulses
 - ABI's if necessary
- Neurologic Exam



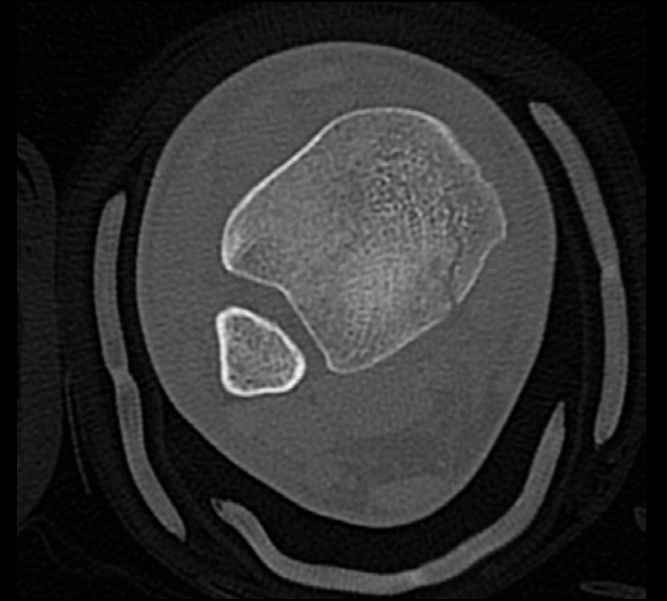
Evaluation

- Imaging:
 - Full length AP and Lateral Tibia X-rays
 - Ankle and Knee X-rays
 - Distal fibula fracture
 - Proximal tibiofibular joint and ankle syndesmosis
 - Periarticular extension
 - Plateau
 - Plafond (22-56% tibia shaft extend to plafond!)^{7,8}



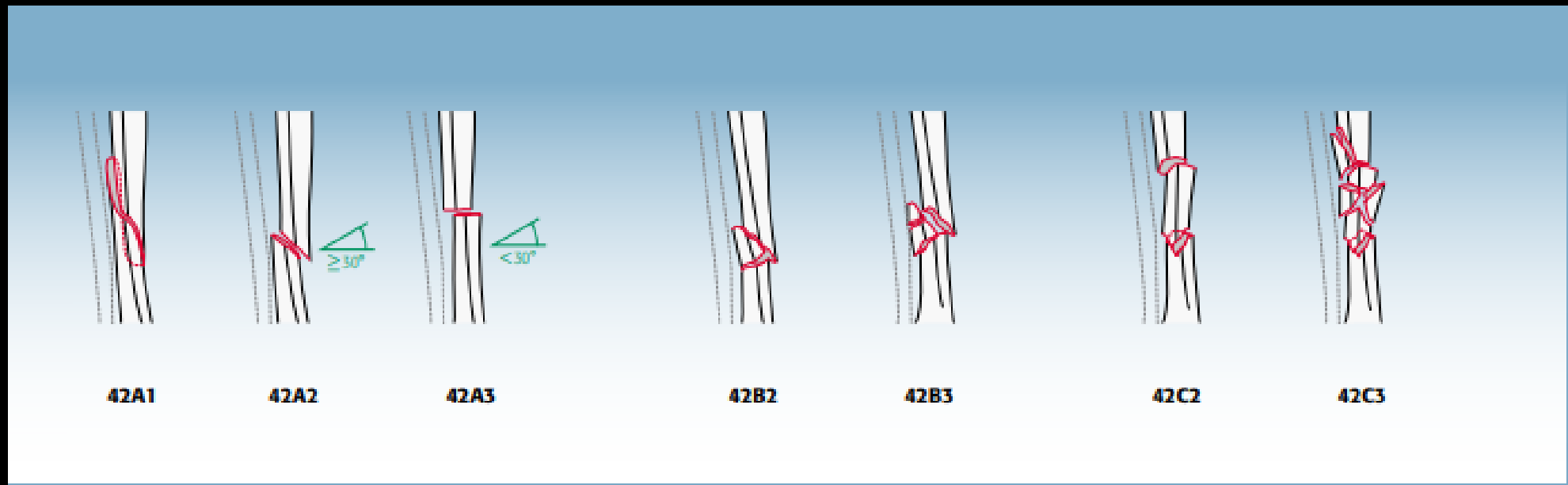
Evaluation

- Imaging:
 - CT Scan
 - Useful for periarticular extension diagnosis and preop planning
 - Consider for distal third shaft fractures
 - Up to 92% spiral 3rd tibia extend to PM⁷
 - Distal extension to plafond not visible on XR in 47-55% of cases⁸
 - CT Angiogram
 - Consider if decreased perfusion + Vascular Consultation
 - Pulses unequal
 - ABI < 0.9



Classification

- AO/OTA Classification - 42



Classification - Open Fractures

Gustilo-Anderson Classification

Type 1	Wound length <1cm	Minimal soft tissue damage, contamination, and comminution	Periosteum intact	Adequate soft-tissue coverage	Vasculature intact
Type 2	Wound length ≥1cm	Moderate soft tissue damage, contamination, or comminution	Periosteum intact	Adequate soft-tissue coverage	Vasculature intact
Type 3a	Extensive wound	Extensive soft tissue damage, contamination, or comminution; segmental fracture	Periosteal stripping	Adequate soft-tissue coverage	Vasculature intact
Type 3b	Extensive wound	Extensive soft tissue damage, contamination, or comminution; segmental fracture	Periosteal stripping	Inadequate soft-tissue coverage	Vasculature intact
Type 3c	Extensive wound	Extensive soft tissue damage, contamination, or comminution; segmental fracture	Periosteal stripping	Inadequate soft-tissue coverage	Arterial Damage

Gustilo RB, Mendoza RM, Williams DN. Problems in management of type III (severe) open fractures: a new classification of type III open fractures. J Trauma. 1984;24:742-746.

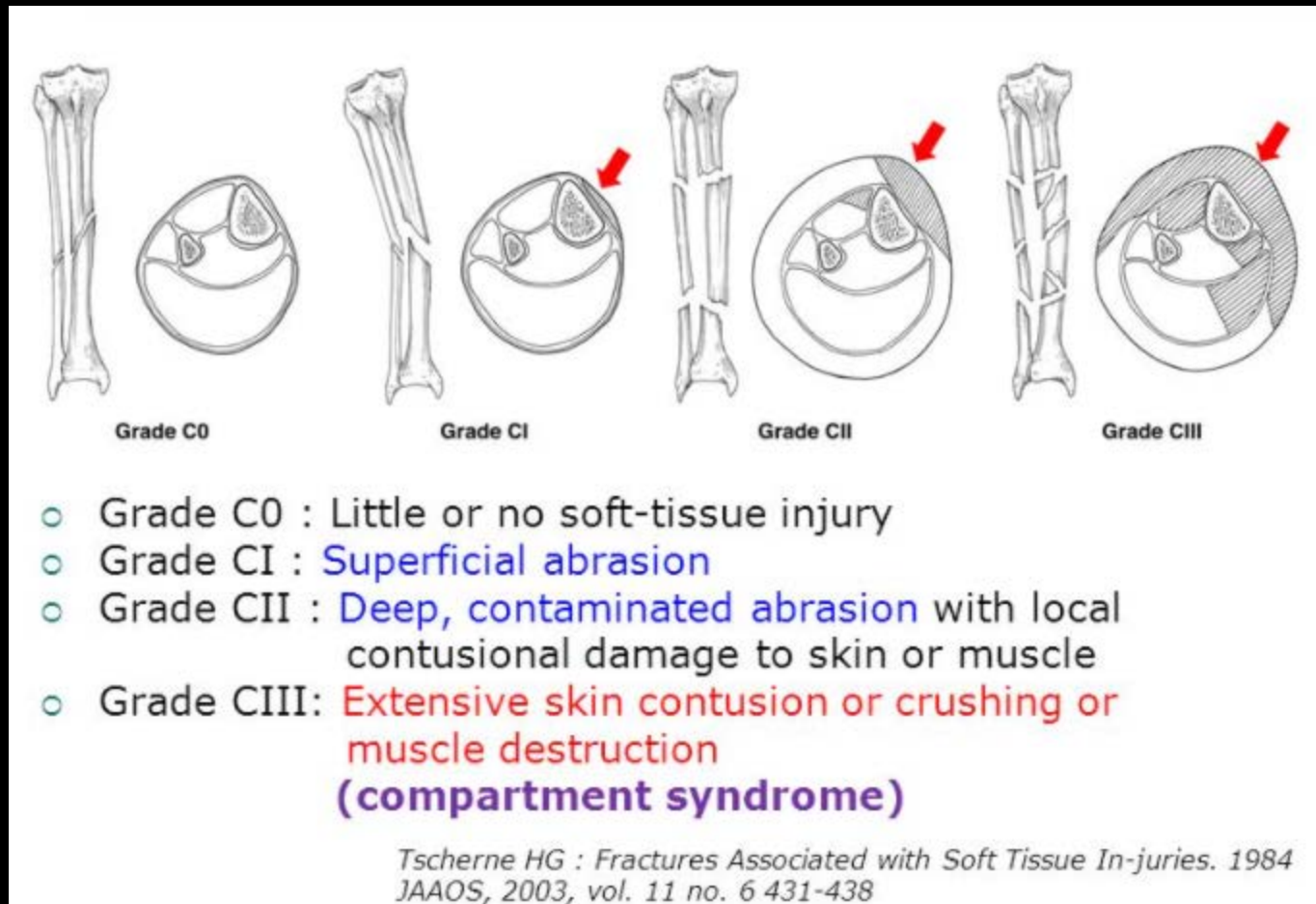


Classification - Open Fractures (OTA-OFC)

Skin	<ol style="list-style-type: none">1. Laceration with edges that approximate.2. Laceration with edges that do not approximate.3. Laceration associated with extensive degloving.
Muscle	<ol style="list-style-type: none">1. No appreciable muscle necrosis, some muscle injury with intact muscle function.2. Loss of muscle but the muscle remains functional, some localized necrosis in the zone of injury that requires excision, intact muscle-tendon unit.3. Dead muscle, loss of muscle function, partial or complete compartment excision, complete disruption of a muscle-tendon unit, muscle defect does not reapproximate.
Arterial	<ol style="list-style-type: none">1. No major vessel disruption.2. Vessel injury without distal ischemia.3. Vessel injury with distal ischemia.
Contamination	<ol style="list-style-type: none">1. None or minimal contamination.2. Surface contamination (not ground in).3. Contaminant embedded in bone or deep soft tissues or high-risk environmental conditions (eg, barnyard, fecal, dirty water).
Bone loss	<ol style="list-style-type: none">1. None.2. Bone missing or devascularized bone fragments, but still some contact between proximal and distal fragments.3. Segmental bone loss.

Classification – Soft Tissue

- Oestern and Tscherne Classification – Soft Tissue in CLOSED Fractures



Treatment Options

- Nonoperative
- Intramedullary Nailing
 - Mainstay of treatment for adults
- Plate Fixation
- External Fixation



Nonoperative Management

- Fracture is length stable
- Within tolerances after reduction →
- Soft tissues can tolerate cast
- Medically unfit for surgery or anesthesia
- 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



Nonoperative Management

- Closed reduction with well molded long leg cast
 - Long leg splint at initial presentation, cast risk compartment syndrome
 - Consider conscious sedation
- Close follow up
 - Weekly radiographs until 3-5 week mark
 - Consider wedging cast
- Transition to WB patella bearing cast at 3-5 weeks
- Boot at 8-12 weeks with callus on XR
- Typical healing 4-6 mo with closed treatment



Nonoperative Management Outcomes

- Sarmiento reported retrospectively on 1000 closed tibia shaft fractures:
 - Nonunion 1.1%
 - 94% healed with \leq 12mm shortening
 - 90% \leq 6 deg angulation
- Obrebsky recently performed prospective multicenter trial of IMN vs casting of stable tibial shaft fractures¹⁵
 - Less ROM, lower rates of return to work, and worse patient reported outcome scores after cast treatment



Operative Management Indications

- Severe initial displacement
- Failure to obtain adequate closed reduction
- Open Fracture
- Vascular Injury
- Soft tissue envelope precludes cast application
- Patient noncompliance with closed treatment
- Patient requires early return to activity



Intramedullary Nailing

- Most common – 96% of cases²⁴
- Advantages
 - Minimizes soft tissue insult
 - Allows immediate weight bearing
- Disadvantages
 - High incidence of knee pain



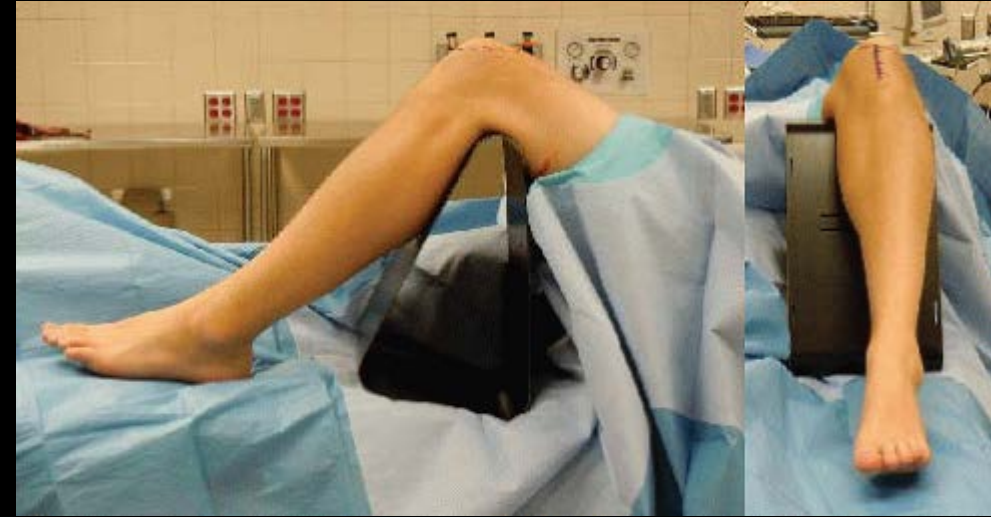
Intramedullary Nailing

- Approaches:
 - Infrapatellar
 - Semiextended
 - Suprapatellar



Intramedullary Nailing Approaches

- Infrapatellar
 - Classic approach
 - Medial, lateral, or through the patellar tendon
 - Knee hyperflexed over triangle to access start point
 - Hyperflexion can deform proximal third fractures
 - Difficulty with xrays
 - Difficulty with reduction (proximal and distal third)



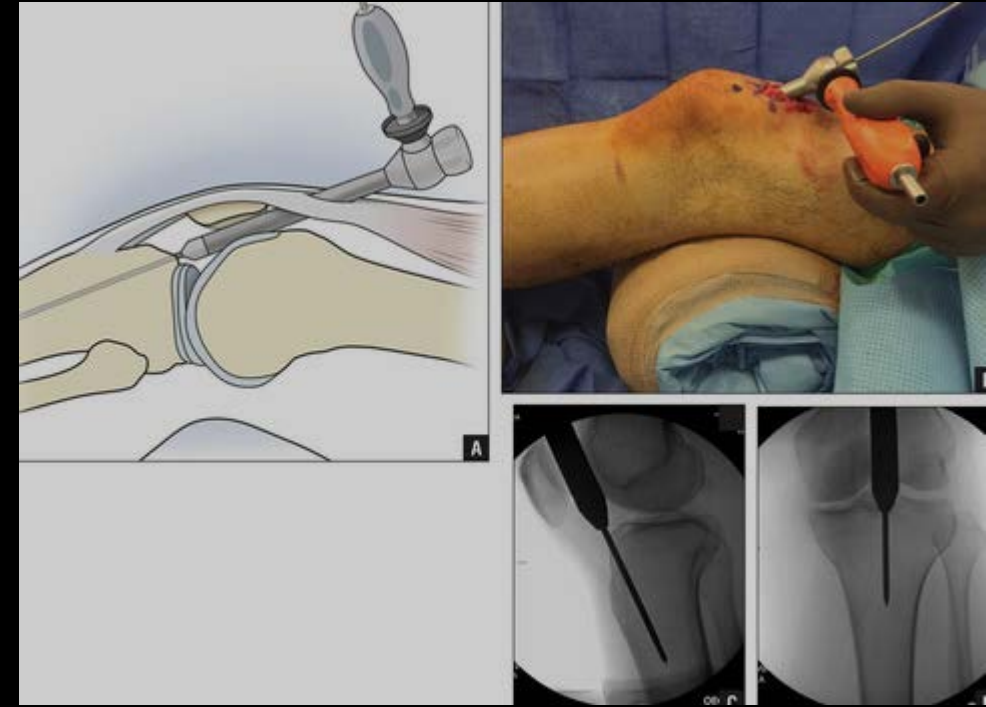
Intramedullary Nailing Approaches

- Semiextended
 - Slight flexion (10-30 deg) over bump
 - Medial or lateral parapatellar approach
 - Incise retinaculum but not synovium
 - Can use standard instrumentation
 - Semiextended position diminishes risk of sagittal plane malalignment due to knee hyperflexion
 - Esp in prox 3rd and dist 3rd



Intramedullary Nailing Approaches

- Suprapatellar
 - Semiextended (10-30 deg knee flexion)
 - Through quad tendon/intra-articular
 - Requires special instrumentation to protect the knee joint
 - Semiextended position diminishes risk of sagittal plane malalignment due to knee hyperflexion
 - Esp in prox 3rd and dist 3rd



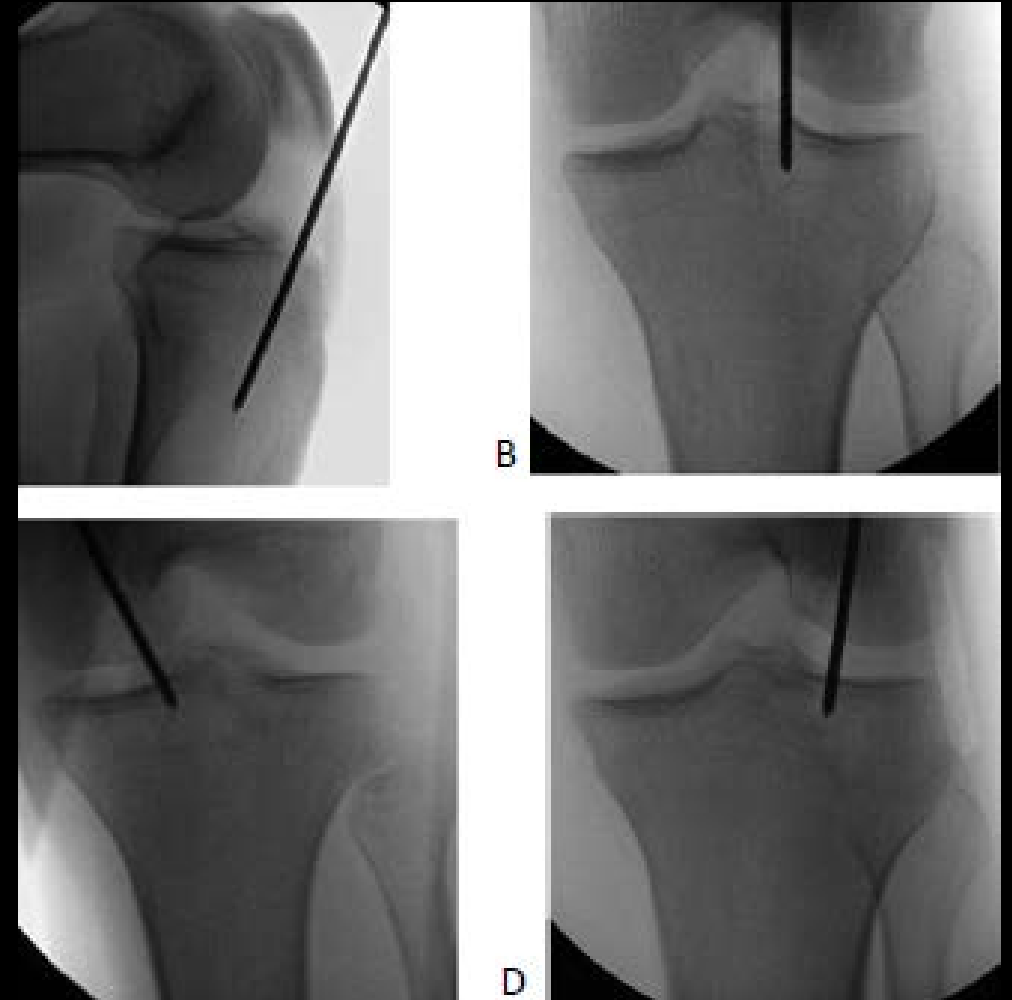
Intramedullary Nailing Approaches

- Suprapatellar
 - Significantly lower rates of sagittal plane malalignment, shorter duration of surgery, and shorter fluoroscopy time compared with infrapatellar approaches^{35,36}
 - No difference in knee ROM and postop knee pain compared with infrapatellar^{35,36}
 - Pressures in patellofemoral joint are greater in SPN, but remain below threshold for chondral damage/death³¹
 - Safe in open tibia fracture, no evidence of increased knee sepsis compared to infrapatellar nails³⁴



Intramedullary Nailing

- Proximal Start Point:
 - Important for fracture alignment
 - Medial border lateral tibial spine
 - Anterior border articular surface
- Must have true AP and lateral!
 - Can affect visualization of start point
 - True AP lateral tibia bisects fibula
 - True lateral overlapping femoral condyles



Intramedullary Nailing

- Distal Guidewire/Nail End Point:
 - Important for fracture alignment
 - Especially in distal third fractures
 - Just lateral to center of the talus on the mortise view⁴²
 - Centered on the lateral view



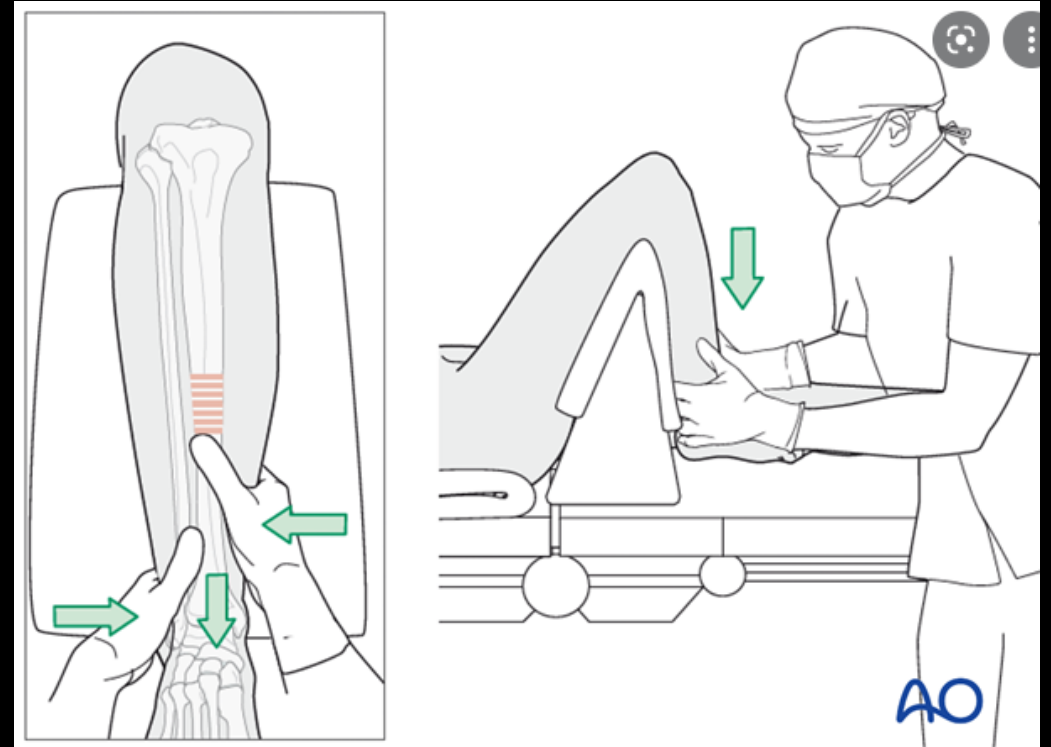
Intramedullary Nailing Reduction Techniques

- Reduction should be performed BEFORE reaming and nailing
- Do not rely on nail to reduce fracture
- Surgeon should weight biological cost of reduction techniques versus benefit



Intramedullary Nailing Reduction Techniques

- Closed reduction techniques
 - Manual Traction
 - Bumps
 - Manual Reduction
- Need to have assistant
- May get tired or lose reduction



Intramedullary Nailing Reduction Techniques

- Percutaneous reduction techniques
 - Percutaneous clamp application
 - Soft tissue friendly
 - Safe
 - Superior cortical contact, alignment, and rate of union compared to closed techniques



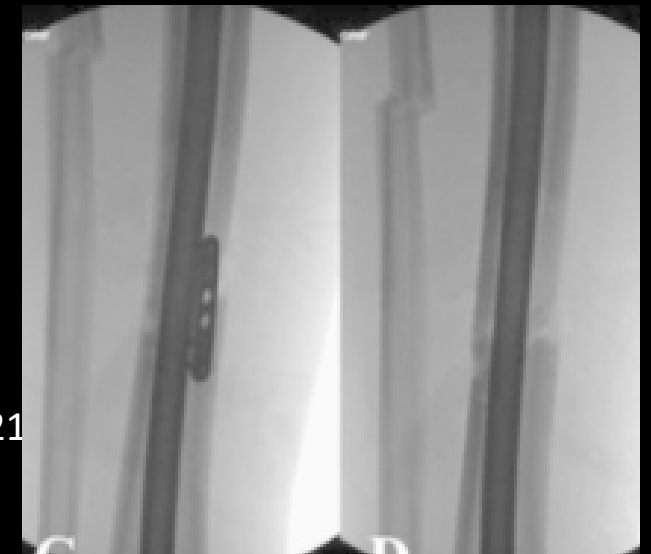
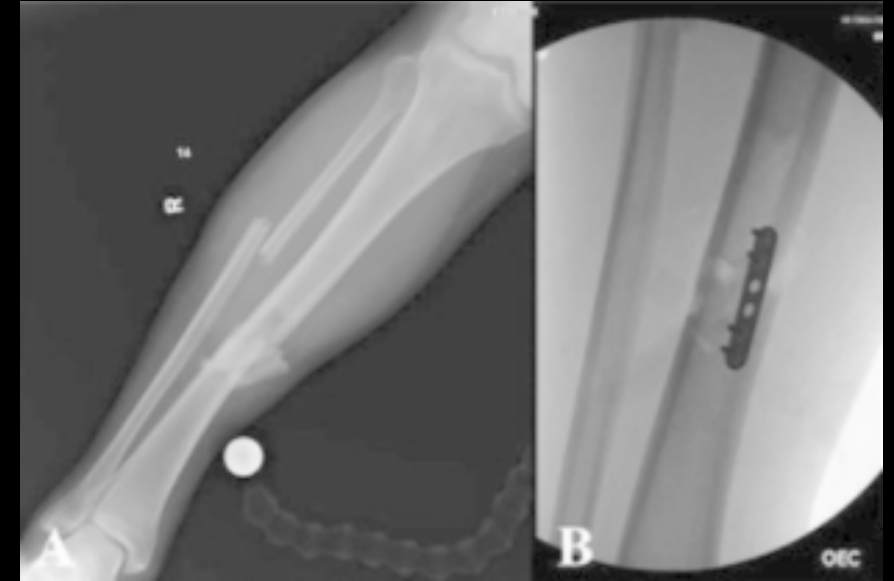
Intramedullary Nailing Reduction Techniques

- Temporary External Fixator
 - “Travelling Traction”
- Universal Distractor
 - Can hold length and alignment for reaming and nailing
 - Does not get tired
 - Helpful for comminuted segments
 - Place pins outside of planned nail path



Intramedullary Nailing Reduction Techniques

- Unicortical small/minifrag plates
 - Can be placed through open wound or new incision
 - Helpful in segmental patterns and open fracture
 - My preference to remove after nailing
 - Don't recommend routine use, most soft tissue stripping of all reduction techniques
 - Open reduction has 2.2x risk of any complication and 3.5 risk of infection compared to closed¹⁷
 - Plate retention not associated with infection/nonunion^{20,21}



Intramedullary Nailing Reduction Techniques

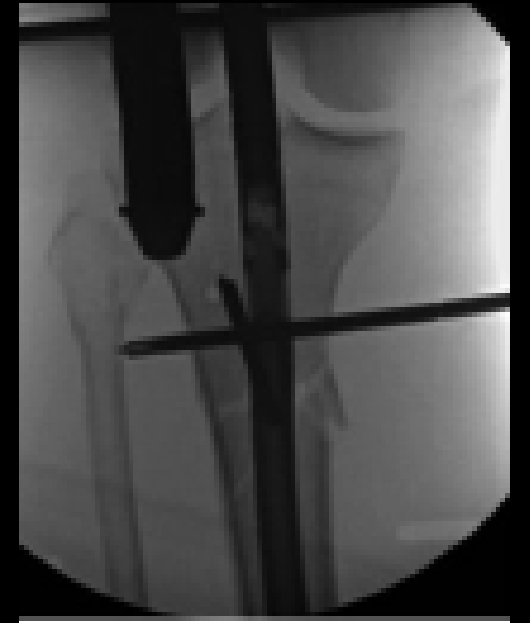
- Fixing the Fibula
 - ORIF vs Intramedullary Screw or Wire
 - May help length and alignment of tibia reduction
- Indicated when there is also a rotationally unstable ankle fracture
 - I usually check this with an external rotation stress exam of ankle after nailing



Intramedullary Nailing Reduction Techniques

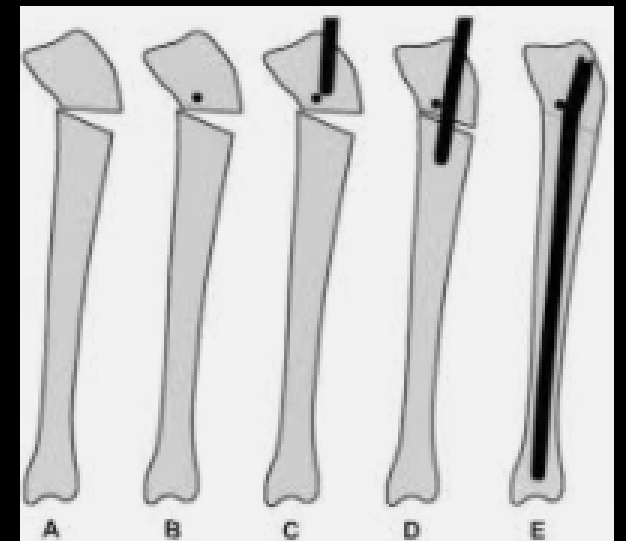
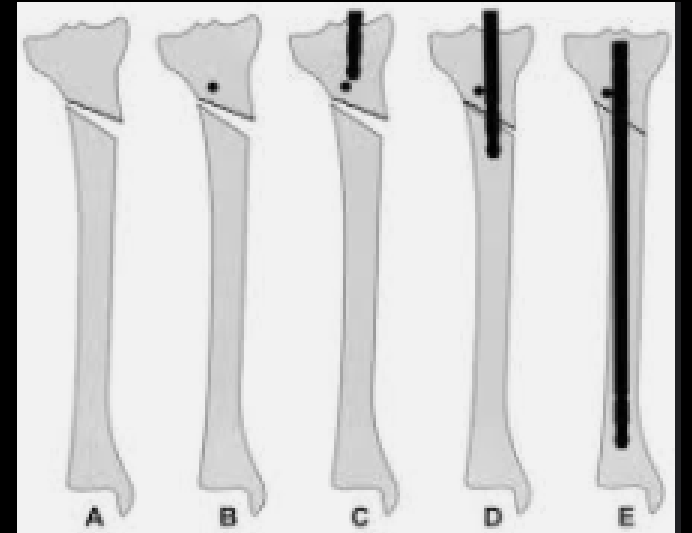
- **Blocking Screws**

- Useful to help guide nail and guide fracture alignment as the nail is passed
- Helps reduce nail/canal mismatch in metaphyseal fractures
- Corrects angular deformities
 - Place in concavity of deformity
- Drill bits, Steinmann pins, or screws
- Retention after nailing helps to keep reduction and increases construct stability



Intramedullary Nailing Reduction Techniques

- Blocking Screws
 - Helpful in proximal and distal 3rd
- Proximal 3rd Fractures Valgus/Procurvatum
 - Lateral
 - Posterior
 - In concavity of deformity



Intramedullary Nailing Reaming

- Creates path for IMN
- Allows for larger diameter nail
 - Increased implant bone contact
 - Larger interlocking screws
 - Increased construct stability
- Deposits autograft, growth factors, and stem cells at fracture site, increasing biology
- Don't ream with tourniquet up (thermal necrosis)?



Intramedullary Nailing Reaming

- Associated with lower risk of implant failure (bigger nails) and lower risk on nonunion (increased biology) in closed fractures⁹
- SPRINT Study^{44, 45}
 - Prospective randomized trial comparing reamed vs unreamed tibia fractures
 - Benefit with reaming in closed fractures
 - Highest failure rates in small unreamed nails (<9 mm with small interlocks)
 - No difference in outcomes and nonunions with between reamed and unreamed nails in open fractures
- Basically, reaming is OK and beneficial for all tibia shaft fractures, open & closed



Open Reduction Internal Fixation (Plating)

- Generally not preferred
 - Increased soft tissue insult/periosteal stripping
- Reserved for:
 - Proximal or distal fractures not amenable to nailing
 - Articular extension
 - Skeletally immature patients
 - Periprosthetic fracture below TKA
 - Tibial deformities
- May improve alignment compared to nailing in prox/dist fx



External Fixation

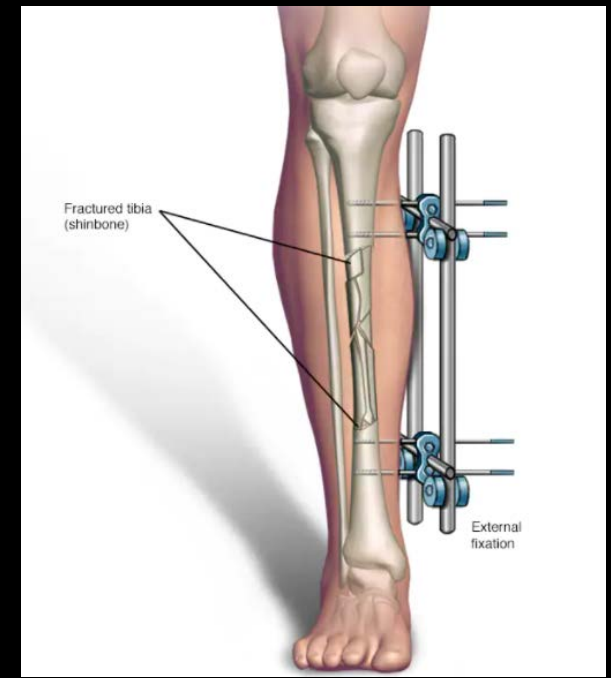
- Provisional stabilization

- Soft tissue injury
- Polytrauma or damage control
- Vascular Injury

- Allows soft tissue rest, decrease in swelling, wound care of soft tissue injury
- Gives time for planning definitive fixation + soft tissue coverage if needed

- Useful in Type IIIB & IIIC open tibia fracture

- For type I, II, and IIIA; immediate IMN associated with diminished infection vs staged ex fix⁶³



External Fixation

- Definitive External Fixation (Multiplanar) Indications:
 - Severe soft tissue injury
 - Bone loss (eg, necessitating bone transport)
 - High infection risk
- Circular frames of type IIB open fx achieve 97% healing, but 50% get pin site infection, 20% wound complication, 16% malunion, 30% knee and ankle contractures⁵³
- Recent RCT shows IMN has better union rate, QOL, and alignment at 3 months compared to ex fix⁵²



Open Tibia Shaft Fractures

- Initial Care
 - Antibiotics <66 min⁵⁵
- Debridement
 - Within 6-24 hours
 - Remove all nonarticular cortical bone without soft tissue attachments
 - Can retain temporarily to help reduction and then remove after fixation
 - Segmental defects after debridement managed with abx spacers
 - FLOW Study – plain saline, at any irrigation pressure OK⁶⁰



Open Tibia Shaft Fractures

- Wound Coverage

- A. Proximal 3rd → Gastroc rotational flap
- B. Middle 3rd → Soleus rotation flap
- C. Distal 3rd → Free Flap or Reverse Sural



- Coverage within 3-5 days decreases risk of infection⁶⁵
- Concomitant definitive soft tissue coverage and immediate fixation decreases infection versus staged fixation and then coverage
 - 4.2% vs 34.6%
 - Mathews JA, Injury 2015



Outcomes

- Physical recovery typically progresses up to and above 1 year
 - Greatest gains in functional outcome and gait 6 mo to 1 yr
 - Strength and QOL remains inferior to uninjured population at 1 year^{71,72}
- Athletes⁷⁴
 - 92% return to sport after surgery at 12 to 54 weeks
 - 67% return without surgery at 28 to 182 week range
- Return to work 66% at 1 year⁷⁴
- 90% union rate; 46% pain free



Complications

- Infection
- Nonunion
- Malunion
- Anterior Knee Pain/Symptomatic Hardware



Complications - Infection

- 29% in open fracture; 3% in closed fracture
- Increased incidence with:
 - ↑ soft tissue injury severity
 - ↑ open fracture classification
 - ↑ time to soft tissue coverage
 - Ex fix use
- Staph aureus most common (64% deep infections)
- Implant retention, surgical debridement, and culture guided antibiotics for low grade infection
- Implant removal, debridement and antibiotic spacer/nail for high grade infection



Complications - Nonunion

- Failure of fracture healing within 6 months with no progression of callus on 3 consecutive xrays
 - Closed tibia shaft 1-8%
 - Open tibia shaft 5-24%
- Risk Factors:
 - Smoking, alcohol, diabetes, open fracture, high energy mechanism, OTA B&C fracture types, ballistic injuries, fracture gap after fixation, and use of steel intramedullary nail
 - Ketorolac (NSAID) administration immediately postop NOT associated⁸⁷



Complications - Nonunion

- Low Intensity Pulsed Ultrasound (LIPUS)
 - TRUST Study – double blind RCT LIPUS did not accelerate healing, failed to improve function, and not cost effective⁸⁸
- Surgical Management
 - Nail dynamization, exchange nailing, bone graft, rBMPs
 - Dynamization 54% effective⁸⁹
 - 88% union after exchange nailing⁹⁰



Complications - Malunion

- Malrotation (>8 deg) can occur in 23-36% of IMN⁷⁹
 - Likely can tolerate 10-12 deg of rotation⁸⁰
- Commonly cited acceptable numbers:
 - Varus/Valgus <5-10 deg
 - Recurvatum/Procurvatum <5-10 deg
 - Rotation 0-10 deg
 - Shortening 1-2 cm



Complications – Anterior Knee Pain/Sx HWR

- Anterior knee pain common in both infra & suprapatellar nailing
 - 19-73%
 - Lower in suprapatellar approach MacDonald DRW, Bone Joint J. 2019
- Multifactorial
 - Infrapatellar nerve damage, proximal interlock pain, prominent nail proximally, postop changes to patellar tendon, fat pad scarring/adhesions
- Symptomatic hardware
 - Long or subcutaneous interlocks, prominent nail in IMN
 - Subcutaneous plate/screws in ORIF
- Hardware removal frequently resolves Sx HWR, but not knee pain William BR, JAAOS 2020



Summary

- Common fracture with bimodal distribution, commonly open
- IMN is gold standard for most closed and low grade open fractures
- ORIF useful for very proximal/distal/articular extension/periprosthetic
 - Soft tissue concerns
- Ex Fix useful for damage control and soft tissue management
- Outcomes decent but not great
- Open and high energy tibia shaft fractures have high complication rates

Thank You! Questions/Comments?

