Tibial Plateau Fractures, Tibial Shaft Fractures, and Knee Dislocations

Daniel Coll, MBA, PA-C, DFAAPA
Tahoe Forest Hospital District
Truckee California

CONFLICTS

- No conflicts regarding this discussion

Acknowledgements

OTA Resident Core Curriculum lectures made by the Orthopaedic Trauma Association for Education were used as the foundation of this presentation.

I wish to acknowledge all of the many OTA Authors' work that prepared me today.

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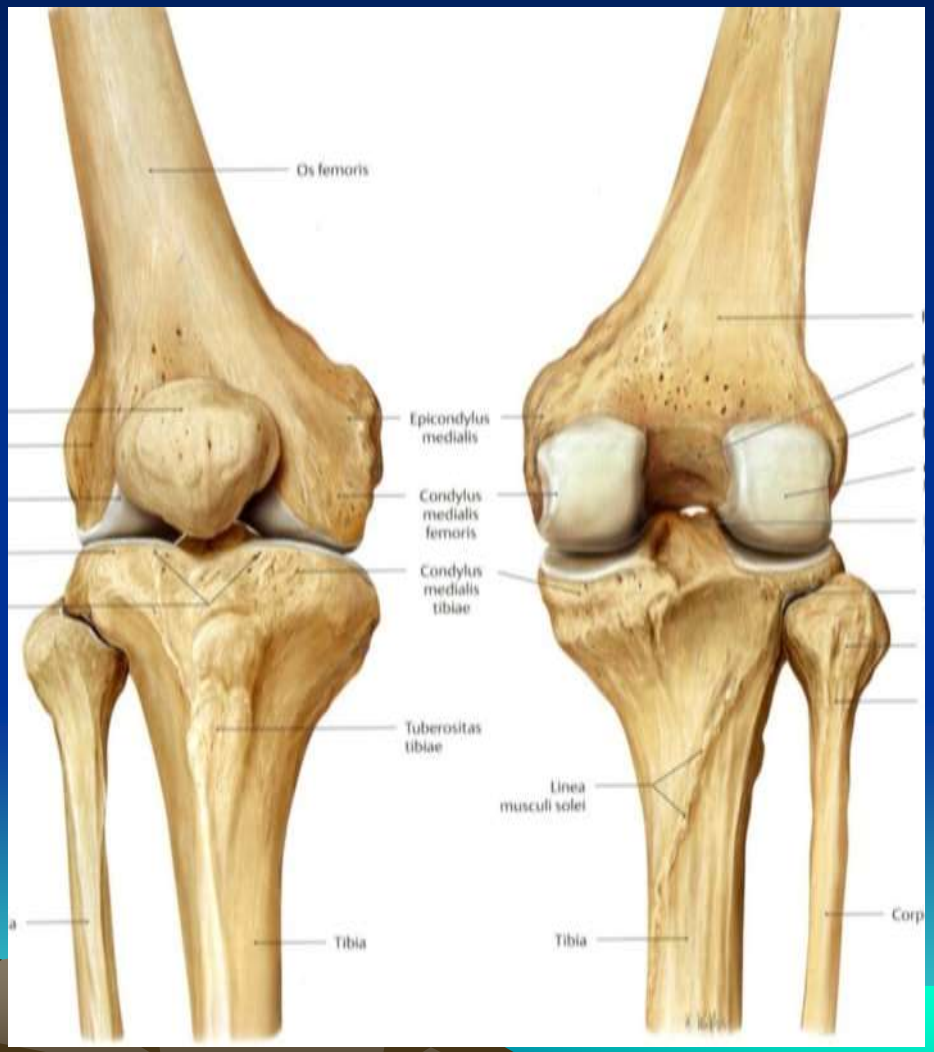
At the end of this session, participants will be able to:

- Identify common pitfalls with knee dislocations and fractures of the proximal tibia and shaft.
- Identify injury patterns, physical exam techniques/evaluation, and care.
- Explain imaging modalities and some of their limitations.

Anatomy: Tibiofemoral Joint

- Bones
  - femoral condyles
  - tibial plateau
- Dissimilar surfaces
- Little/**No** inherent bony stability
- May be cause of additional instability if fractured

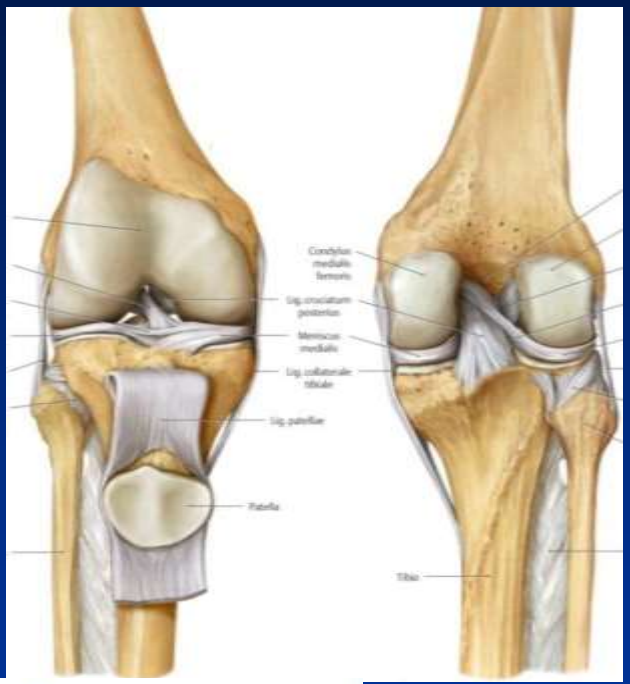


Anatomy of the Tibial Plateau

- Proximal Tibia
  - Made up of medial and lateral plateau or condyles
  - Bony prominences (attachments)
    - Intercondylar eminence (ACL)
    - Tibial tubercle (Patellar Tendon)
    - Gerdy's tubercle (ITB)
  - Joints
    - Knee joint (Distal Femur/Patella)
    - Proximal tib/fib joint

Stabilizers of the Tibiofemoral Joint

- Soft tissues: stabilize while allowing ROM
  - Ligaments
  - Joint capsule
  - Menisci
  - Musculotendinous units (DYNAMIC)



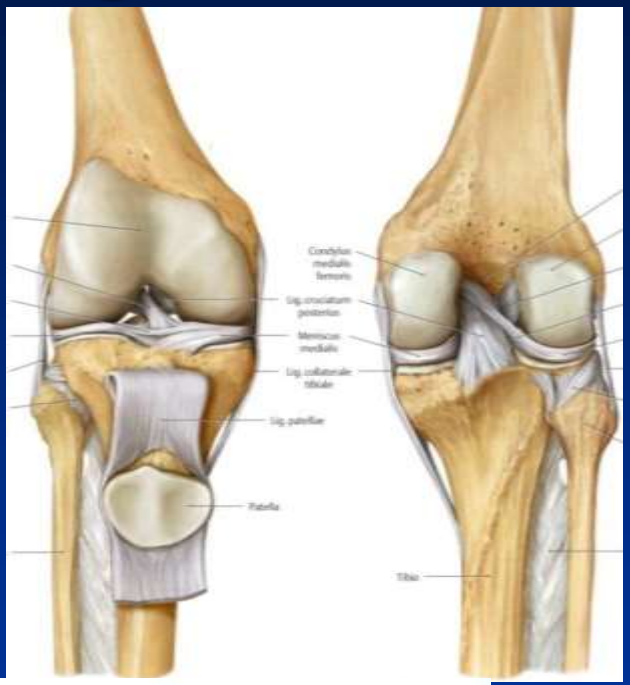
Anatomy of the Tibial Plateau

- Medial Plateau
  - Concave
  - Larger
  - Cartilage thick ~ 3 mm
  - Posterior slope of 10°
- Lateral Plateau
  - Convex
  - Higher on lateral view
  - Larger meniscus
  - Cartilage thick ~ 4 mm
  - Posterior slope of 7°

MCL, ACL, LCL, Popliteal artery, peroneal nerve are all potentially at risk for injury

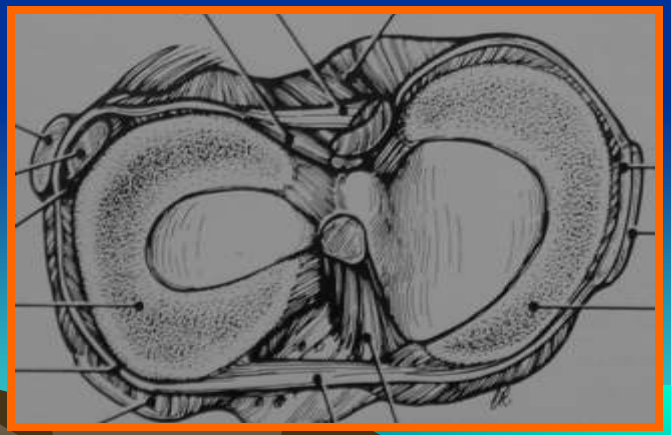
Anatomy – 4 groups of ligaments

- ACL
- PCL
- MCL, posteromedial capsule
- LCL & PLC (popliteofibular ligament, popliteus, capsule, ITB, biceps femoris)



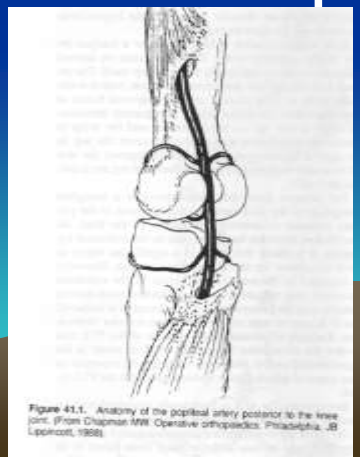
Meniscus

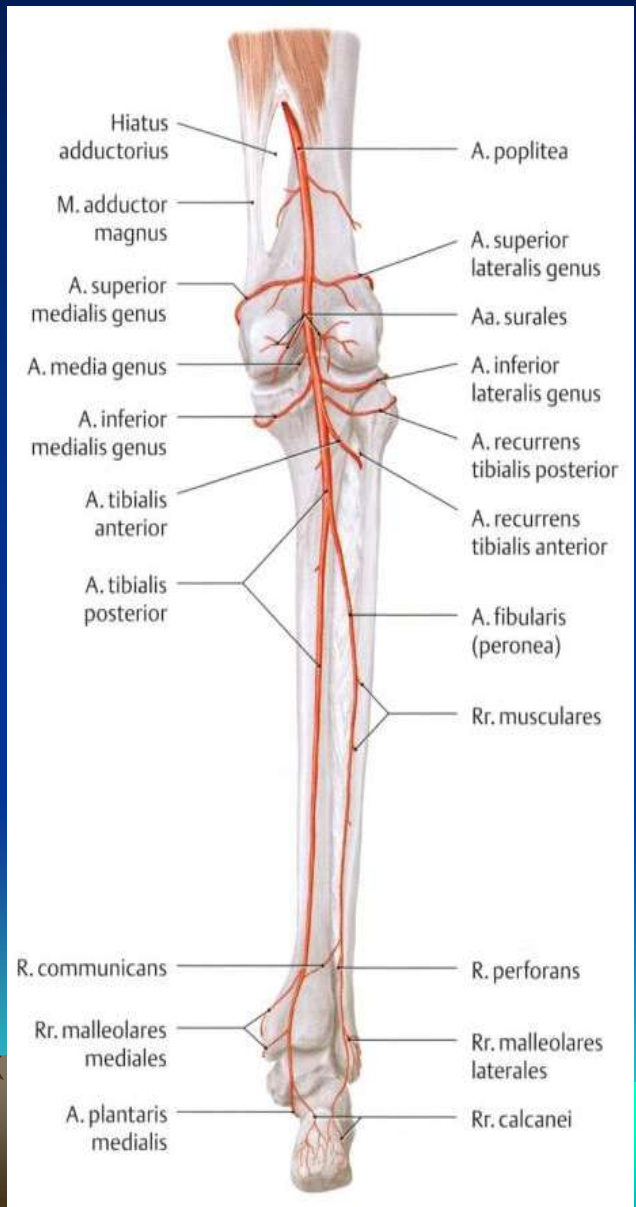
- Lateral meniscus
  - More circular than medial
  - Covers more of articular surface than medial
  - Attached to PCL via ligaments
    - Humphry (anterior)
    - Wrisberg (posterior)
  - No attachment to LCL
  - Bears more joint reactive force
- Medial meniscus
  - “C” shaped
  - intimately attached to MCL
  - bears equal joint reactive force as bone



Vascular Anatomy

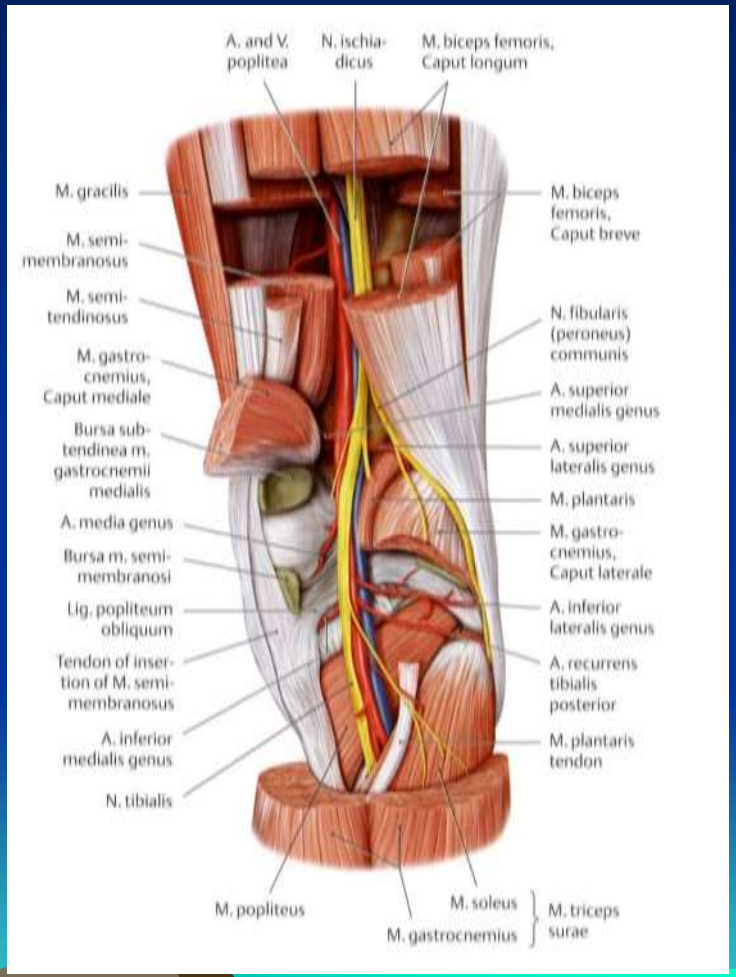
- Popliteal artery at risk for being tethered
  - Adductor hiatus
  - Soleus arch
- If blood flow through popliteal artery disrupted
  Inadequate blood supply





Anatomy: Nerves

- Influences LongTerm Outcome Peroneal nerve
  - More commonly injured
  - Tethered around the fibular neck
  - Mechanism of injury
    - Tension (Varus ± hyperextension, Translation (Anterior /Posterior dislocation)
    - Direct impact
    - Iatrogenic (aggressive varus/hyperextension during EUA (!)
- Tibial nerve



Knee Dislocation– Multiligamentous Injury

- Disruption of normal relationship of tibiofemoral joint
- Usually requires the injury to 2 of the 4 major groups of ligaments

Dislocation Pathomechanics

- May occur not only with high energy but also with low energy
- Low energy
  - Athletic activity (more with contact sports)
  - Fall down stairs
  - Jump of the low height
- High energy
  - MVA
  - PVA
  - Fall from height

Dislocation Epidemiology

- True incidence is underreported
  - Spontaneous reduction
  - Definition (documented complete dislocation vs. ≥1 cruciate + one collateral injury)
  - Obesity interferes with exam and mechanism
- Presented in a variety of clinical practices
  - Trauma Center
  - Sport Medicine
  - General Orthopaedics

BEWARE OF THE PEDIATRIC TIBIAL PLATEAU FRACTURE CAUSE BYUNRECOGNIZED DISLOCATION

Dislocation Epidemiology

- 0.2 % of all orthopaedic injuries
- Young ♂
- MVA, sports trauma
- 14-44 % associated w multiple trauma
- Bilateral 5 %

Robertson A et al. 2006

Dislocation Diagnosis

If any of the following present r/o Multiligamentous injury (Spontaneous reduction UNDERDIAGNOSED)

- Hyperextension
- Popliteal ecchymosis
- Vascular insufficiency
- Peroneal nerve deficit
- Diffuse tenderness but Absence of hemartrosis (capsular disruption)
- Obese pt low energy fall

Physical Examination

- Evaluate soft tissues
  - Open
  - Puckering (irreducible dislocation)

Mechanisms and Associated Injuries

- **High energy**
  - Popliteal artery injury (14-65%)
  - Nerve injuries (16-40%)
  - Multiple fractures (41%)
  - Head, chest trauma
  - Compartment syndrome
- **Low energy**
  - Popliteal artery injury (<5%)
  - Meniscal injury (20%)
  - Osteochondral fracture (5

Tibial Plateau Demographics

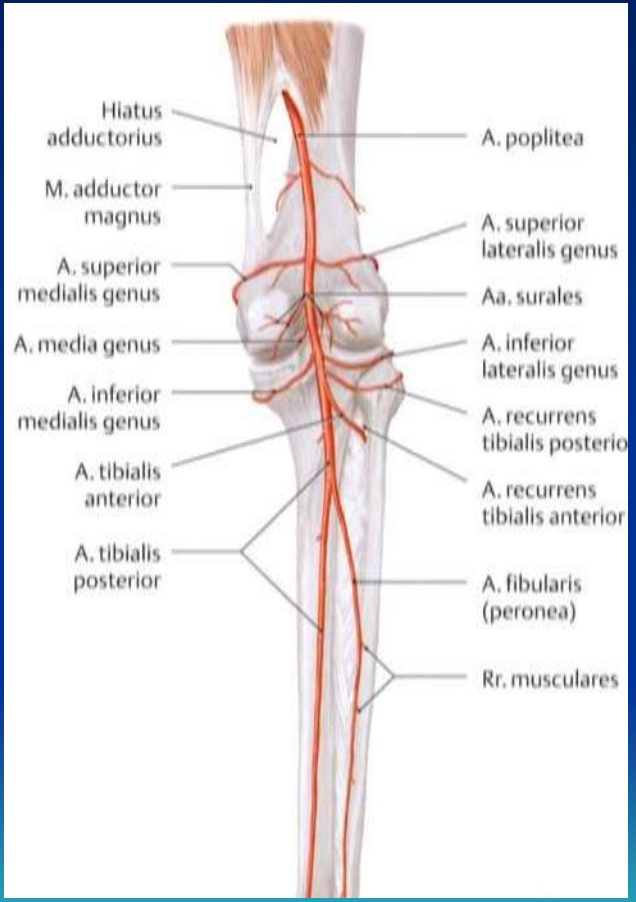
- 1% of all fractures
- 8% of all fractures in the elderly
- Lateral plateau involved 55-70%
- Medial plateau involved 10-20%
- Both involved 10-30%

Vascular Examination

- Color, temperature, Pulses
- Dorsalis Pedis a. & Tibialis Posterior a.
- ABI (Ankle Brachial Index)
  - ≥0.9: Serial examination
  - <0.9: further study/exploration
  - Johanson, K, JT
- Reduce if dislocated and Reexamine

Vascular Examination

- ABI ≥0.9 & no signs of vascular injury: Arterial study may not be necessary if
  - Serial examination q 2-4 hrs for 48 hrs can reliably be performed
- If not, arterial study may be ordered to r/o vascular injury



Mills WJ 2004, Stannard JP 2004

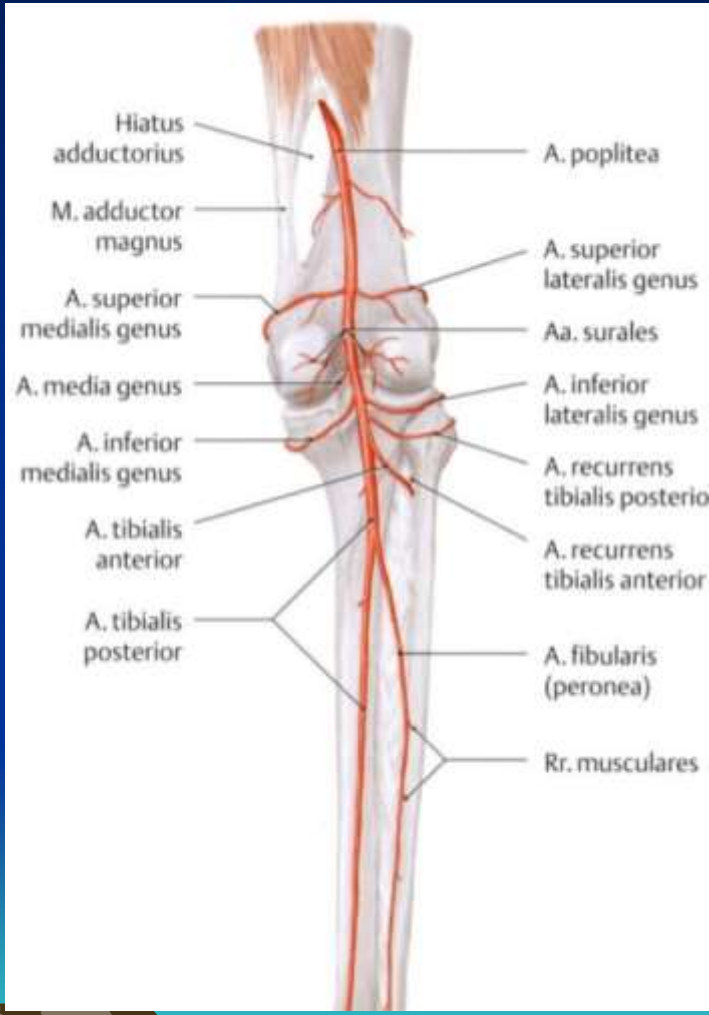
Vascular Examination

- ABI <0.9 OR
- ↓ Temperature, Color, OR
- Expanding swelling (hematoma) around the knee

- Arterial study
  - Arteriography in OR (on table by surgeon)
  - Angiography (radiology suite)
  - CT- Angiogram

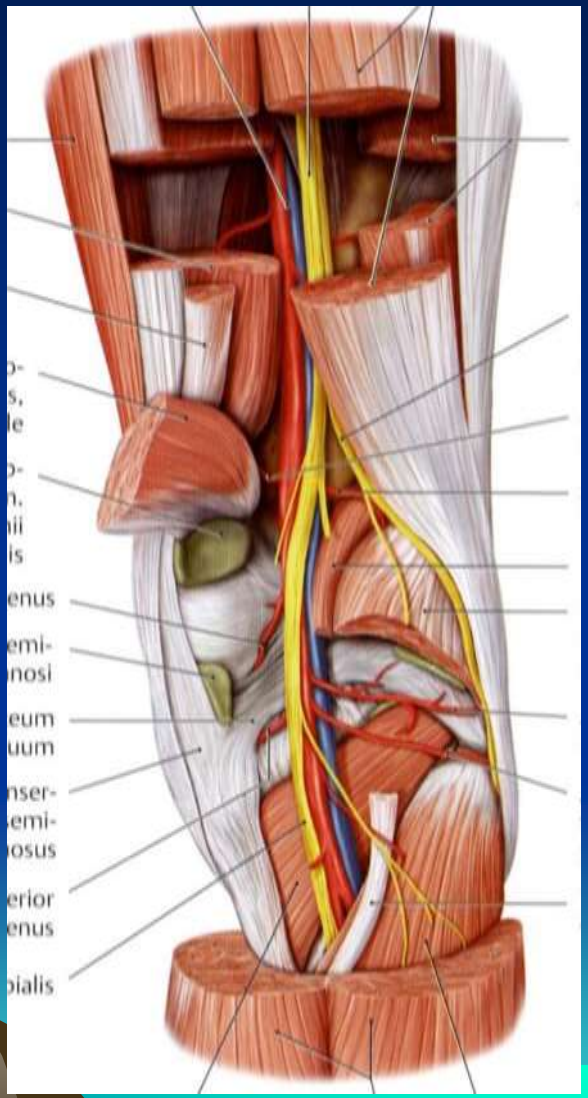
Vascular Injury

- ~20% (5-30%) of all dislocations
- EMERGENCY if NO distal perfusion
- Patterns of Vascular injury
  - rupture
  - incomplete tear
  - intimal injury (may cause thrombosis)



Neurologic Injury

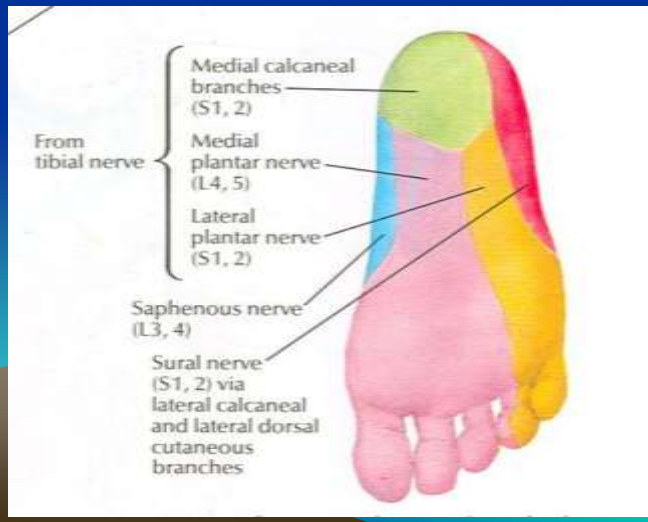
- Common peroneal nerve palsy
- Incidence ~20% (10-40%)
- Most Common with varus injury
- Usually axonothmesis
- PROGNOSIS is POOR
- Complete recovery ~ 20%



Neurologic Examination

- Peroneal Nerve
  - Motor: EHL, Tib. Anterior, Peroneals
  - Sensory: dorsum of the foot and 1st web space

- Tibial Nerve
  - Motor: FHL, Gastrosoleus, Tib Posterior
  - Sensory: Plantar surface and lateral border of the foot



Tibia Fractures

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

Open Fracture 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

Tibia History & Physical

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

Tibia 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

Priorities

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

Knee/Plateau/Tibia 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
  - Check joint above & below
- Oblique views may be helpful in follow-up to assess healing

Plateau Radiographic Evaluation

- AP, Lateral on Large Cassettes
- Obliques
  - Internal rotation view
  - Shows postero-lateral fragment
- Traction Films
  - Defines fragments
  - Bridging Ex-fix can provide traction
- CT scan with reconstruction
  - Obtain after ex fix if using
  - Coronal
  - Sagittal
- Arteriography when necessary (or check ABI > 0.9)
- ? MRI – unsuspected fxs or soft tissue injury

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

Plateau Classification

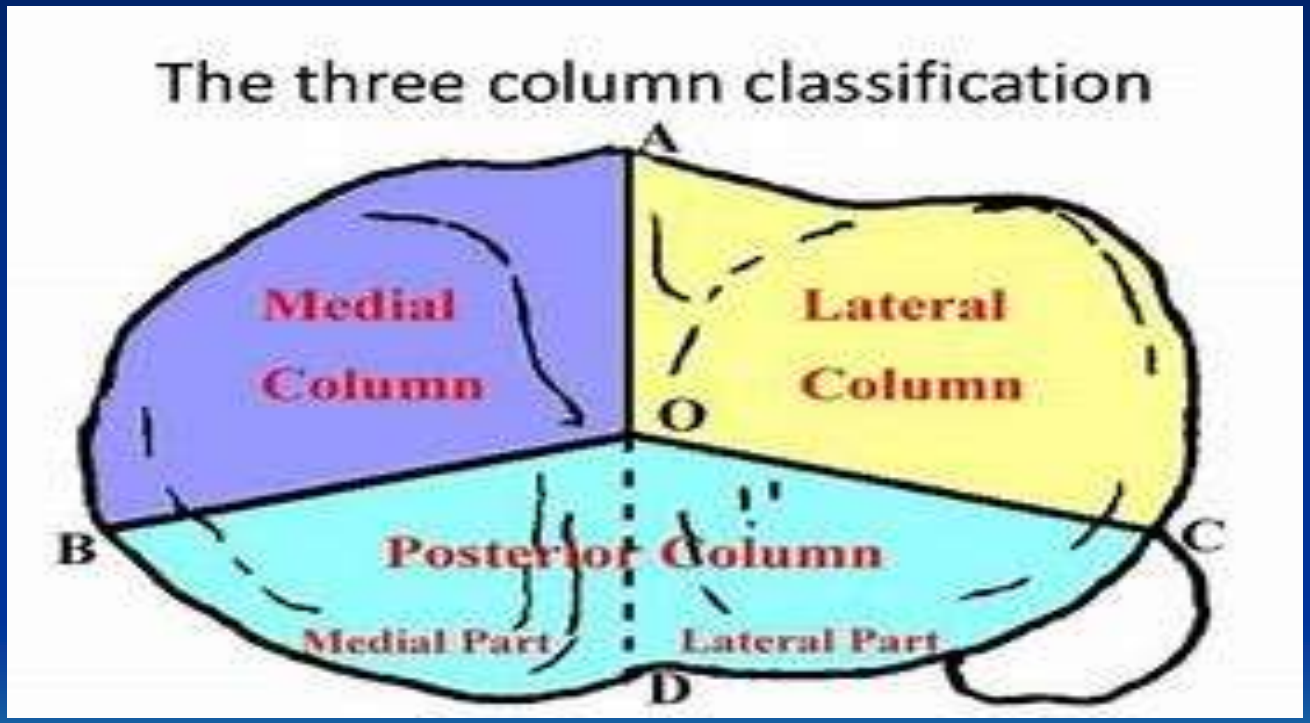
Schatzker, Clin Orthop, 1979

- Type I - Split Lateral Tibial Plateau Fx
- Type II - Split/Depression Lateral Plateau Fx
- Type III - Pure Depression Lateral Plateau Fx
- Type IV - Medial Tibial Plateau Fx (Fx Disloca)
- Type V - Bicondylar Split Fx
- Type VI - Tibial Plateau Fx with Metaphyseal - Diaphyseal Separation

AO/OTA Plateau Classification

- Type A - Extraarticular
- Type B - Partial Articular
- Type C - Intra-articular and Metaphyseal

Current Discussion on 3 Columns of Plateau Fractures



Tibial Shaft Classification

- Numerous systems
- Important variables
  - Fracture Pattern
  - Location
  - Comminution
  - Associated Fibula Fx
  - Degree of soft-tissue injury

Timing of Surgery

- Stable, resuscitated patient
- Define fracture
- Soft tissue envelope
  - Swelling
  - Ecchymosis
  - “Damage Control Orthopaedics”
- Positioning of patient
  - Other injuries

"Damage Control Orthopaedics"

- Temporary Stabilization
  - Soft Tissue Rest
  - Bony Stabilization
- Bridging ExFix
  - Across the Knee
  - Pins Out of Zone of ORIF in Tibia
  - Types V & VI Primarily
- ORIF When Soft Tissues Allow

Surgical Techniques

- Ligamentotaxis
  - Helps with Condyle Architecture
  - Does not reduce Joint Depression
- Joint Distraction
  - Temporary Bridging ExFix
  - Femoral Distractor
- Indirect Reduction

Surgical Consensus

- Joint Depression
  - Reduce From Below
  - Bone Graft Defects
- Compress with Lag Screws
- Repair Associated Ligament Avulsions
  - Restore ligamentous stability
- Preserve Meniscus
- Restore Alignment of Proximal Tibia

Surgical Considerations

- Unicondylar (Schatzker I-IV)
- Bicondylar (V and VI)
- CPT Codes
  - 27535 (Unicondylar)
  - 27536 (Bicondylar)

Unicondylar

- Single plate or screws (I)
- Rarely need locking plate
  - Osteoporotic
  - Only available implant
    - Can use non-locking screws
    - Pre-contoured newer gen plates
- Support depression
  - Bone graft
  - Substitutes

Fixation Lateral Plateau Fractures

- Traditional
  - large fragment “L” or “T” buttress plate
  - 6.5mm subchondral lag screws
  - 4.5mm diaphyseal screw
- Current Recommendation
  - small fragment fixation
  - pre-contoured peri-articular plates
  - clustered sudchondral k-wires
  - “rafting”

Bicondylar

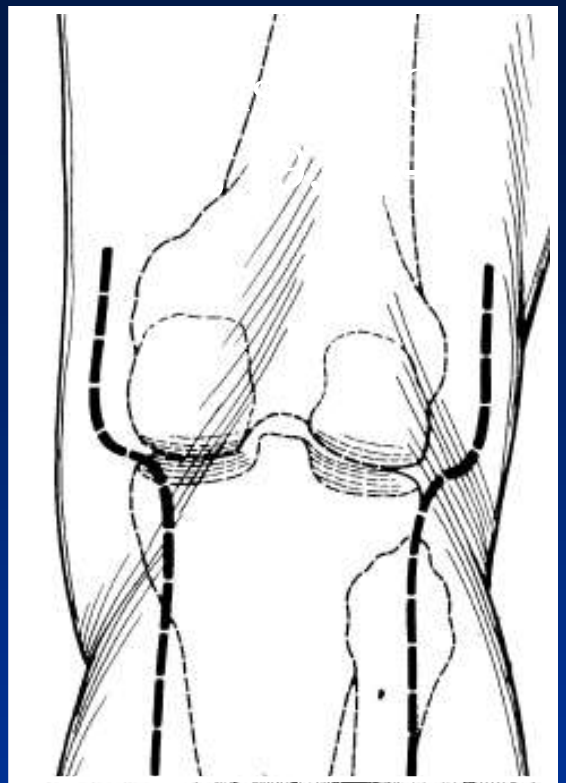
- Single Locked Plate
- Dual Plates
  - Definitely if non-locking
- Beware the Posteromedial fragment
  - Direct Reduction and Antiglide Plate
  - Indirect Reduction and AP screws
- Tibial Tuberosity Avulsion
  - AP screws
- Support depression

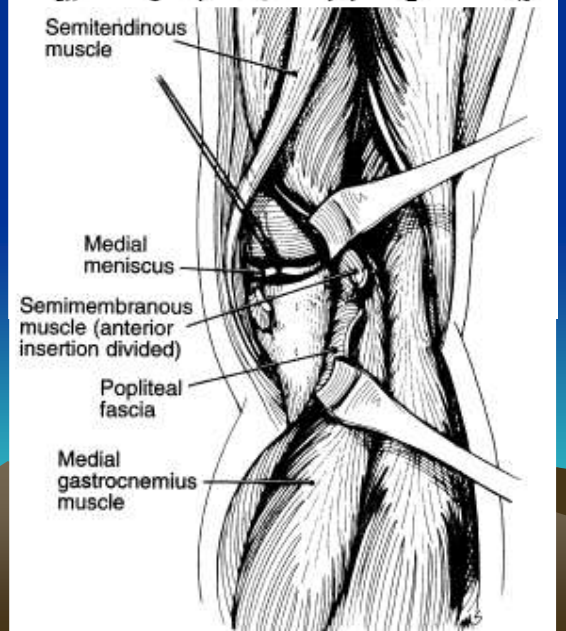
Posteromedial and Posterior Column Fragments

BEWARE !!

- Often missed
- Must Identify
- Must Reduce
  - –Direct
  - – Indirect
- Must Stabilize with Orthogonal fixation

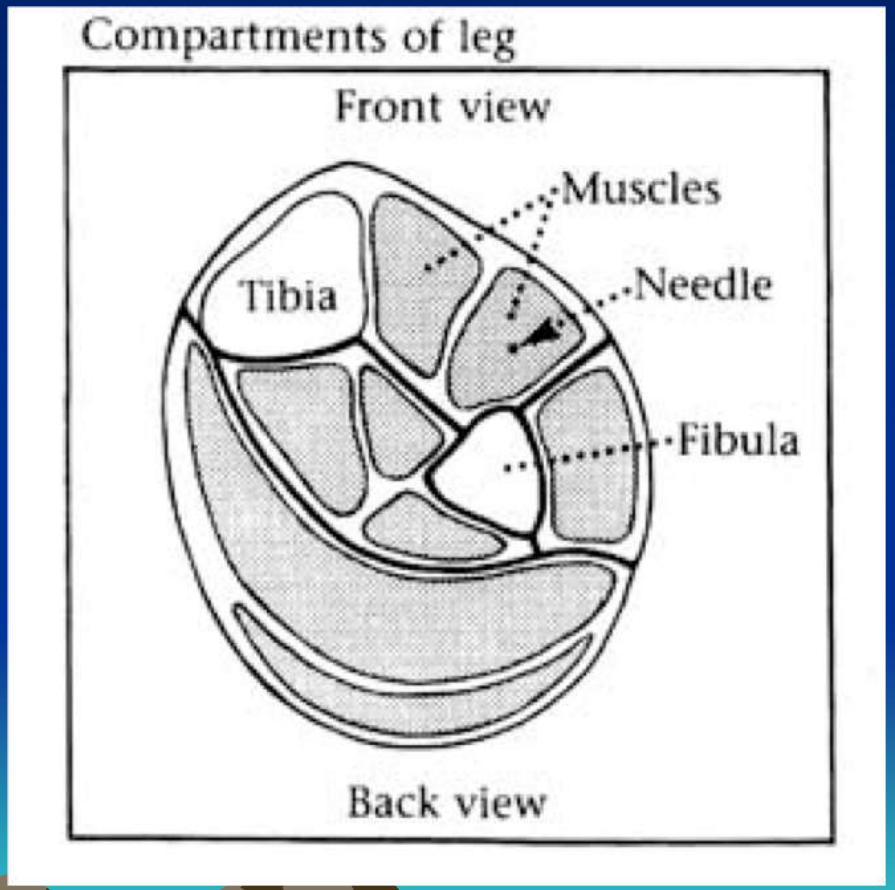
Posterior Approach(es)





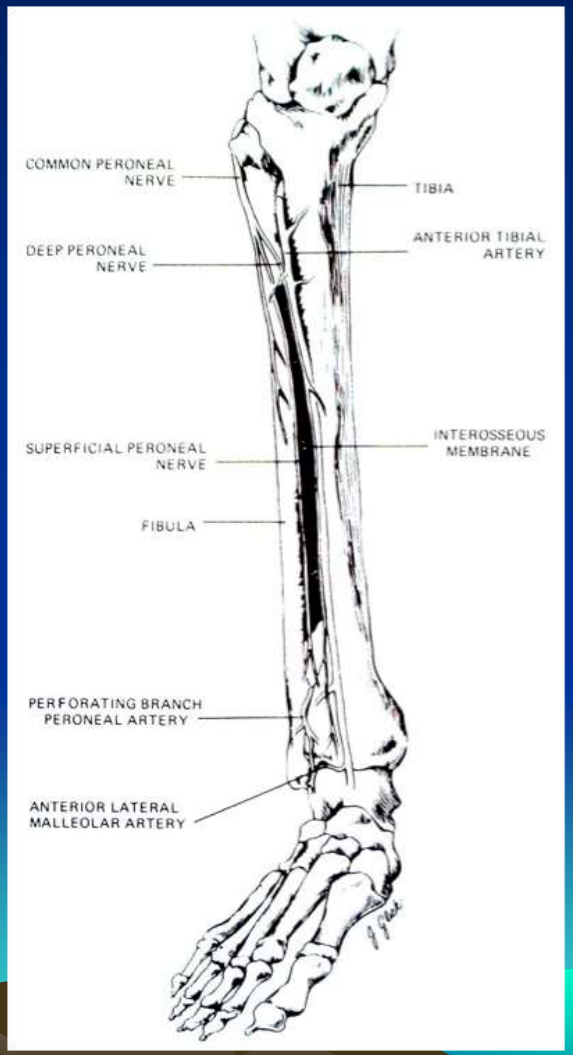
Compartment Syndrome

- Incidence:
  - 5-15%
- History
  - High-Energy
  - Crush
  - Prolonged Down Time
    - Direct External Compression
- Exam
  - 4 Compartments
  - 6 P's
    - PAIN
    - PAIN WITH PASSIVE STRETCH
    - Parasthesias
    - Pulsless
    - Pallor
    - Paralysis



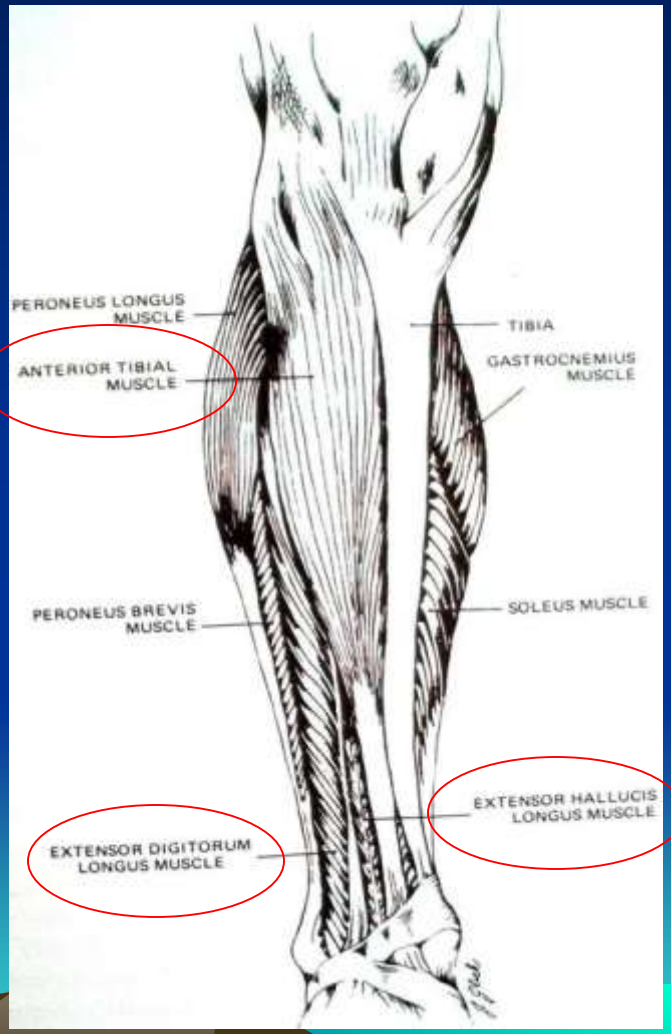
Compartment Anatomy

- Anterior
  - Deep Peroneal N.
- Lateral
  - Sup. Peroneal N.
- Deep Post.
  - Tibial N.
- Sup. Post.
  - Sural N.



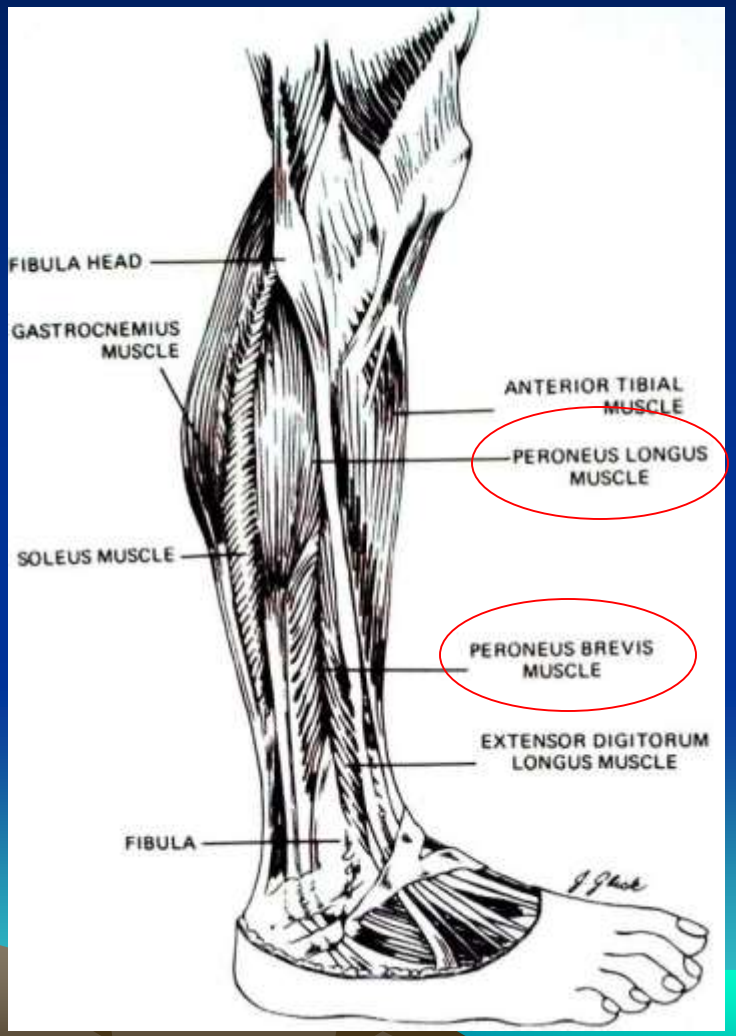
Anterior Compartment

- Action
  - Ankle dorsiflexion
- Muscles
  - Tib. Ant.
  - EDL
  - EHL
  - Peroneus Tertius
- Vessels
  - Anterior Tibial A./V.
- Nerves
  - Deep Peroneal N..
    - 1st webspace sensation



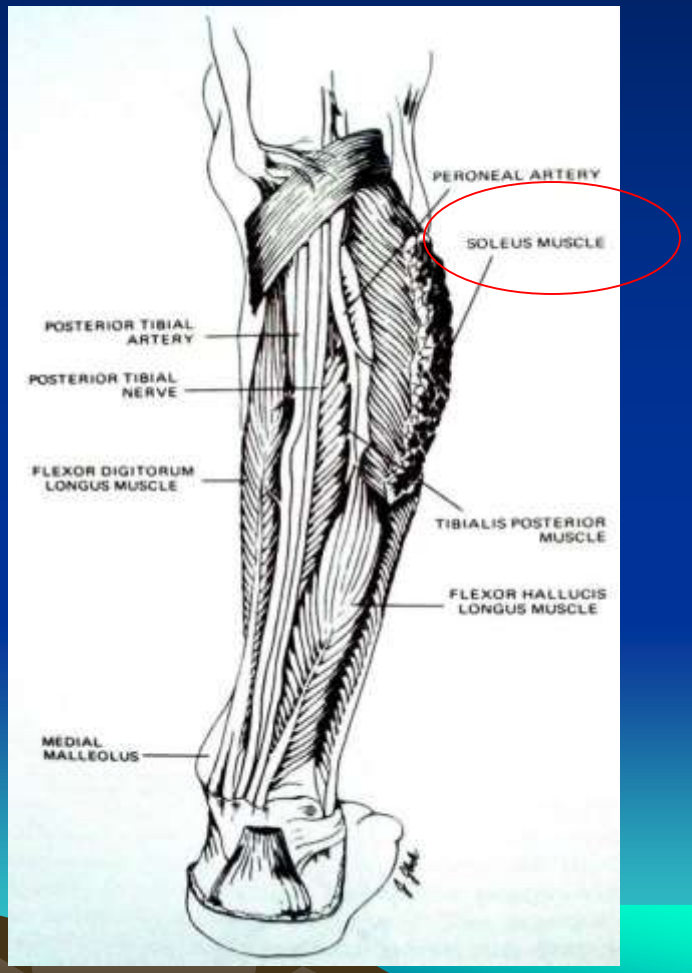
Lateral Compartment

- Action
  - Foot Eversion
- Muscles
  - Peroneus Brevis & Longus
- Nerves
  - Superficial Peroneal N.
    - Dorsal foot sensation



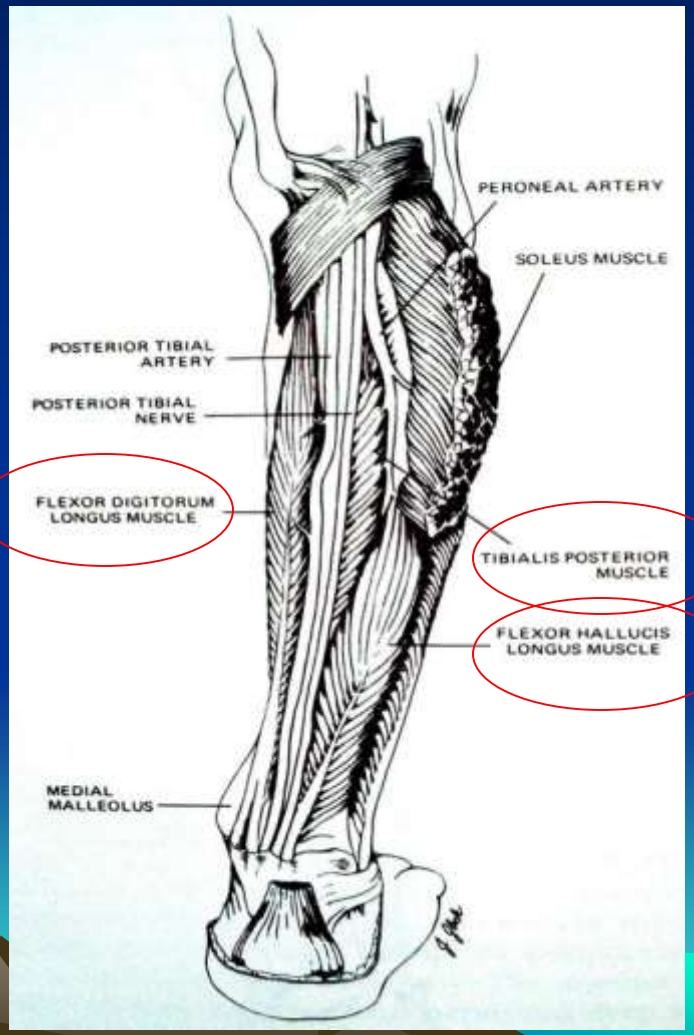
Superficial Posterior

- Action
  - Ankle Plantarflexion
- Muslces
  - Gastrocnemius
  - Soleus
  - Popliteus
  - Plantaris
- Vessels
  - Greater and Lesser Saphenous V.
- Nerve
  - Sural N.
    - Lateral heel sensation



Deep Posterior

- Actions
  - Ankle plantarflexion
  - Foot inversion
- Muscles
  - FDL
  - FHL
  - Tib. Post.
- Vessels
  - Post Tibial A./V.
  - Peroneal A.
- Nerve
  - Tibial N.
    - Plantar foot sensation



Compartment Syndrome Remains a Clinical Diagnosis

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

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

Reamed vs. Nonreamed Nails

- Reamings (osteogenic)
- Larger Nails (& locking bolts)
  - Hardware failure rare w/ newer nail designs
- Damage to endosteal blood supply?
  - Clinically proven safe even in open fx

Forster Injury ‘05
Bhandari JOT ‘00

Reamed vs Unreamed: SPRINT Trial Bhandari M, **Randomized trial of reamed and unreamed intramedullary nailing of tibial shaft fractures *JBJS*, 2008**

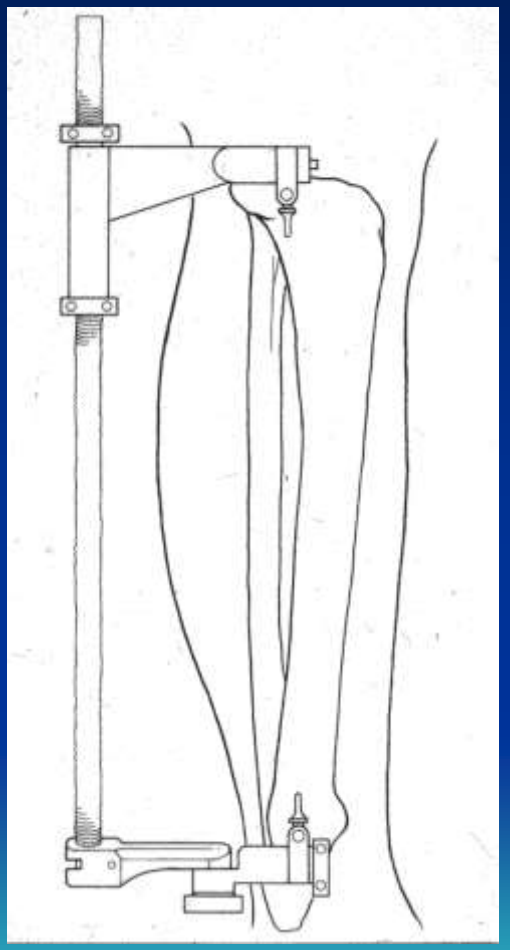
- Possible benefit of reamed IM nails in closed fractures
- No difference in open fractures
- Delaying reoperation for nonunion for at least 6 months significantly lowers the need for reoperation

Expanded Indications

- Proximal 1/3 fractures
  - Beware Valgus and Procurvatum
- Distal 1/3 fractures
  - Beware Varus or valgus
  - Beware of intraarticular extension

Hyperextended position

- Pulls patella proximally to allow straight starting angle
- Universal distractor



Beuhler JOT ‘97

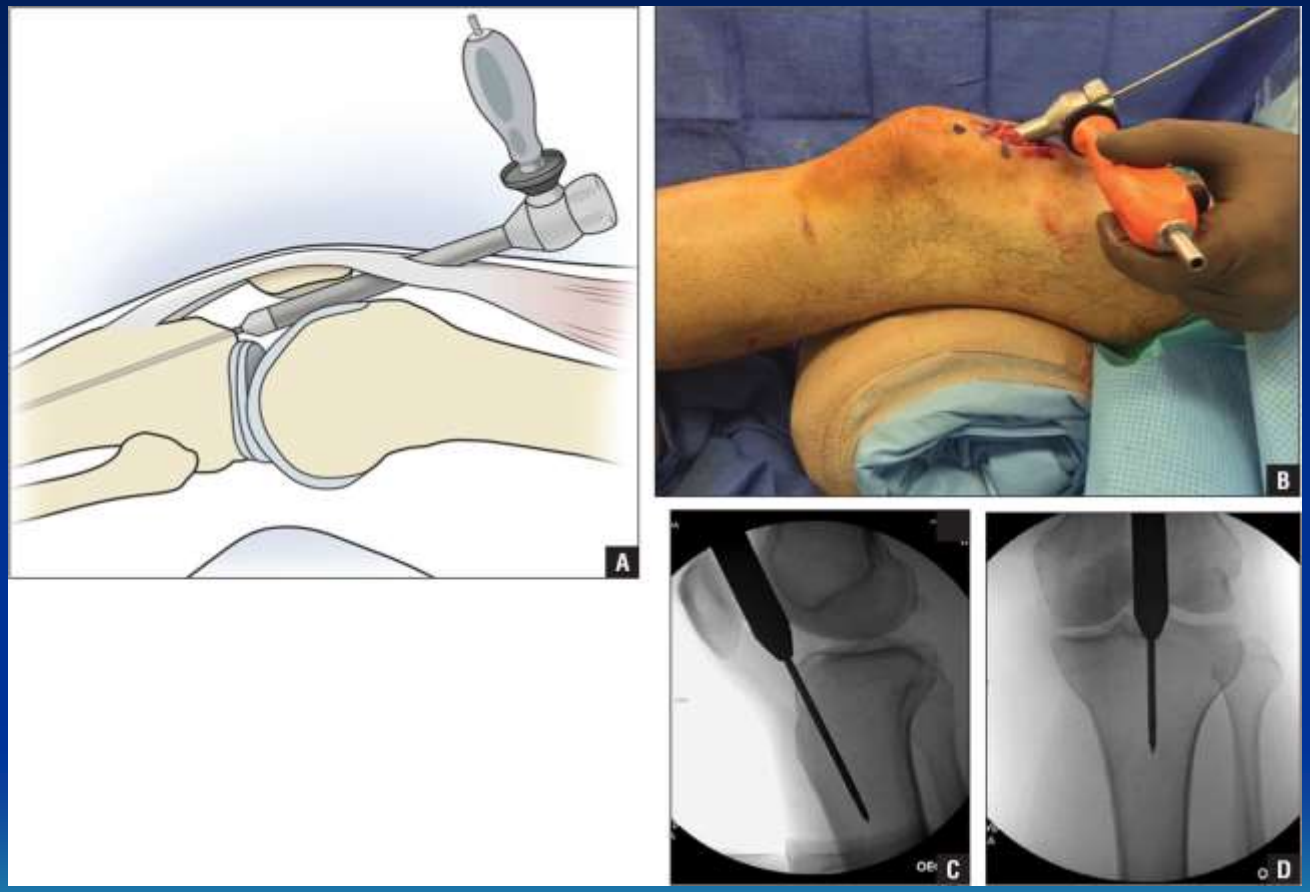
Semiextended Position and now Suprapatellar

- Neutralize quadriceps pull on proximal fragment
- Medial parapatellar approach
  - subluxate patella laterally
- Use handheld awls to gently ream through the trochlear groove

Tornetta CORR ‘96

- Now Many Manufacturers offer Suprapatellar Options with Benefits of Semi-extended

Suprapatellar



https://m3.healio.com/~/media/journals/ortho/2015/12_december/10_3928_01477447_20151119_06/fig1.jpg

Blocking (Poller) Screws

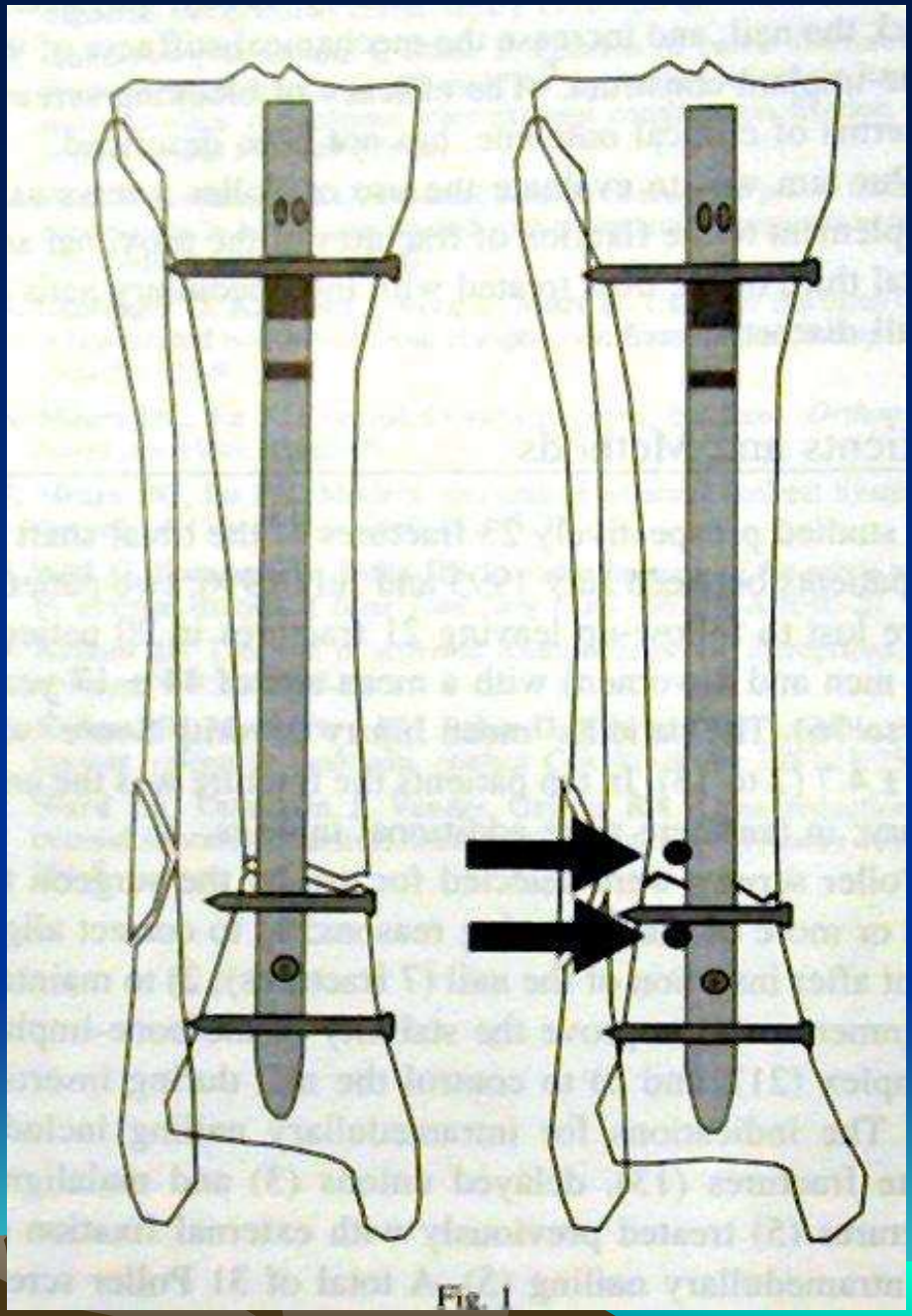
- Functionally narrows IM canal
  - Increases strength and rigidity of fixation
  - Place on concave side of deformity

- 21 patients
  - All healed within 3-12 months
  - Mean alignment 1° valgus, 2° procurvatum

Krettek JBJS ‘99

Technique

- Screws placed on concave side of deformity
- Proximal or distal fractures



Distal Tibial Fractures

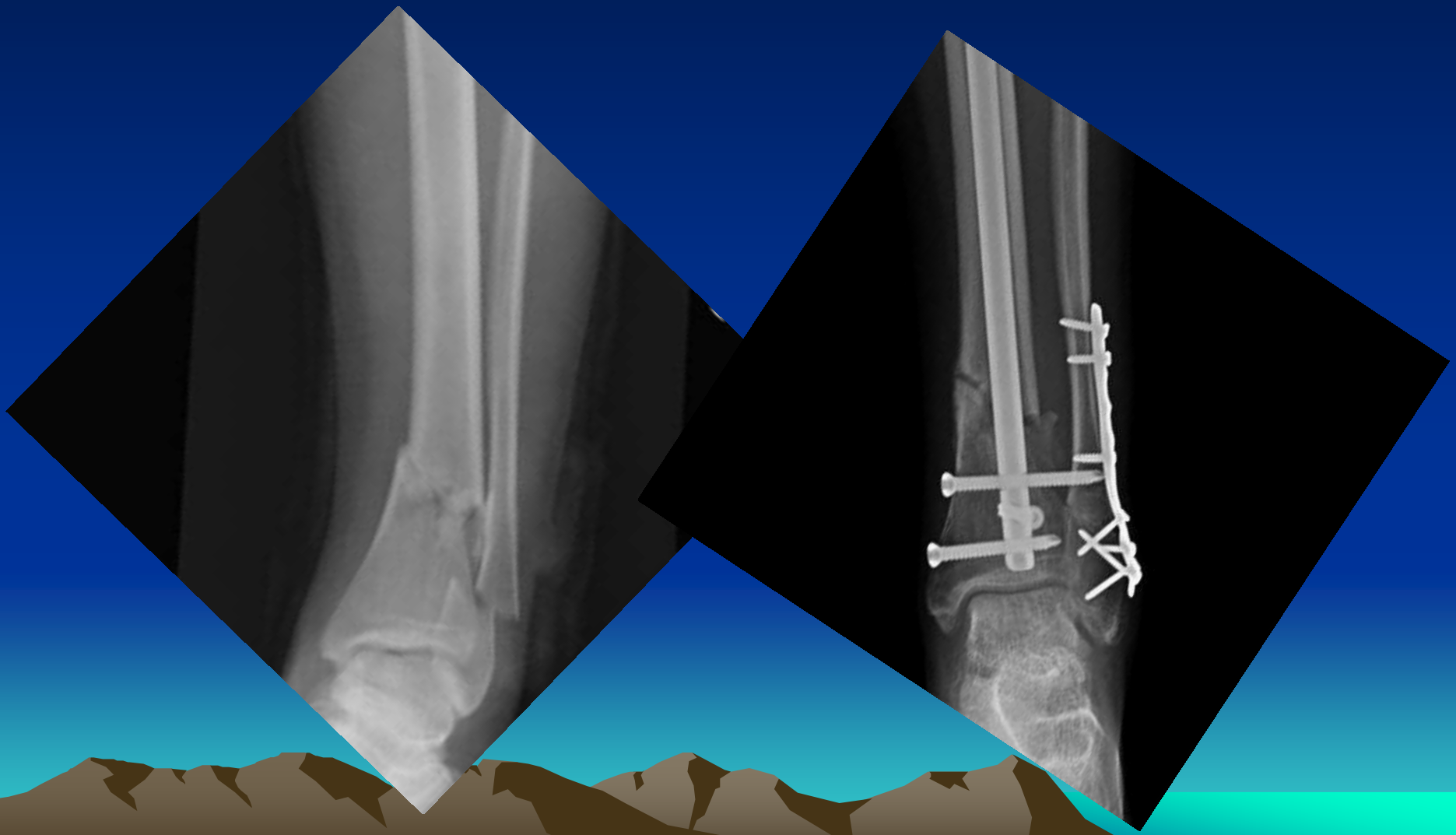
- Reduction before reaming

- Distractor
- Fibula plate/nail
- Joy Stick
- Calcaneal Traction

Universal Distractor Reduction

Beuhler JOT ‘97

Plate Fibula



Distal Tibial Joystick

Outcomes of IM Nailing

- 859 closed tibia fractures
- 92.5% union rate
- 18.5 weeks to union
- 1.9% infection rate
- 4.4% aseptic nonunion

- “Reamed intramedullary nailing will probably continue to be the best method of treating tibial diaphyseal fractures.”

Court-Brown JOT ‘04

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

Percutaneous Plate Fixation

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

- Large prospective studies yet to be evaluated

Advantages of Plating

- Anatomic reduction usually obtained
- In low energy fractures
  - 97% G/E results reported
    - Ruedi Injury

Disadvantages of Plating

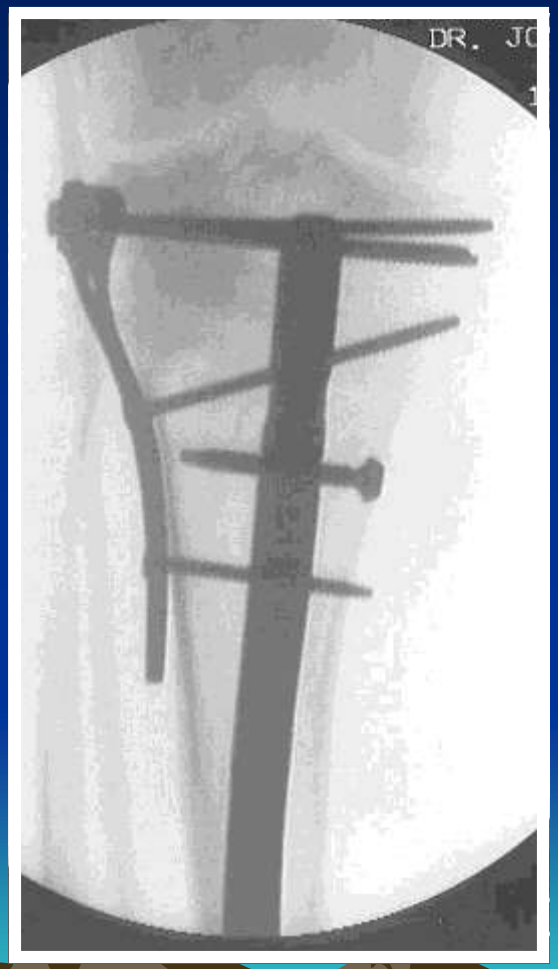
- Increased risk of infection and soft tissue problems, especially in high energy fractures
- Higher rate hardware failure than IM nail
- Delayed WB (load bearing)

Johner CORR ‘83

External Fixation

- Generally reserved for open tibia fractures or periarticular fractures

Combination Reduction



Advantages of External Fixator

- Can be applied quickly in polytrauma patient
- Allows easy monitoring of soft tissues and compartments
- Modifiable
- No long term deep HW
- Evolution: More Commonly used for Temporary Damage Control

Bibliography

- Bonnevialle P et al. OTRC. 2010;96(1): 64-9.
- Engebretsen L et al. KSSTA 2009; 17(9):1013-26.
- Fanelli GC et al. Arthroscopy 2002;18:703–714.
- Harner CD et al. JBJS 2004; 86A;262-273.
- Kennedy JC. JBJS 1963; 45A:889-904.
- Liow RW et al. JBJS Br 2003:85(6):845-51.
- Meyers MH et al. JBJS 1971; 53A:16-29.
- Mills WJ et al. JOT. 2003;17(5):338-45.
- Mills WJ et al. J Trauma 2004;56(6):1261-5.
- Moore TM. CORR 1981; ;(156):128-40.
- Niall DM et al. JBJS Br 2005: 87(5):664-7.

Bibliography

- Ohkoshi Y et al. CORR 2002; ;(398):169-75.
- Robertson A et al. JBJS Br 2006; 88;706-11.
- Schenck RC et al. South Med J 1992; 85(3S): 61.
- Schenck RC et al. Arthroscopy 1999; 15(5):489-495.
- Shelbourne KD et al. Orthop Rev 1991;20:995-1004.
- Stannard JP et al. JBJS 2004 86:910-915, 2004.
- Szalay MJ et al. Injury. 1990;21(6):398-400.
- Templeman DC et al. JBJS 1989;71(9):1392-5.
- vanRaay JJ et al. AOTS 1991 ;110(2):75-7.
- Walling AK et al. JBJS 1982;64(9):1324-7.

Bibliography

- Rasmussen Acta Orthop Scand 1972; 43:566-572
- Rasmussen P, JBJS 55, 1973
- Schatzker, Clin Orthop, 1979
- Moore, Clin Orthop, 1981
- Lansinger JBJS 1986; 68A:13-19
- Jensen et al JBJS 1990; 72B:49-2
- Honkonen J Orthop Trauma 1995; 4:273-277
- Beris et al Bull Hosp Joint Dis 1996
- Koval, J Orthop Trauma, 1996
- Twaddle et al AAOS, 1997
- Hubbard et al. Amer J Ortho, 1999
- Lobenhoffer et al, JOT 13 1999
- Westmoreland et al J Ortho Trauma 2002
- Karunaker et al. J Ortho Trauma 2002

Recent Bibliography

- Gaston et al, JBJS 87B(9) 2005
- Barei et al, JBJS 88A(8) 2006
- Berkson and Virkus, JAAOS 14(1) 2006
- The COTS, JBJS 88A(12) 2006
- Barei et al, JOT 22(3) 2008
- Russell et al, JBJS 90(10) 2008
- Mahadeva et al, Arch Orthop Trauma Surg 128 2008
- Musahl et al, JBJS 91B(4) 2009
- Hall et al, JBJS 91A(Suppl 2) 2009
- Cullen et al, JOT 23(7) 2009
- Higgins et al, JOT 23(1) 2009
- Brunner et al, Injury 41 2010
- Lindeque and Baldini, Orthopaedics 33(1) 2010