Trauma Review

Kent State University
College of Podiatric Medicine
2019 Board Review Course

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Podiatric Traumatology

History

- "The world's oldest known surgical
- document, the Edwin Smith Surgical
- Papyrus (ca. 17th century BC), classified 48 traumatic injuries from the ancient Egyptian battlefields and construction sites as successfully treatable, possibly curable, or untreatable"

Mattox KL, Moore EE, Feliciano DV: TRAUMA, 7th ed., 2013

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Podiatric Traumatology

History

- French and Indian War
- American Revolutionary War
- American Civil War
- World War I
- World War II
- Korean War
- Vietnam War
- Iraq Wars

Townsend CM et al.: SABISTON TEXTBOOK OF SURGERY: The Biological Basis of Modern Surgical Practice, 19th ed, 2012.

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JOINT TRAUMA SYSTEM CLINICAL PRACTICE GUIDELINE (JTS CPG)

Orthopaedic Trauma: Extremity Fractures (CPG ID: 56)

To describe the initial non-surgical and surgical management of extremity fractures and to define care guidelines for fractures of upper and lower extremities.

Contributors

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Opinions, interpretations, conclusions, and recommendations are those of the authors and are not necessarily endorsed by the Services or DoD.

Trauma Evaluation

Pre hospital Care
Evaluate the scene
Perform initial assessment
Critical interventions/triage
Transport patient

Townsend CM et al.: SABISTON TEXTBOOK OF SURGERY: The Biological Basis of Modern Surgical Practice, 19th ed, 2012.

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Personality of Injury

Extremity Evaluation
Entire extremity
Gross deformity
Neurovascular status
Joint motion
Wound
Bleeding

Court-Brown CM et al: ROCKWOOD AND GREEN'S: FRACTURES IN ADULTS, 8th edition, Vols. 1 & 2., 2015

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Soft Tissue Injury

High Energy
Axial Load
Crush Injury
Closed Fracture
Compartment Syndrome
Open Fracture
Gunshot Wound

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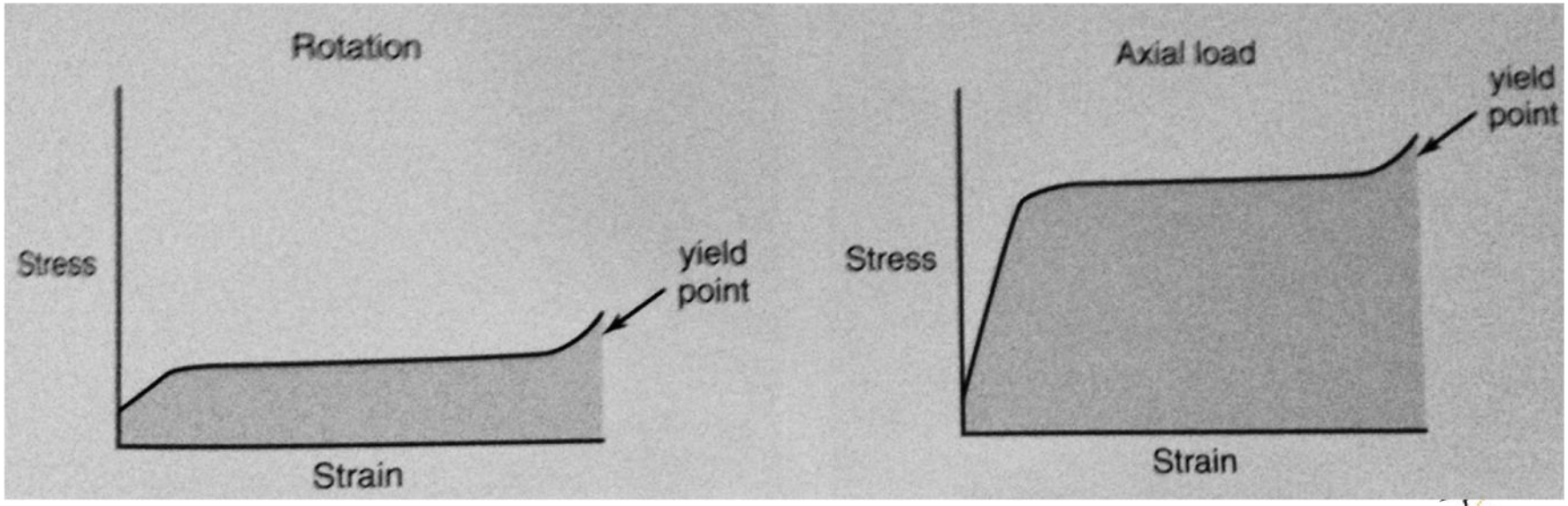
Axial Load

Indirect soft tissue injury
Rapid axial load force
Viscoelastic property of bone
At failure, released energy imparted to surrounding soft tissues



High Energy Injuries

TABLE 10-1 Energy Transmitted by Injury Mechanism (ft–lb)[37]

• Fall from curb	100
• Skiing injury	300–500
• High-velocity gunshot wound (single missile)	2000
• 20-mph bumper injury (assumes bumper strikes fixed target)	100,000

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High Energy Injuries

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Crush Injuries

Direct soft tissue injury
Quick, high energy
Sustained, low energy
Zone of Injury
Demarcation

Crush Injuries

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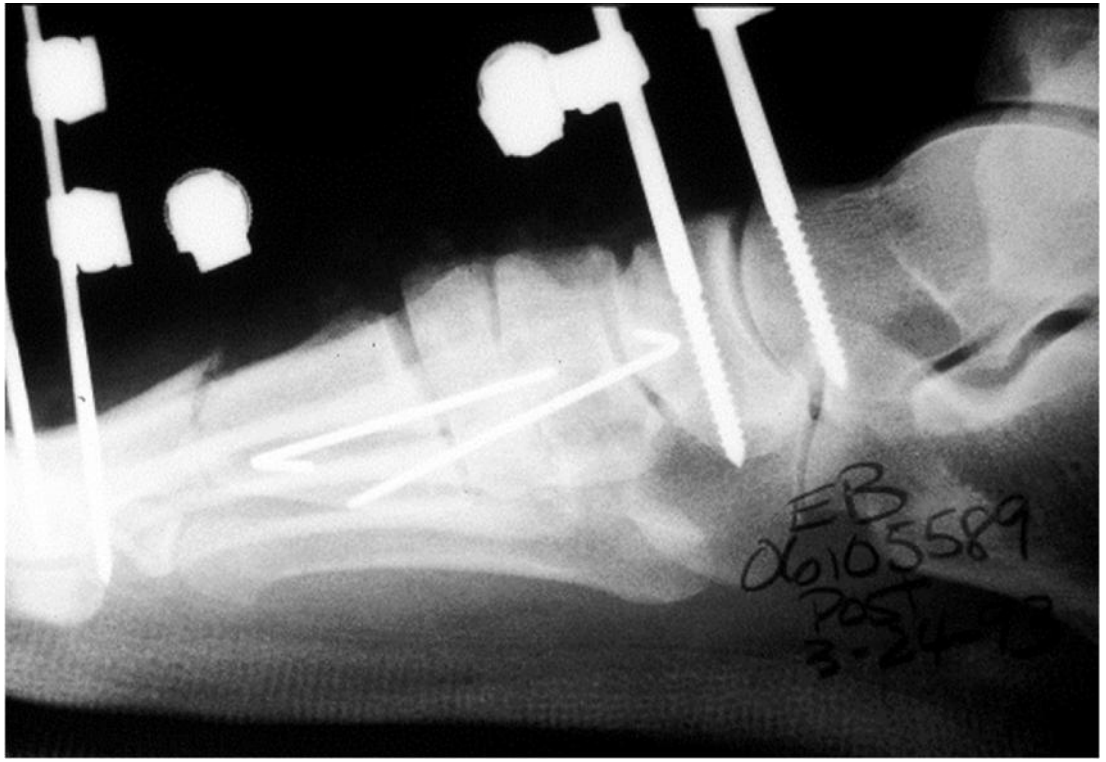

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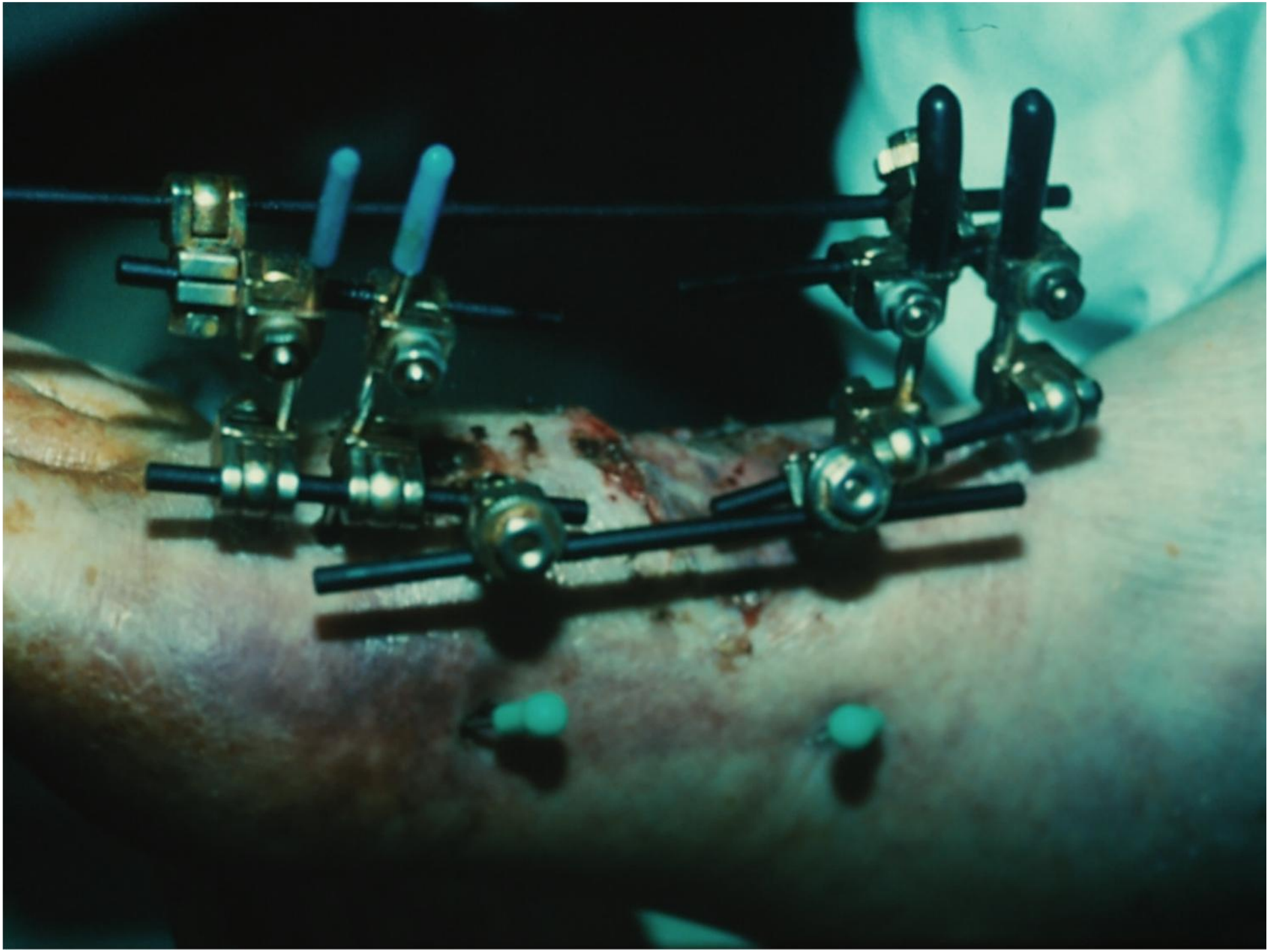

Soft Tissue Injury

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Soft Tissue Injury

Full understanding the "zone of injury" may not be appreciated for several days

Skin and fascia

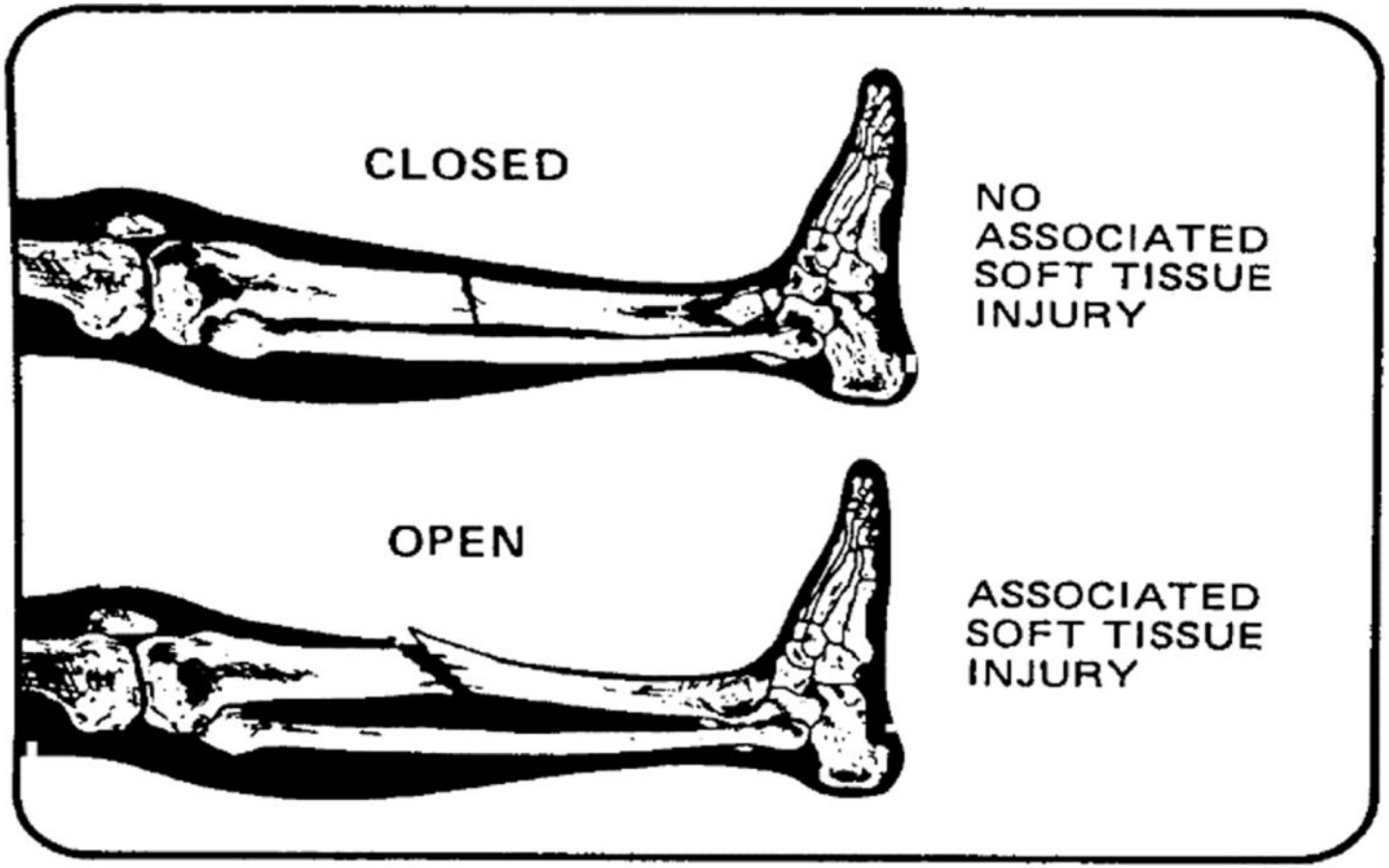
Musculotendinous unit

Neurovascular structures

Fracture Blisters

Open Fracture

- Osseous injury with a concomitant break in skin integrity



Goals of Open Fracture Treatment

1. Prevent Infection
2. Promote Fracture Healing
3. Restore Function without Complications

Principles of Treatment

- Avoid infection
  - Early meticulous debridement
- Salvage the soft tissue envelope
- Fracture stabilization

Open Fracture Treatment

- Trauma assessment
- Lower extremity examination
- X-rays/CT scan
- Tetanus
- IV antibiotics
- Emergent washout
- OR debridement & fracture stabilization
- Return to OR for further debridement/definitive procedures

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Wound Size

The size and the nature of external wound may not reflect the damage to the deeper structure

Presence of open wound does not preclude the occurrence of compartment syndrome

Court-Brown CM et al: ROCKWOOD AND GREEN'S: FRACTURES IN ADULTS, 8th edition, Vols. 1 & 2., 2015

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Contamination

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Contamination

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Table 1

Short Version of the Gustilo Classification System of Open Fractures[a]

Type	Description
I	Wound <1 cm, clean
II	Wound >1 cm, no extensive soft tissue damage
IIIA	Extensive soft tissue damage with adequate coverage
IIIB	Extensive soft tissue damage with inadequate coverage
IIIC	Arterial injury requiring repair

[a]*Data from Gustilo and Anderson[10] and Gustilo et al.[11]*

Table 2

Expanded Version of the Gustilo Classification System of Open Fractures[a]

	Fracture Type				
Feature	**I**	**II**	**IIIA**	**IIIB**	**IIIC**
Wound size, cm	<1	>1	>1	>1	>1
Energy	Low	Moderate	High	High	High
Contamination	Minimal	Moderate	Severe	Severe	Severe
Deep soft tissue damage	Minimal	Moderate	Severe	Severe	Severe
Fracture comminution	Minimal	Moderate	Severe/ segmental fractures	Severe/ segmental fractures	Severe/ segmental fractures
Periosteal stripping	No	No	Yes	Yes	Yes
Local coverage	Adequate	Adequate	Adequate	Inadequate	Adequate
Neurovascular injury	No	No	No	No	Yes
Infection rate	0%-2%	2%-7%	7%	10%-50%	25%-50%

[a]*Data from Gustilo et al,[3] Gustilo and Anderson,[10] and Gustilo et al.[11]*

Gustilo and Anderson

Type I
Wound < 1cm
Contaminated by definition
Minimal soft tissue injury
Usually Simple fracture pattern

Court-Brown CM et al: ROCKWOOD AND GREEN'S: FRACTURES IN ADULTS, 8th edition, Vols. 1 & 2., 2015

The Goldfarb Foundation

Gustilo and Anderson

Gustilo and Anderson

Type II
Wound > 1cm
Contamination
No extensive soft tissue injury
Simple or Moderate comminution

Court-Brown CM et al: ROCKWOOD AND GREEN'S: FRACTURES IN ADULTS, 8th edition, Vols. 1 & 2., 2015

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Gustilo and Anderson

Gustilo and Anderson

Type III
Wound > 5cm
Highly contaminated
Severe soft tissue injury with crush component
Usually Comminuted Fracture

Court-Brown CM et al: ROCKWOOD AND GREEN'S: FRACTURES IN ADULTS, 8th edition, Vols. 1 & 2., 2015

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Gustilo and Anderson

Type III
A: High energy, soft tissue coverage possible (no periosteal stripping)
B: Inadequate soft tissue coverage with periosteal stripping
C: open fracture with arterial injury regardless of soft tissue component

Gustilo and Anderson

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Gustilo and Anderson

Infection

- ALL open fractures are contaminated wounds that can become infected
- Type 1 = gram + cocci
- Type 2 & 3 = gram – rods

Initial Management

Infection Prevention
Antibiotic Prophylaxis
Surgical Debridement
Tetanus Prophylaxis

Court-Brown CM et al: ROCKWOOD AND GREEN'S: FRACTURES IN ADULTS, 8th edition, Vols. 1 & 2., 2015

Table 3

Dosages of Some of the Most Commonly Used Antibiotics in the Treatment of Open Fractures[a]

Antibiotic	Dose
Cefazolin (first-generation cephalosporin)	100 mg/kg/d divided into 3 doses every 8 h, maximum 2 g per dose
Gentamicin (aminoglycoside)	5-7.5 mg/kg/d divided into 3 doses every 8 h
Penicillin	150,000 units/kg/d divided into 4 doses given every 6 h, maximum dose of 6 million units per dose
Clindamycin	15-40 mg/kg/d divided into 3 doses every 8 h, maximum dose of 2.7 g/d

[a]*Data from Johnson et al.*[32]

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Systemic Antibiotics

Why?

946 open fractures

Infection rates

Antistaphylococcal cephalosporin – 2.3%

PCN and Streptomycin – 9.7%

No antibiotics – 13.9%

When?

Ideally within 3 hours of trauma

Patzakis MJ: West J Med. 130:62, 1979

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JOINT TRAUMA SYSTEM CLINICAL PRACTICE GUIDELINE (JTS CPG)

Infection Prevention in Combat-Related Injuries (CPG ID: 24)

Provides rationale and guidance for the prevention of infection after combat-related injuries.

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First Publication Date: 14 Nov 2009 | Publication Date: 08 Aug 2016 | Supersedes CPG dated 02 Apr 2012

Opinions, interpretations, conclusions, and recommendations are those of the authors and are not necessarily endorsed by the Services or DoD.

LEVEL OF CARE*	CARE CATEGORY	RECOMMENDATIONS
Role 1 (Prehospital)	Initial care in the field	• Bandage wounds with sterile dressings (avoid pressure over eye wounds) • Stabilize fractures • Transfer to surgical support as soon as feasible
	Post-injury antimicrobials	• Provide single dose point of injury antimicrobials (Appendix B) if evacuation is delayed or expected to be delayed
Role 1 and Role 2 without surgical support (IIa)	Post-injury antimicrobials	• Provide intravenous antimicrobials for open wounds (Appendix B) as soon as possible (within 3 hours). • Provide tetanus toxoid and immune globulin as appropriate. • Gram negative coverage with aminoglycoside or fluoroquinolone not recommended. • Addition of penicillin to prevent clostridial gangrene or streptococcal infection is not recommended. • Redose antimicrobials if large volume blood product resuscitation • Use only topical antimicrobials for burns.
	Debridement and irrigation	• Irrigate minor wounds to remove gross contamination with normal saline, sterile, or potable water without additives. • Debridement and irrigation of large wounds should be done at a surgical facility (Role IIb or III). • Do not attempt to remove retained deep soft tissue fragments if criteria met. Provide Cefazolin 2 gm IV x 1 dose.
Role 2 with surgical support and Role 3	Post-injury antimicrobials	• Provide intravenous antimicrobials (Appendix B) as soon as possible (within 3 hours). • Provide tetanus toxoid and immune globulin as appropriate. • Gram negative coverage with aminoglycoside or Fluroquinolone not recommended. • Addition of penicillin to prevent clostridia gangrene or streptococcal infection is not recommended. • Redose antimicrobials if large volume blood product resuscitation. • Use only topical antimicrobials for burns • Antimicrobial beads or pouches may be used. • Provide post splenectomy immunizations if indicated.
	Debridement and irrigation	• Irrigate wounds to remove contamination with normal saline or sterile water using bulb irrigation, gravity irrigation, or pulse lavage without additives. For open fractures, use 3 L for each type I, 6 L for each type II, and 9 L for each type III extremity fractures. • Repeat debridement and irrigation every 24-48 hours until wound is clean and all devitalized tissue is removed. • Do not attempt to remove retained deep soft tissue fragments if criteria met.† Provide Cefazolin 2 gm IV x 1 dose. • Do not obtain cultures unless infection is suspected.
	Other surgical management	• Surgical evaluation as soon as possible. • Only dural and facial wounds should undergo primary closure. • Negative pressure wound therapy (NPWT) can be used. • External fixation (temporary spanning) of femur/tibia fractures.

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INJURY	PREFERRED AGENT(S)	ALTERNATE AGENT(S)	DURATION
EXTREMITY WOUNDS (INCLUDES SKIN, SOFT TISSUE, BONE)			
Skin, soft tissue, no open fractures	Cefazolin, 2 gm IV q6-8h†‡	Clindamycin (300-450 mg PO TID or 600 mg IV q8h)	1-3 days
Skin, soft tissue, with open fractures, exposed bone, or open joints	Cefazolin 2 gm IV q6-8h†‡§	Clindamycin 600 mg IV q8h	1-3 days
THORACIC WOUNDS			
Penetrating chest injury without esophageal disruption	Cefazolin, 2 gm IV q6-8h†‡	Clindamycin (300-450 mg PO TID or 600 mg IV q8h)	1 day
Penetrating chest injury with esophageal disruption	Cefazolin 2 gm IVq 6-8h†‡ PLUS metronidazole 500 mg IV q8-12h	Ertapenem 1 gm IV x 1 dose, OR moxifloxacin 400 mg IV x 1 dose	1 day after definitive washout
ABDOMINAL WOUNDS			
Penetrating abdominal injury with suspected/known hollow viscus injury and soilage; may apply to rectal/perineal injuries as well	Cefazolin 2 gm IV q 6-8h†‡ PLUS metronidazole 500 mg IV q8-12h	Ertapenem 1 gm IV x 1 dose, OR moxifloxacin 400 mg IV x 1 dose	1 day after definitive washout
MAXILLOFACIAL AND NECK WOUNDS			
Open maxillofacial fractures, or maxillofacial fractures with foreign body or fixation device	Cefazolin 2 gm IV q6-8h†‡	Clindamycin 600 mg IV q8h	1 day
CENTRAL NERVOUS SYSTEM WOUNDS			
Penetrating brain injury	Cefazolin 2 gm IV q6-8h.†‡ Consider adding metronidazole 500 mg IV q8-12h if gross contamination with organic debris	Ceftriaxone 2 gm IV q24h. Consider adding metronidazole 500 mg IV q8-12h if gross contamination with organic debris. For penicillin allergic patients, Vancomycin 1 gm IV q12h PLUS ciprofloxacin 400 mg IV q8- 12h	5 days or until CSF
Penetrating spinal cord injury	Cefazolin 2 gm IV q6-8h.†‡ ADD metronidazole 500 mg IV q8-12h if abdominal cavity is involved	As above. ADD metronidazole 500 mg IV q8- 12h if abdominal cavity is involved	5 days or until CSF leak is closed, whichever is longer
EYE WOUNDS			

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IV Antibiotics

- Therapeutic, NOT Prophylactic
- First generation cephalosporin
  - Ancef = 2 gm initially, then 1gm Q8 hours
- Aminoglycoside
  - Gentamycin = 3-5 mg/kg daily
- Soil contamination or farm injuries = 10-20 million units penicillin G daily
- Broad Spectrum?
- PCN allergy = clindamycin or vancomycin
- Duration = 72 hours

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IV Antibiotics

Classic Recommendations
Absence of organic/sewage contamination
Ancef 2gm or clindamycin 600mg
Gustilo Type III fractures
Aminoglycoside 1.5mg/kg loading dose
Organic/sewage contamination
PCN +/- Metronidazole

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IV Antibiotics

Evidence Supports
Intravenous antibiotics within three hours
Use of metronidazole and aminoglycoside in severely contaminate open fractures
Equivalent efficacy of oral to parenteral antibiotics during follow-up

Court-Brown CM et al: ROCKWOOD AND GREEN'S: FRACTURES IN ADULTS, 8th edition, Vols. 1 & 2., 2015

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IV Antibiotics

Duration
72 hours or wound closure
Reinstituted with each procedure
Prolonged utilization is discouraged
Drains, drainage or pin tract
As a substitute for debridement

Glass GE et al: J Plast Reconstr Aesthet Surg 64: 375-380, 2011

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Tetanus Prophylaxis

Previously immunized

Patients who have been previously immunized against tetanus (received 3 or more doses of toxoid - Td) do not require booster dose of vaccine unless it has been more than 5 years since their last dose. They do not require tetanus immune globulin (TIG)

Not immunized or unknown

Patients should receive TIG and vaccine (with additional doses of vaccine given at 4 weeks and 6 months) post injury

Hospenthal DR: J Trauma 71: S290-S298, 2011

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Surgical
STEEL!

Debridement

Of the edge of the skin
take a piece very thin
The tighter the fascia
the more you should slash'er
Of the muscle much more
till you see fresh gore
And the bundles contract
at the least impact
Leave intact the bone
except bits quite alone

Sir James Learmonth from D'Ambrosia et al Orthopedic Infections 1989

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Debridement

Skin Viability
Bleeding edge
Fluorescein dye – Indocyanine green
LUNA and SPY
Split thickness skin excision

Southerland JT et al: MCGLAMRY'S COMPREHENSIVE TEXTBOOK OF FOOT AND ANKLE SURGERY, 4th edition, Vols. I & II. 2014

Debridement

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Debridement

Muscle Viability
Color
Consistency
Contractility
Capacity to bleed

Court-Brown CM et al: ROCKWOOD AND GREEN'S: FRACTURES IN ADULTS, 8th edition, Vols. 1 & 2., 2015

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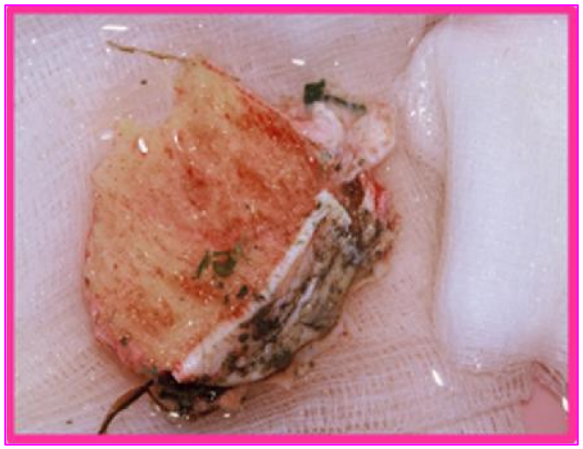
Debridement

Bone
Bone ends and medullary cavity
Impregnated foreign material
Excise pieces devoid of soft tissues



Court-Brown CM et al: ROCKWOOD AND GREEN'S: FRACTURES IN ADULTS, 8th edition, Vols. 1 & 2., 2015

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Irrigation

Evidence Supports

I: 3 Liters, II: 6 Liters, & III: 9 Liters

Decrease bacteria / contamination

Clears nonviable tissue and debris

No advantage antiseptic / antibiotics

Antiseptics

Impair osteoblast fx and wound healing

Court-Brown CM et al: ROCKWOOD AND GREEN'S: FRACTURES IN ADULTS, 8th edition, Vols. 1 & 2., 2015

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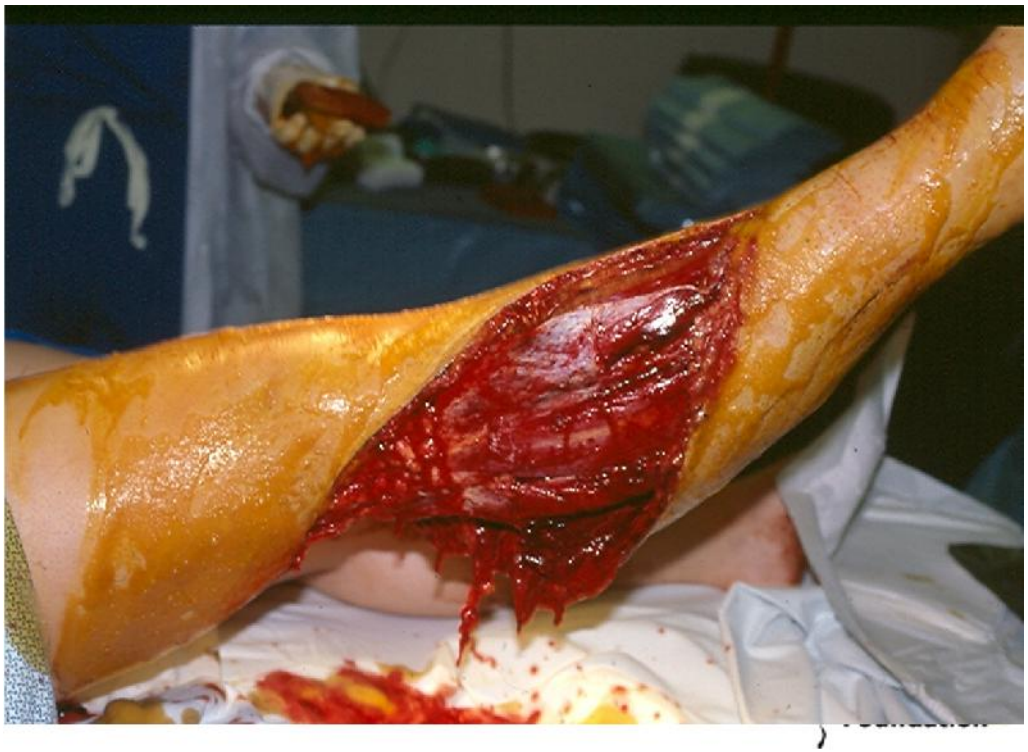
“Golden Period”

- First 8 hours post injury
- Contaminated Wound
- > 8 hours = Infected Wound



Fracture Stabilization

Restoration of length
Alleviate pain
Prevent further soft tissue damage
Aid in wound care and healing

Court-Brown CM et al: ROCKWOOD AND GREEN'S: FRACTURES IN ADULTS, 8th edition, Vols. 1 & 2., 2015

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Fracture Stabilization

Plaster casts and traction
External fixation
Primary internal fixation
Plate fixation
IM Nail
Percutaneous pins/wires

Court-Brown CM et al: ROCKWOOD AND GREEN'S: FRACTURES IN ADULTS, 8th edition, Vols. 1 & 2., 2015

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Fracture Stabilization

Fracture Stabilization

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Musculoskeletal Stability

Protects noninjured tissue/microvasculature

Enhances capillary proliferation

Improves tissue micro perfusion

Optimizes local wound condition

Provision for soft tissue care

Eliminates dead space

Chapman M Instr Cours Lect 31: 75-87, 1982

Fracture Stability

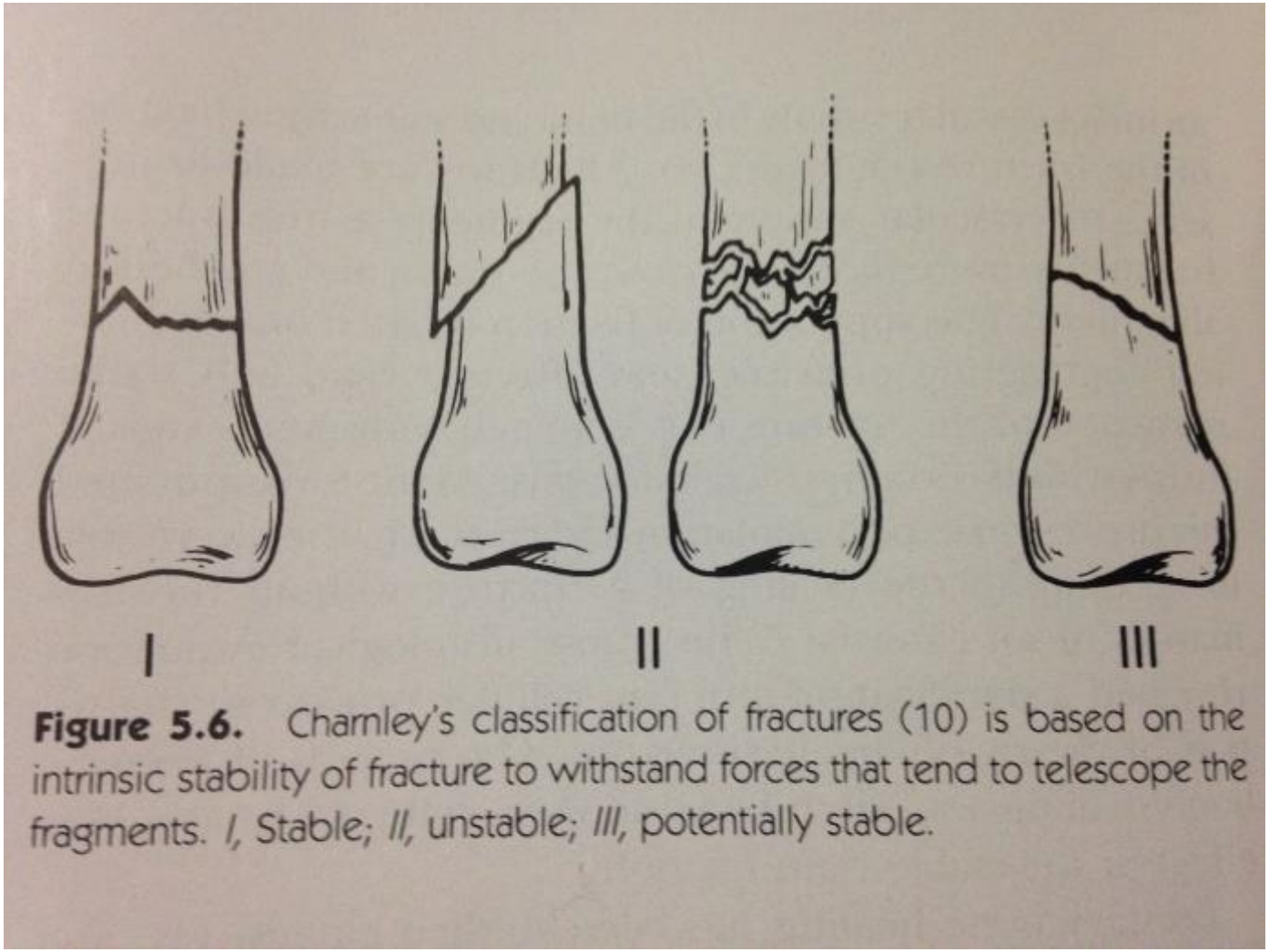

Figure 5.6. Charnley's classification of fractures (10) is based on the intrinsic stability of fracture to withstand forces that tend to telescope the fragments. *I*, Stable; *II*, unstable; *III*, potentially stable.

Fixation Principles

Relative Stability: maintain reduction and still keep the mechanical stimulation for fracture repair by callus formation

External fixators, intramedullary nails, and internal fixators

Ruedi TP, Buckley RE, Moran CG: AO PRINCIPLES OF FRACTURE MANAGEMENT, Vols. 1 & 2, 2nd edition, Thieme, New York, 2007.

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Fixation Principles

Absolute Stability: provide a mechanically neutral environment at the fracture site, no motion at the fracture site.

Lag screws, plates

Ruedi TP, Buckley RE, Moran CG: AO PRINCIPLES OF FRACTURE MANAGEMENT, Vols. 1 & 2, 2nd edition, Thieme, New York, 2007.

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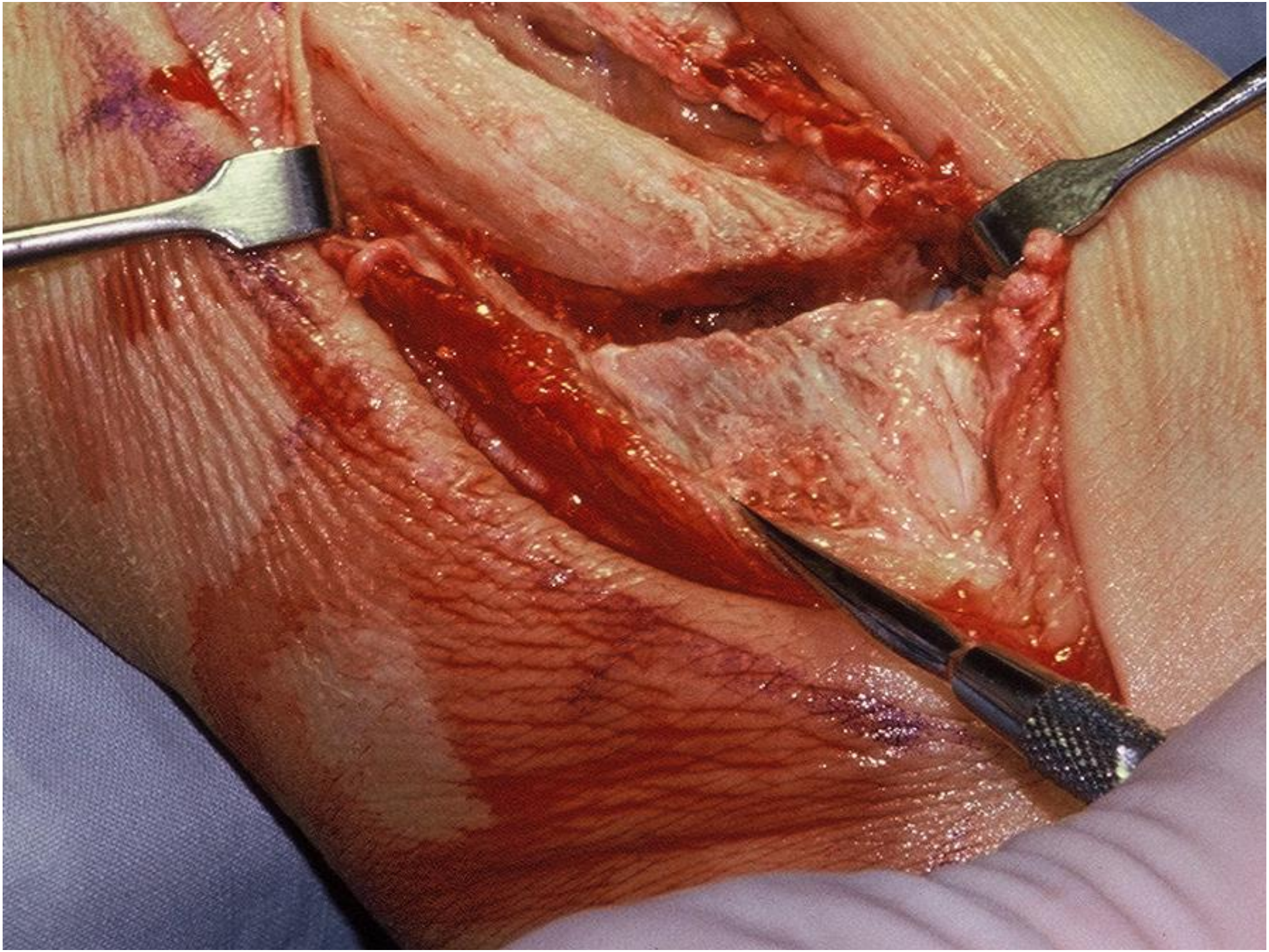

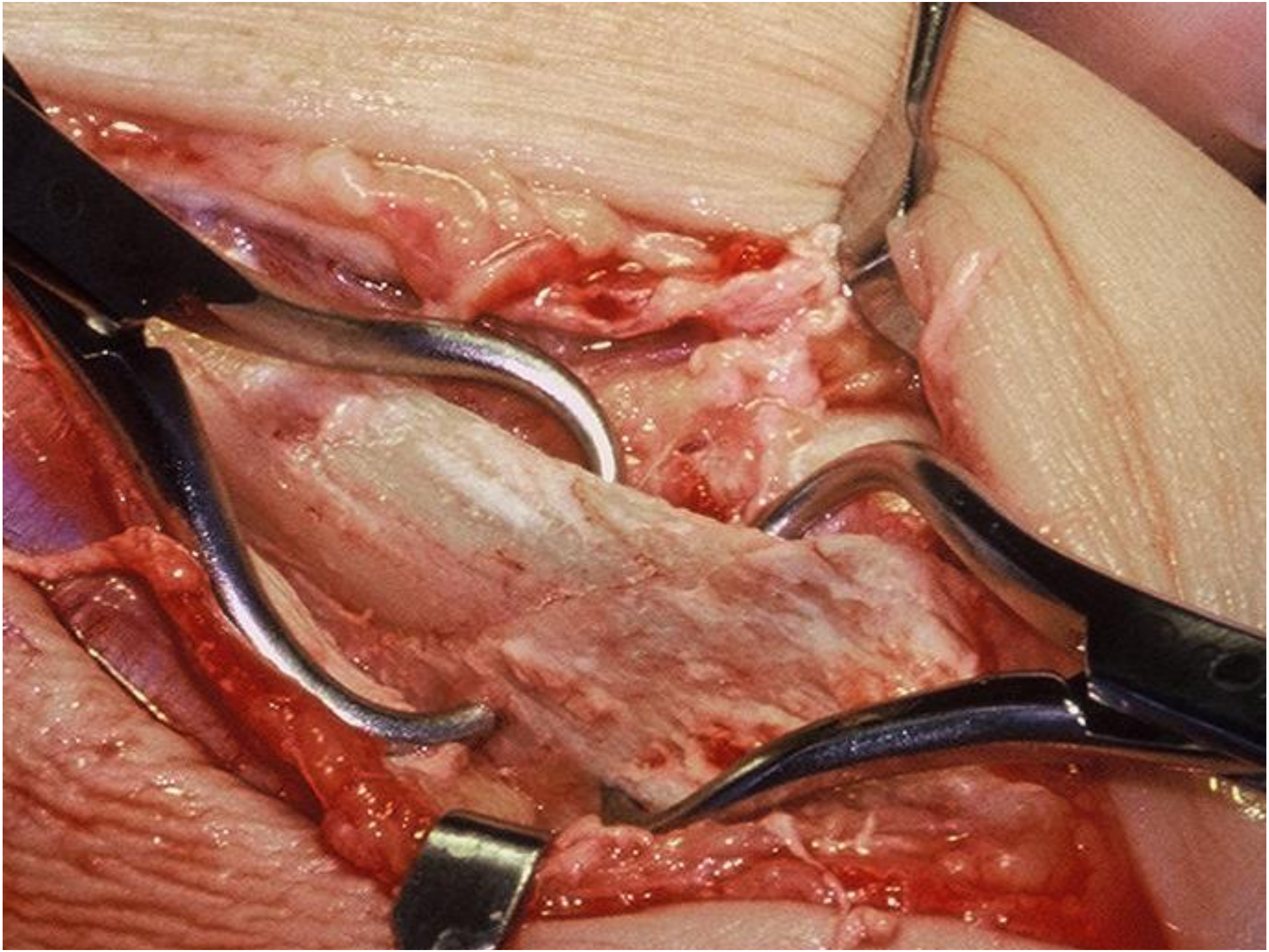

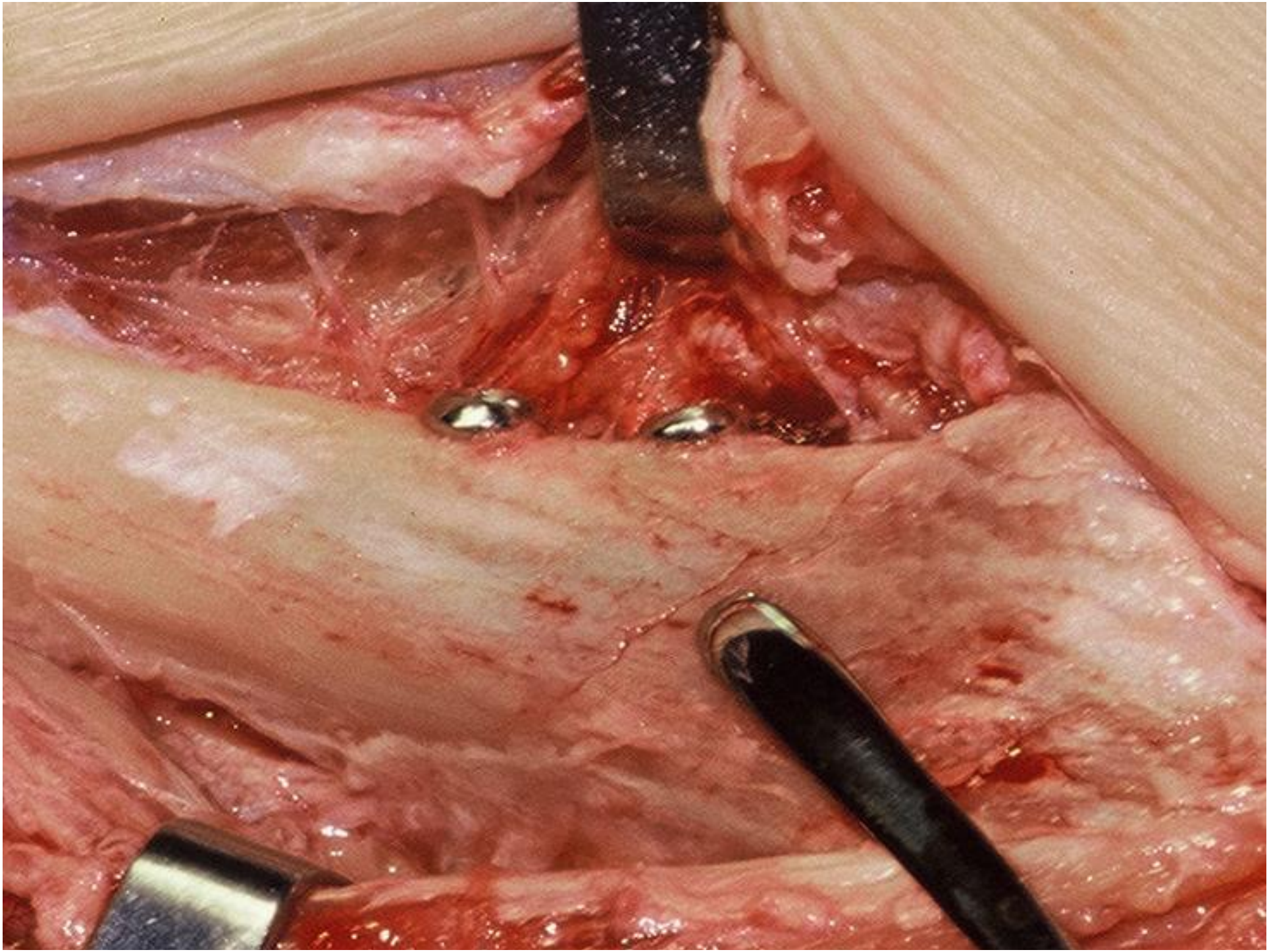

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Closed Reduction

Indications

- Gross malignement
  - Soft tissue compromise
- Joint dislocation
  - N/V compromise
  - Soft tissue compromise

Closed Reduction

Technique

- Sedations
- Local anesthetic
- Position patient
- Have splint materials within reach
- Increase deformity, distract, and reduce

Closed Reduction

Document pulse(s) before and after reduction attempt

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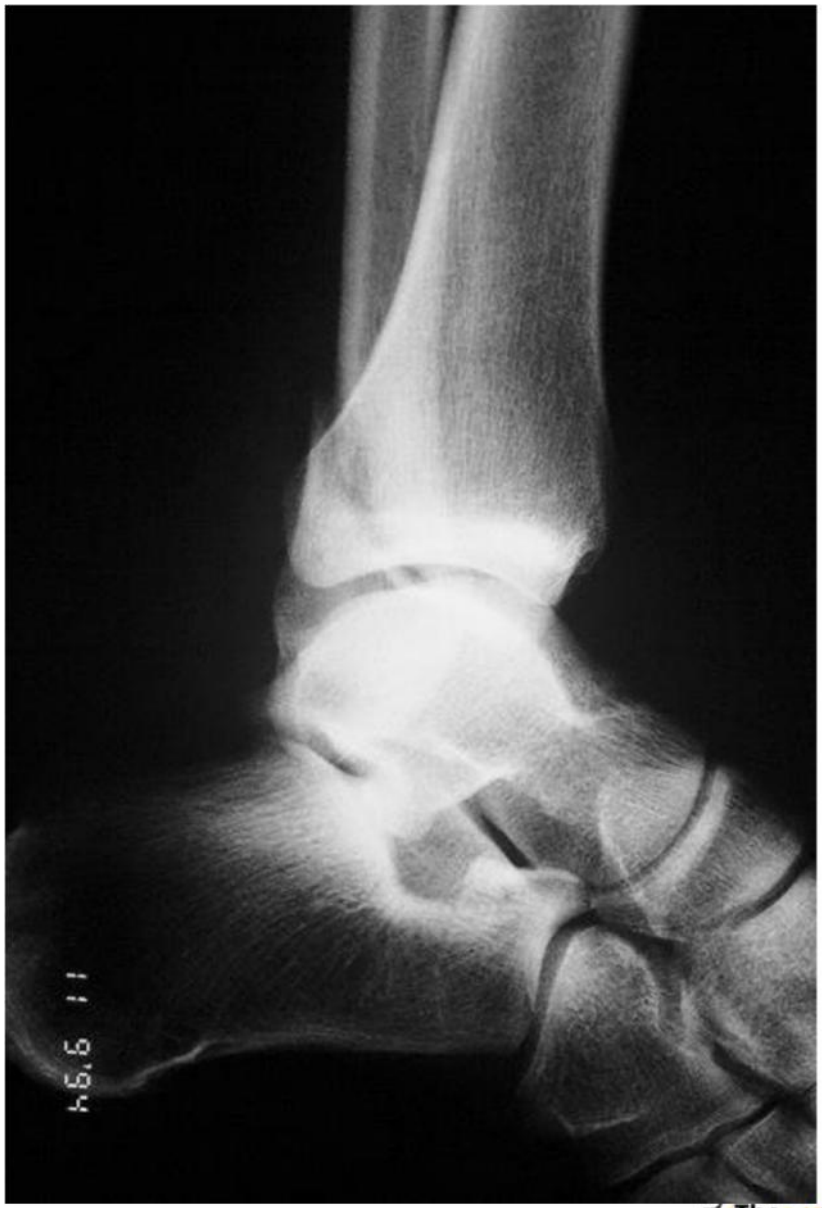

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Closed Reduction& Percutaneous Fixation

Indications

- Medically unstable
- Multitrauma
- Peripheral vascular disease
- Diabetes / Neuropathy

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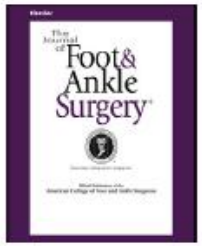

Case Reports and Series

The Use of Pediatric Flexible Intramedullary Nails for Minimally Invasive Fibular Fracture Fixation

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ARTICLE INFO

Level of Clinical Evidence: 4

Keywords:
fibula
flexible fibular nail
fracture fixation
osteosynthesis
tibia

ABSTRACT

Fibular fractures in the setting of an unstable ankle joint require surgical fixation; however, several factors contradict open surgical correction. Severe soft tissue compromise can delay adequate fracture reduction and preclude the standard incisional approach. The soft tissue envelope in the setting of obesity, diabetes, and/or peripheral vascular disease further complicates definitive treatment. Poorly timed open fixation can lead to delayed healing of the incision site, with wound breakdown and the potential for hardware failure. Proximal fibular fractures are also at unique risk of neurovascular compromise with open reduction and internal fixation. Surgical fixation has now focused on minimizing the soft tissue insult using percutaneous techniques in the comorbid patient. We present a case that highlights a minimally invasive technique that provides dynamic stable internal fixation of fibular fractures with the use of flexible pediatric intramedullary nails, typically used in long bone fractures of children.

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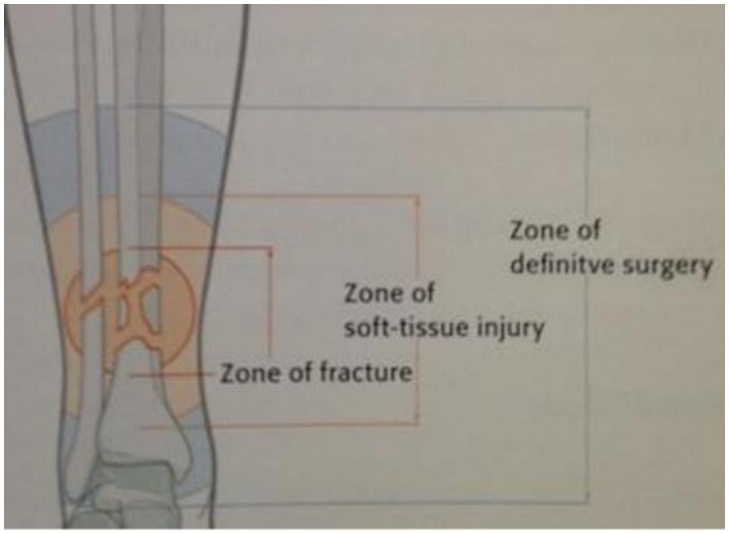
External Fixation

Indications
- Open Fractures
- Closed Fractures
- Polytrauma
- Articular Fractures
- Bone/soft tissue loss
- Indirect reduction



Ruedi TP, Buckley RE, Moran CG: AO PRINCIPLES OF FRACTURE MANAGEMENT, Vols. 1 & 2, 2nd edition, Thieme, New York, 2007.

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External Fixation

Goals

- Musculoskeletal stability
- Maintenance of alignment
- Fracture reduction
- Restoration of length

Ruedi TP, Buckley RE, Moran CG: AO PRINCIPLES OF FRACTURE MANAGEMENT, Vols. 1 & 2, 2nd edition, Thieme, New York, 2007.

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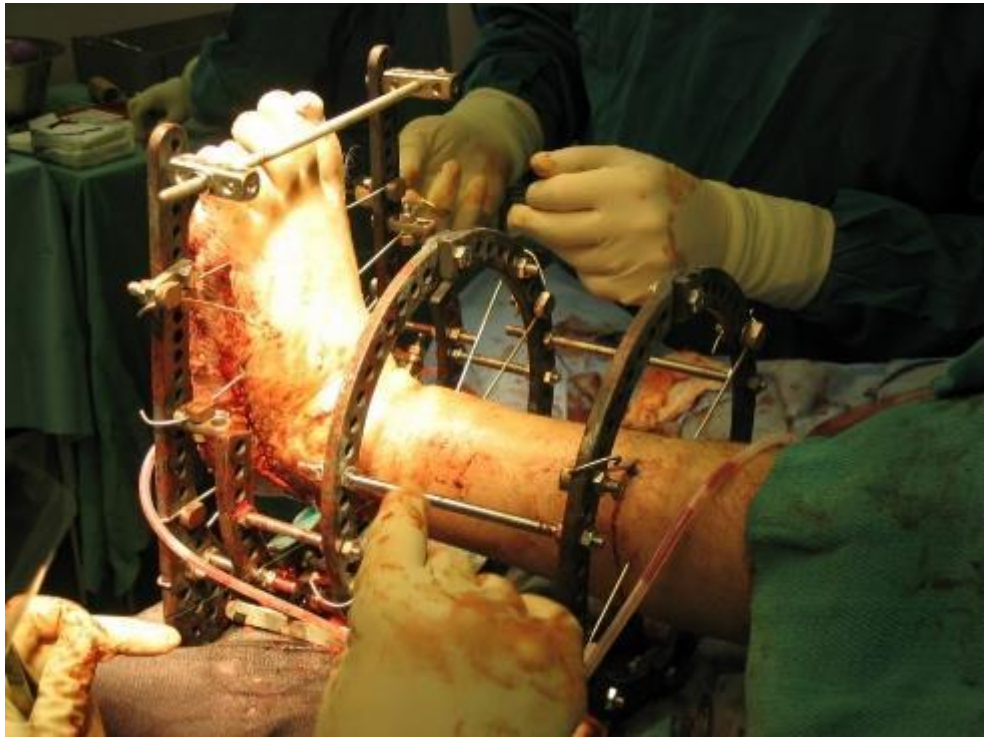
Fracture Stabilization

- Allows framework for soft tissue healing, protects soft tissue
- Decreases inflammatory response
- Decreases spread of bacteria
- Facilitates tissue perfusion
- Encourages wound repair
- Decreases pain
- Aids in patient mobilization
- Enhances recovery of neurovascular bundles
- Enables cellular and humoral defenses to act more effectively
- Decreases delayed union & non-union



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Ligamentotaxis

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Definitive Treatment

- Fixation
- Grafting
- “Low Tide”
- 5-7 days post-op & beyond
- Adequate soft tissue coverage
- Type 1&2 - bone grafting at delayed closure
- Type 3 - bone grafting 6 weeks after wound has healed

Open Fracture Summary

- Keep it Clean!
- “Golden Hour”
- Debridement and Lavage is CRITICAL
- IV Abx per guidelines
- Keep Bone Fragments STABLE

Puncture Wounds

- Tetanus
- Antibiotics
- Copious irrigation
- Soft tissue infection = Staph aureus
- Osteomyelitis = Pseudomonas

Wound Care

Primary Closure
Standard wound care
Negative pressure wound therapy
Orthobiologics
PRP/BMA
Antibiotics bead pouch

Court-Brown CM et al: ROCKWOOD AND GREEN'S: FRACTURES IN ADULTS, 8th edition, Vols. 1 & 2., 2015

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Reconstructive Ladder

Primary Closure
Secondary Closure
Skin Graft
Local Flaps
Distant Flaps
Free Flaps

Yehuda U et al: Ann Plast Surg 56: 401-405, 2006

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Primary Closure

Contraindications
Type IIIC injuries
Contamination
  Amount and type
Peripheral vascular disease
Immunocompromised

Court-Brown CM et al: ROCKWOOD AND GREEN'S: FRACTURES IN ADULTS, 8th edition, Vols. 1 & 2., 2015

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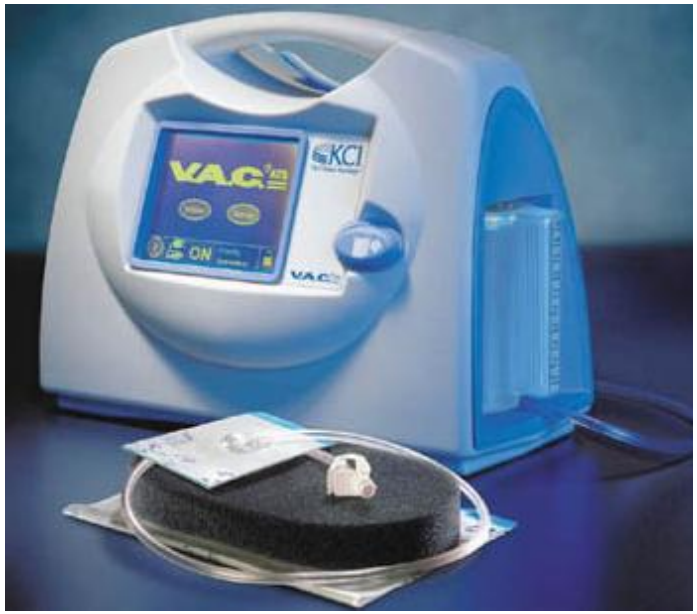
Wound Closure

- Do not close Type 2 or 3 injuries primarily?
- Most wound complications with Type 3B & 3C
- Plastic surgery repair



Negative Pressure Wound Therapy

Promotes wound contraction
Removes excess edematous fluid
Stimulates cellular response and growth factors
Decrease bacterial burden
Enhances wound healing environment
Prevents wound dessication

Streubel PN et al: J Am Acad Orthop Surg 20: 564-574, 2012

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Negative Pressure Wound Therapy

Contraindications
Presence of necrotic skin/eschar
Untreated osteomyelitis
Exposed neurovascular bundle
Exposed vascular anastomosis

Streubel PN et al: J Am Acad Orthop Surg 20: 564-574, 2012

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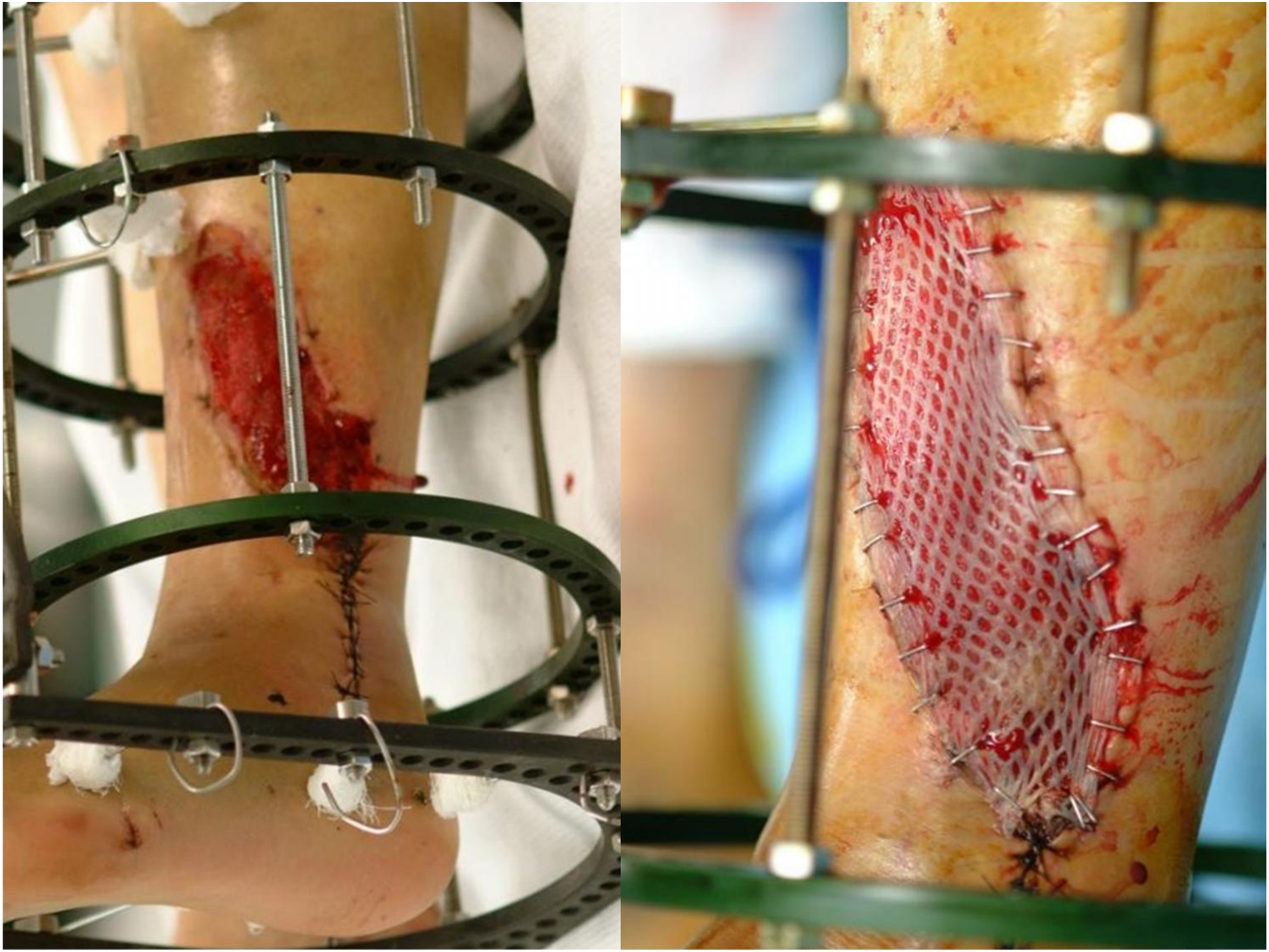
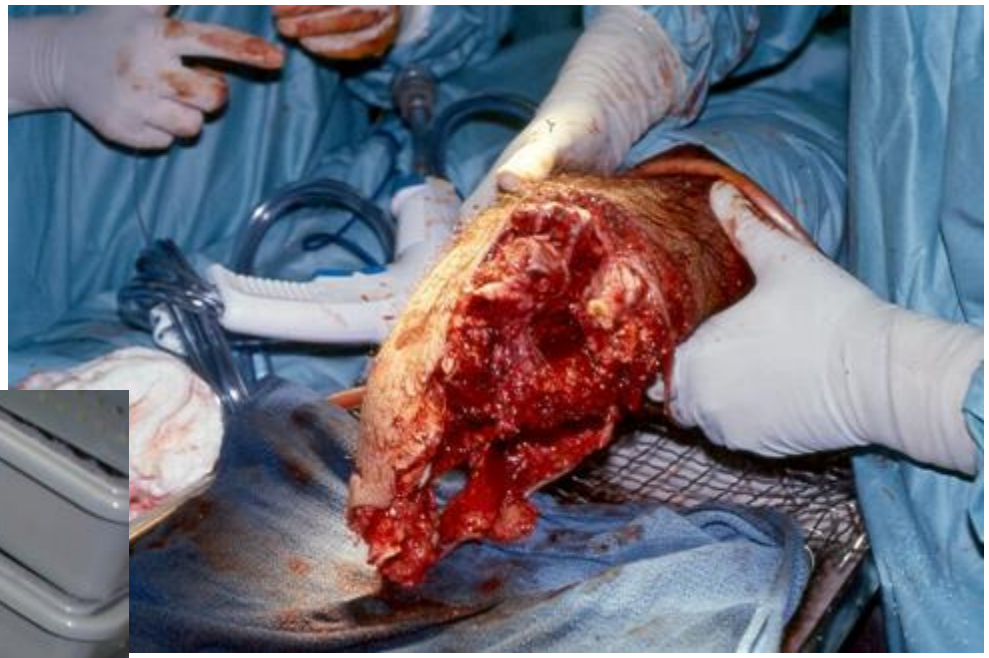


Primary Amputations

- Toes
- Benefits vs Morbidity



Crush Injury

- Definition

- An extrinsic compressive force applied to the foot over a variable period of time

- Mechanism

- Quick blow
- Extended contact/compression
  - Gradual squeezing
- High Energy
- Low Energy
- Has prognostic significance

Zone of Injury

- Tissue damage from crushing is always far worse than that which is immediately and grossly apparent.
  - Myerson, foot and Ankle Disorders

Zone of Injury

- Demarcation
  - Days to weeks

Principles of Treatment

- Thorough H&P
- Radiographic Studies
- Wound inspection/irrigation
- Compartment Pressures
- Compressive Dressing
- Appropriate Splinting
- RICE

Degloving Injuries

- Inspection
- Debridement of devitalized tissue
- Pulse lavage
- Non-adherent dressing
- Negative pressure wound therapy
- Multiple debridement

Degloving Injuries

- Closure:
  - Delayed primary
  - STSG
    - Wound VAC
  - Flaps
  - Biologic dressings

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Compartment Syndrome

- Increase in interstitial fluid pressure with in the foot compartments.
  - > 30mmHg

Compartment Syndrome

- <u>Signs & Symptoms</u>
  - High Index of Suspicion!!
    - Severe, unrelenting pain out of proportion to the injury

Compartment Syndrome

- Compartment syndrome can be associated with open fractures
- Early Signs:
  - Paralysis (digital weakness)
  - Paresthesias
  - Pain out of proportion (unrelieved)
  - Gross edema
  - Mottled dusky skin
- Late Signs:
  - Pallor
  - Delayed capillary refill
  - Pulselessnes

Compartment Syndrome

- Signs & Symptoms
  - Exacerbation of symptoms with passive stretch of toes
  - Gross edema
  - Decreased light touch
  - Decreased 2 point discrimination
  - Decreased vibratory perception
  - Non- palpable pulses (late)

Compartments

- 5 compartments of clinical importance:
  - Medial
  - Central
  - Lateral
  - Interosseous
  - Calcaneal

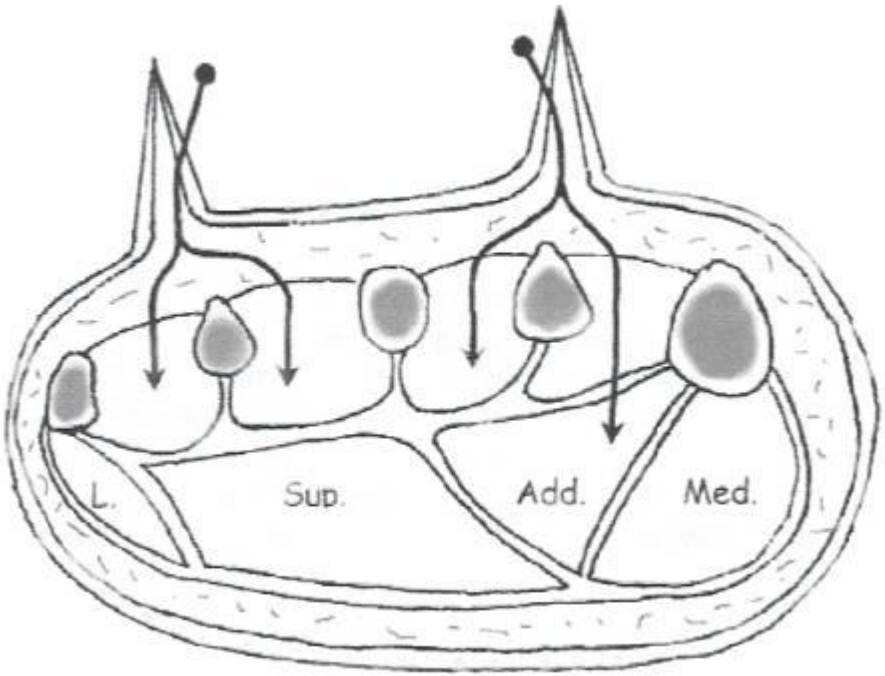
Compartment Syndrome

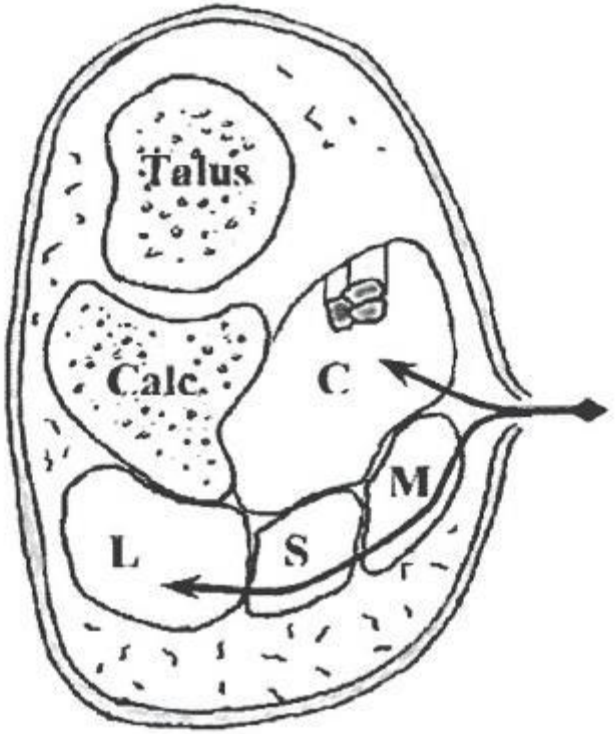
- Diagnosis:
- Multi-stick needle catheterization
- Pressure > 30mmHg
- Delta P = compartment pressure is 10-30mmHg below the patient's diastolic BP
  - Accounts for hypertension or hypotension

Compartment Syndrome

- Treatment
  - Surgical emergency
  - Open fasciotomy
    - 3 incision approach
  - Pack open

Open Fasciotomy





Compartment Syndrome

- Treatment
  - Surgical emergency
  - Open fasciotomy
    - 3 incision approach
  - Pack open
  - Associated fractures
    - Ex-fix, K-wires, etc.

Compartment Syndrome

- <u>Closure:</u>
  - 5-7 days after decompression
  - Delayed primary
  - STSG

Undiagnosed Compartment Syndrome

- Rhabdomyolysis
- Rigid toe contractures
- Cavus foot
- Equinus
- Paralysis
- Sensory neuropathy
- Chronic pain

Complications

- Infection
- Skin loss
- Delayed union
- Non-union
- Chronic pain
- Deformity
- Loss of Function

Evidence Based Treatment of Open Ankle Fractures
-Arch Orthop Trauma Surg, 2011

- <u>Recommended Guidelines</u>:
  - Gross debris and contamination removed in ED
  - Cephalosporins administered in ED
  - Wound cultures unnecessary
  - Optimal antibiotic duration unknown
  - Should be taken to OR within 24 hours
  - Thorough debridement and irrigation
  - No evidence against the use of tourniquets

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Evidence Based Treatment of Open Ankle Fractures
-Arch Orthop Trauma Surg, 2011

- <u>Recommended Guidelines</u>:
  - Rigid internal fixation should be used. Only when there is inadequate soft tissue coverage, external fixation should be considered
  - Grade 1 wounds may be closed primarily
  - Grade 2 wounds should be left to heal by secondary intention, or delayed primary closure
  - Grade 3 wounds should be closed by skin grafts or free flaps

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Summary

- Golden Period
- Open Fracture Protocol
- Antibiotics - Duration
- Emergencies/Urgencies
- Staged Procedures
- Closure

Nail Trauma

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Nail Trauma

- **Etiology**: a crush injury to the digit
- If there is a subungual hematoma present of greater than 25% of the nail plate, than the nail bed should be considered ruptured
- If the nail bed is lacerated, the fracture is considered an open fracture
- Nail and distal tip injuries were classified by **Rosenthal** in 1983 for finger injuries
  - Modified for the foot

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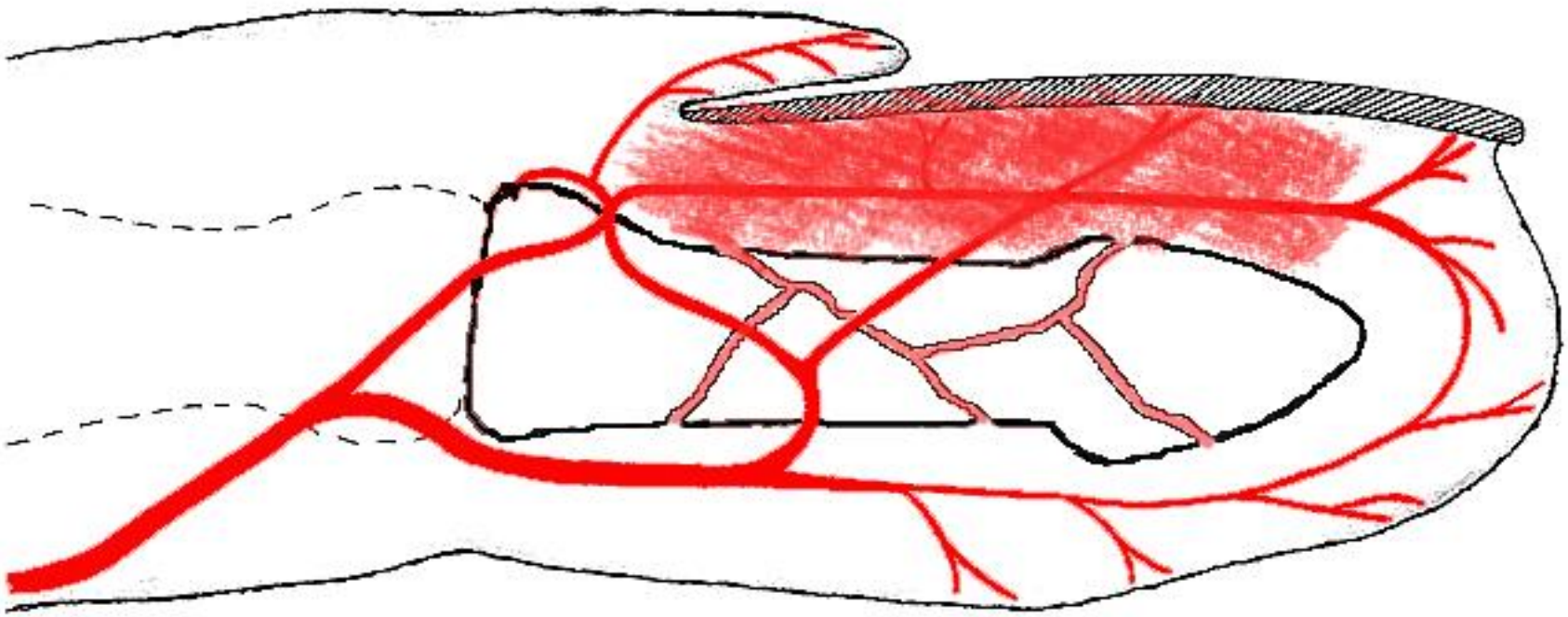
Subungual Hematoma



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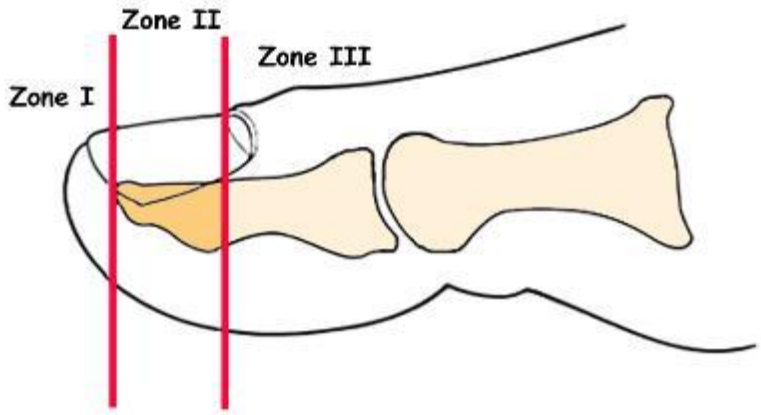
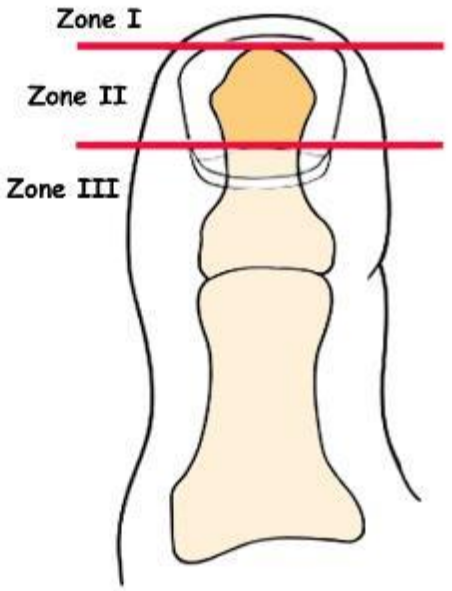
Nail Trauma

•Rosenthal Classification

- **Zone I**: distal to bony phalanx
- **Zone II**: distal to lunula
- **Zone III**: proximal to distal end of lunula





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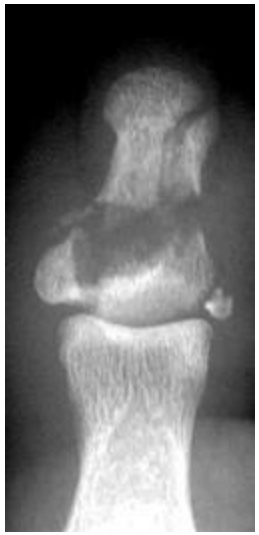

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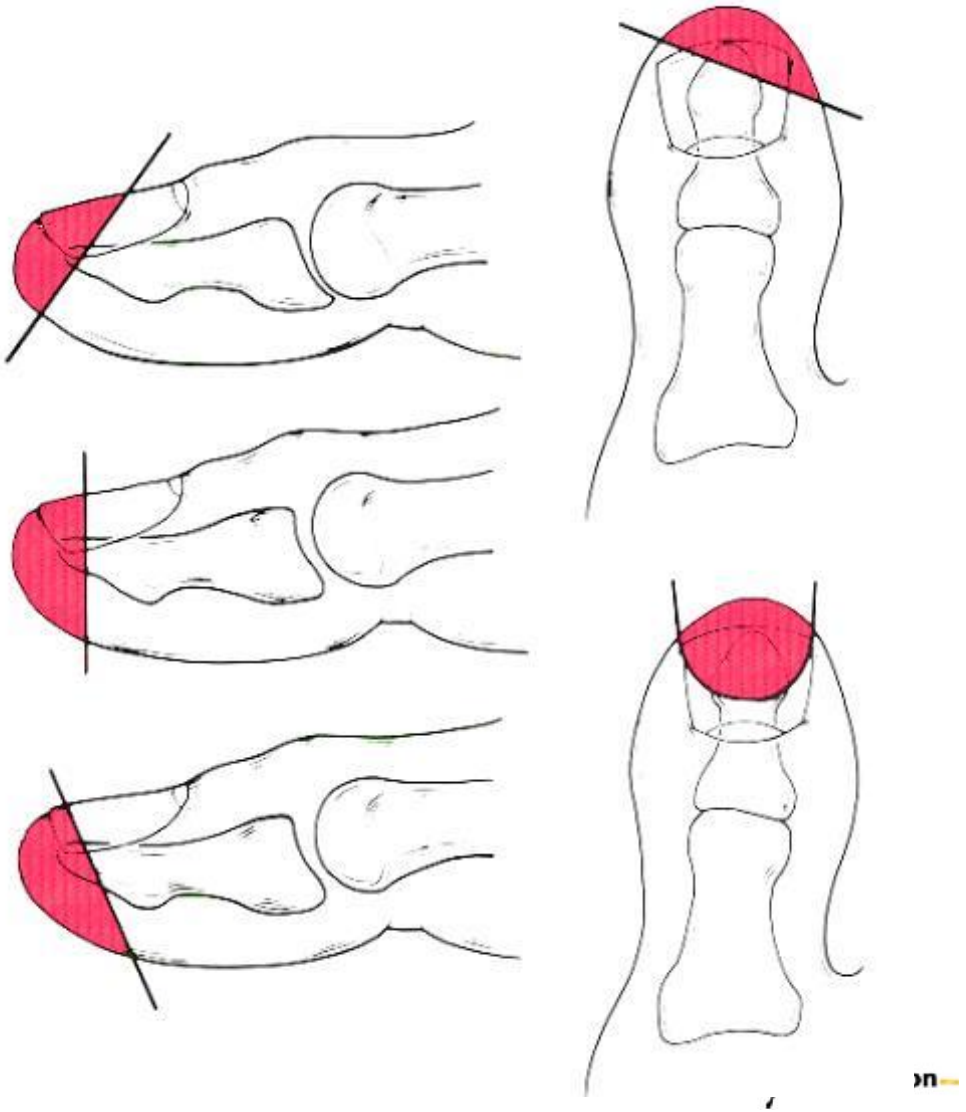
Zones of Rosenthal

- A. **Dorsal**
  - oblique
- B. **Transverse**
- C. **Plantar**
  - oblique
- D. **Axial**
  - medial
  - lateral
- E. **Central**
  - gauging



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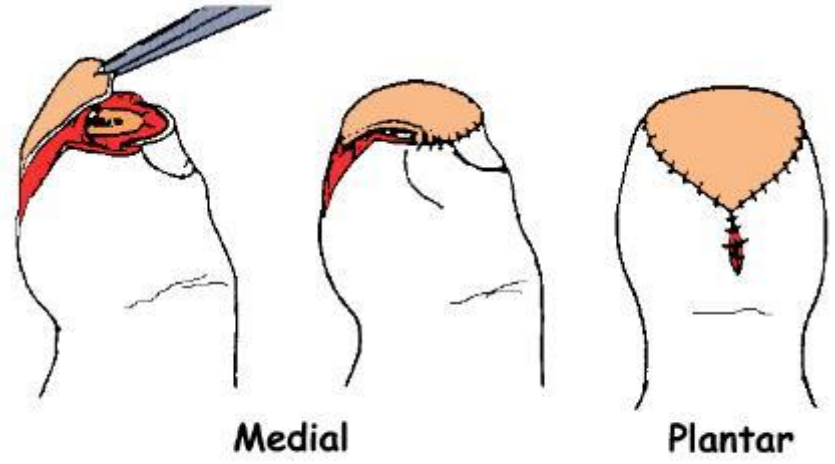
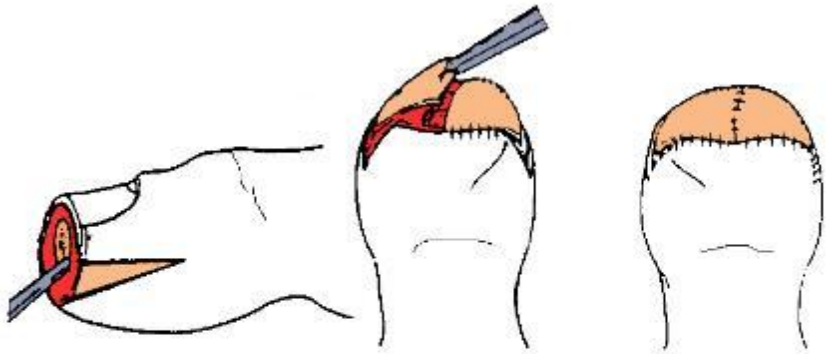
  - oblique
- D. **Axial**
  - medial
  - lateral
- E. **Central**
  - gauging

Treatment of Nail Trauma

- **Zone I**
  - Less than 1.0 cm – secondary intent healing
  - Greater than 1.0 cm – possible skin graft
- **Zone II**
  - Must cover bone
  - *Atasoy flap* is a plantar V-Y advancement flap
  - *Kutler flap* is a biaxial V-Y advancement flap
- **Zone III**
  - Usually amputation is required



Atasoy Flap



Kutler Flap

Digital Fractures

- **Etiology**: blunt trauma
- **Treatment**: buddy splint to medial digit

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Digital Fractures

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Digital Fractures

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Digital Dislocations

- **Etiology**: hyperextension injury most commonly
- Treatment: closed reduction
- **Reduction principles**:
  - Increase the deformity
  - Apply distal traction
  - Reverse mechanism of injury

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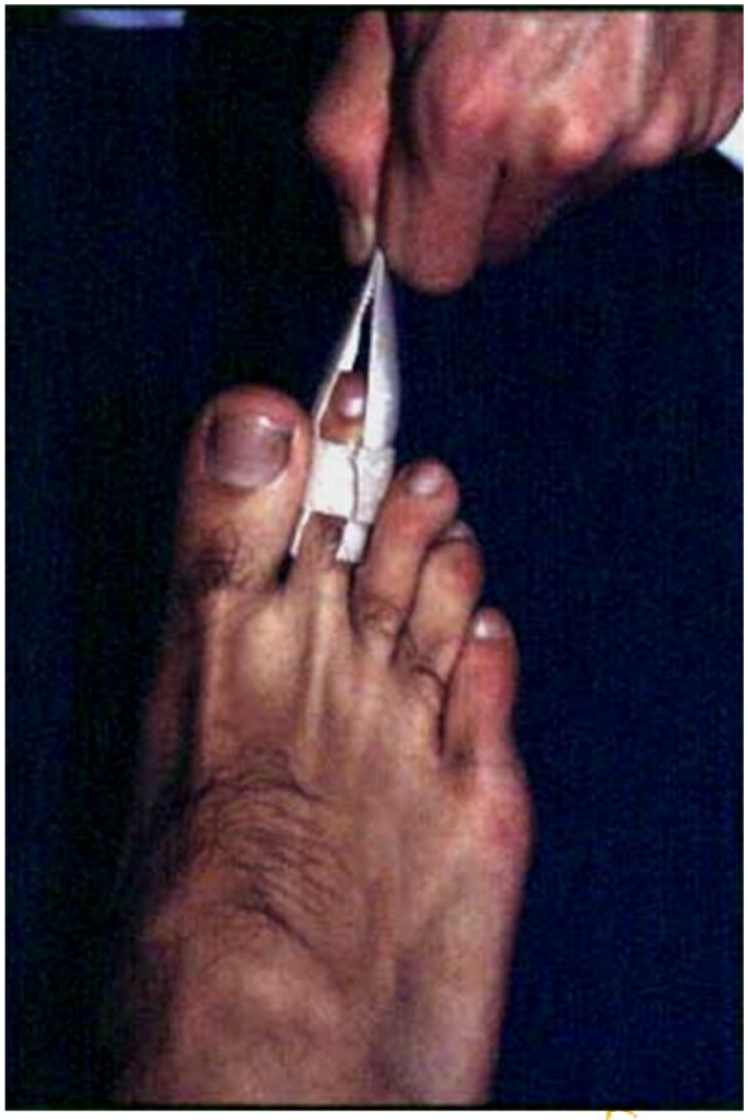

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1st MPTJ Dislocation

- Etiology: ***hyperextension***

- **Jahss Classification**
  - **Type I**: dorsal dislocation of the proximal phalanx and sesamoids with an intact intersesamoidal ligament
  - **Type IIA**: dorsal dislocation of the proximal phalanx with wide separation of the sesamoids without fracture of either of the sesamoids
  - **Type IIB**: dorsal dislocation of the proximal phalanx and the sesamoids with transverse fracture of one of the sesamoids and rupture of the intersesamoidal ligament
  - **Type IIC**: dorsal dislocation of the proximal phalanx and the sesamoids with complete disruption of the intersesamoidal ligament and fracture of both sesamoids

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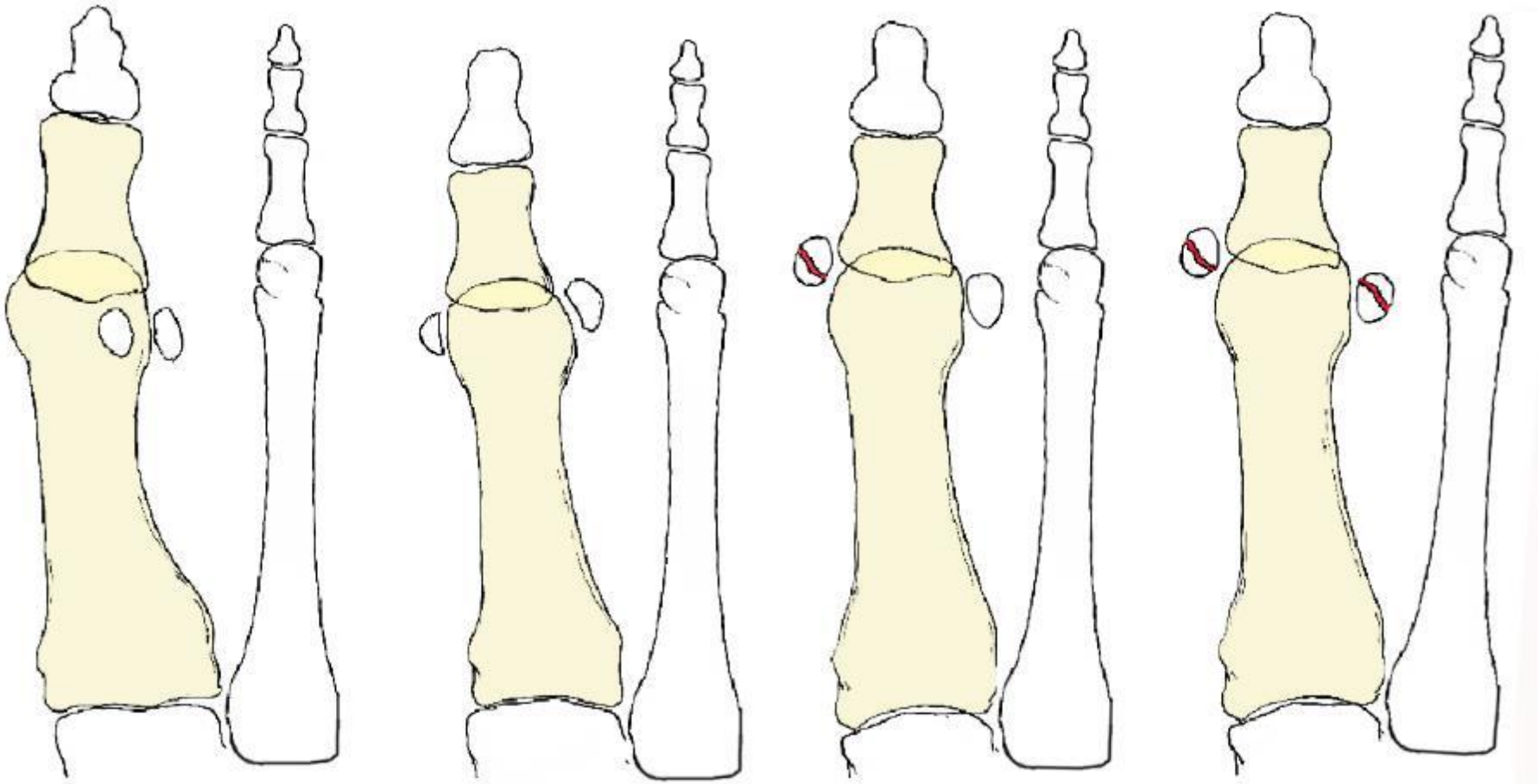
Jahss Classification



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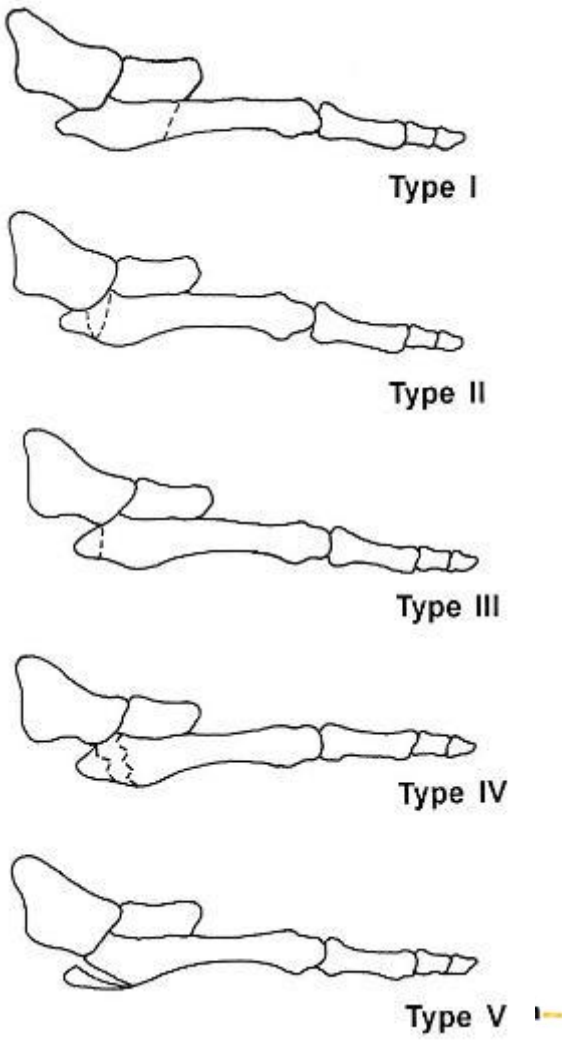
5th Metatarsal Fractures

- **Stewart Classification**
  - **Type I**: supra-articular fracture occurring at the metaphyseal-diaphyseal junction. *This is the true Jones' fracture.*
  - **Type II**: intra-articular avulsion fracture with one or two fracture lines
  - **Type III**: extra-articular avulsion fracture in which PB tears a small fragment from the syloid process
  - **Type IV**: intra-articular, comminuted fracture
  - **Type V**: extra-articular avulsion fracture of the epiphysis in children



What Stewart Type?

What Stewart Type?

Treatment of 5th Metatarsal Base Fractures

Treatment of 5th Metatarsal Base Fractures

5th Metatarsal Jones Fractures

- **Torg Classification**
  - **Type I**: acute Jones fracture
  - **Type II**: delayed union Jones
  - **Type III**: non-union Jones
  - **Type IV**: diaphyseal stress fracture

5th Metatarsal Jones Fractures

- **Torg Classification**
  - **Type I**: acute Jones fracture
  - **Type II**: delayed union Jones
  - **Type III**: non-union Jones
  - **Type IV**: diaphyseal stress fracture

Notes on Jones' Fracture

- Fracture occurs between the epiphysis and diaphysis (*metaphyseal level*)
- Fracture is always ***extra-articular***
- **Mechanism of injury**:
  - Usually an **internal rotation** of the forefoot while the base of the fifth metatarsal remains fixed
  - Peroneus brevis takes no part in the injury
- Very unstable fracture and has a very poor blood supply
  - High propensity to develop a delayed or non-union, because of the location of the blood supply and poor vascularity in this area

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Lisfranc's Fractures

- Incidence is 1 in 55,000 people per year
- Over 80% are considered polytrauma patients
- Up to 20% of these injuries are misdiagnosed
- Mechanism:
  - Direct – crush, fall
  - Indirect – axial load on PFX foot

- **Classifications**: (be able to switch between systems)
  - Quenu and Kuss (1909)
  - Hardcastle (1982)
    - Myerson modification (1986)

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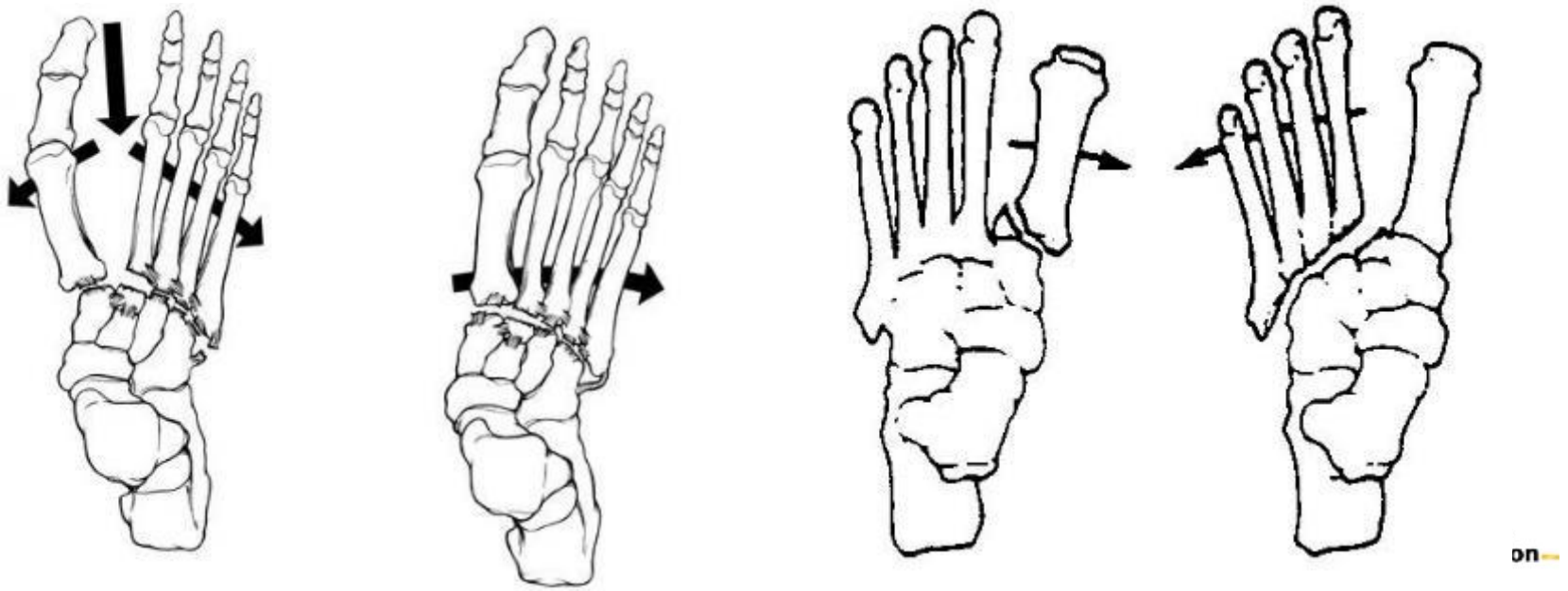
Tarsometatarsal Fracture/Dislocation

- **Quenu & Kuss Classification**
  - **Divergent** fracture/dislocation of LisFranc's joint
  - **Convergent** or **homolateral** fracture/dislocation of LisFranc's joint
  - **Isolateral** injury of LisFranc's joint



Tarsometatarsal Fracture/Dislocation

- Hardcastle (***Myerson Modification***) **Classification**
  - **Type A**: Total incongruity of the entire tarsometatarsal joint with displacement in the sagittal or transverse plane
  - **Type B1**: Partial incongruity with medial dislocation, displacement of the 1st metatarsal in isolation or in combination with displacement of the lesser tarsus
  - **Type B2**: Partial incongruity with lateral dislocation; 1st metatarsal unaffected
  - **Type C1**: Partial divergent displacement; the 1st met is displaced medially and any combination of the lateral 4 metatarsals is displaced laterally in the sagittal or transverse planes or both
  - **Type C2**: Total divergent displacement; the first metatarsal is displaced medially and any combination of the lateral 4 metatarsals is displaced laterally

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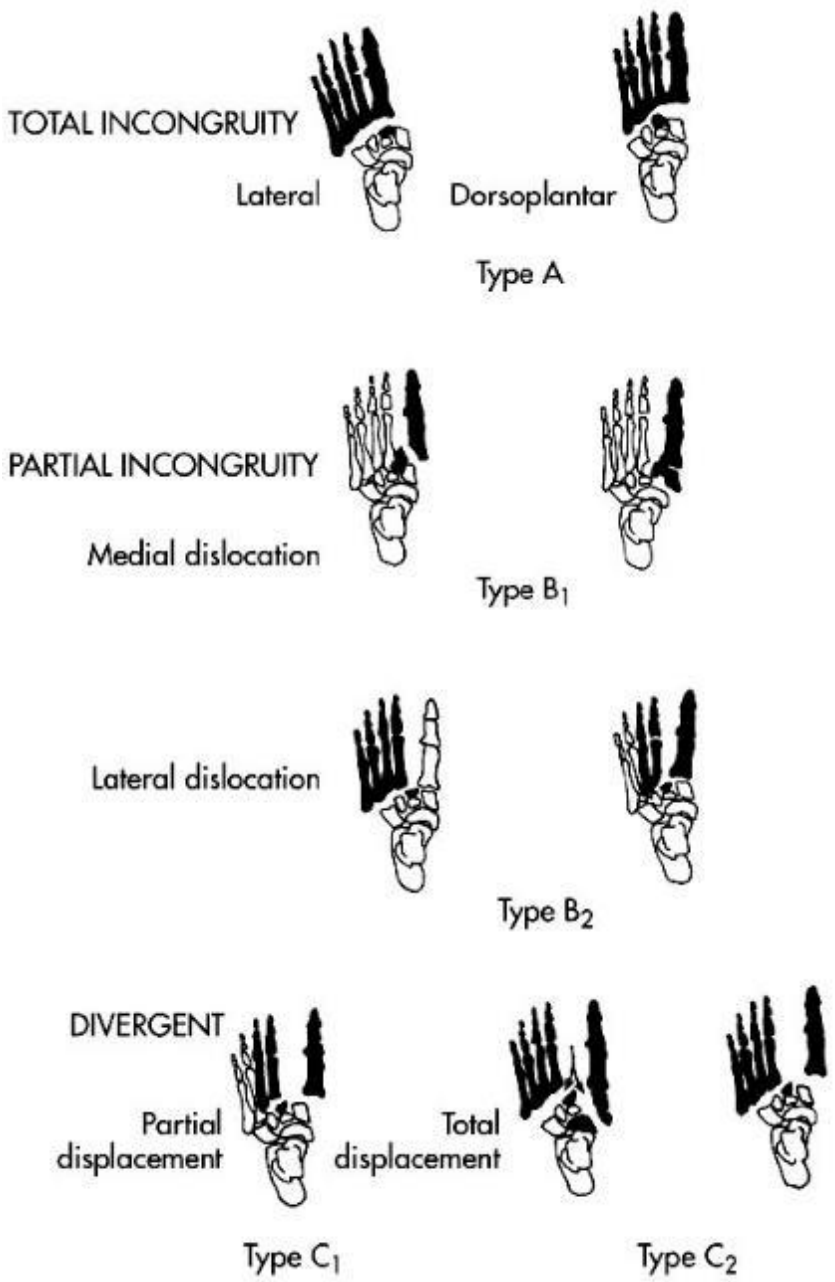

Hardcastle (Myerson Modification) Classification

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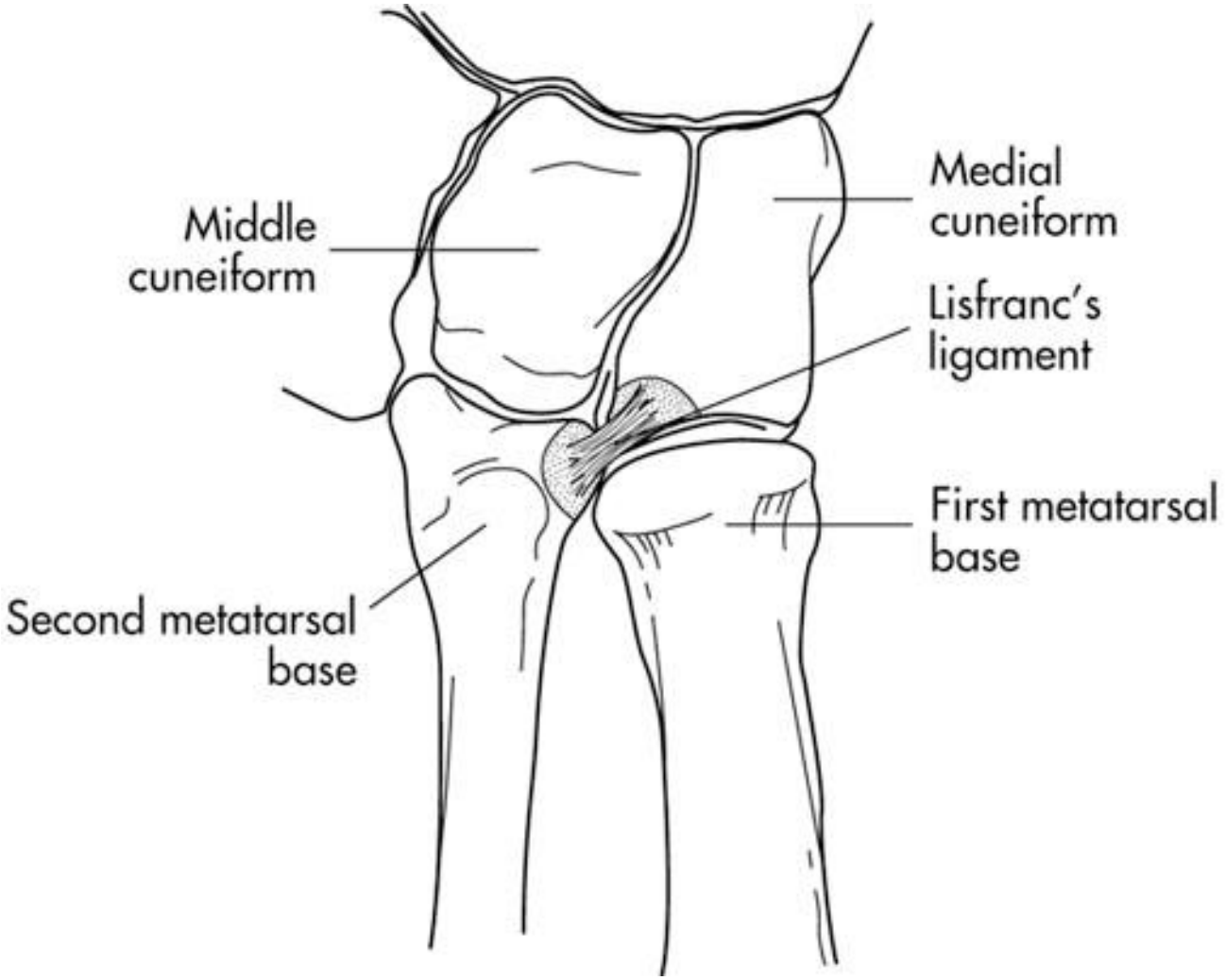
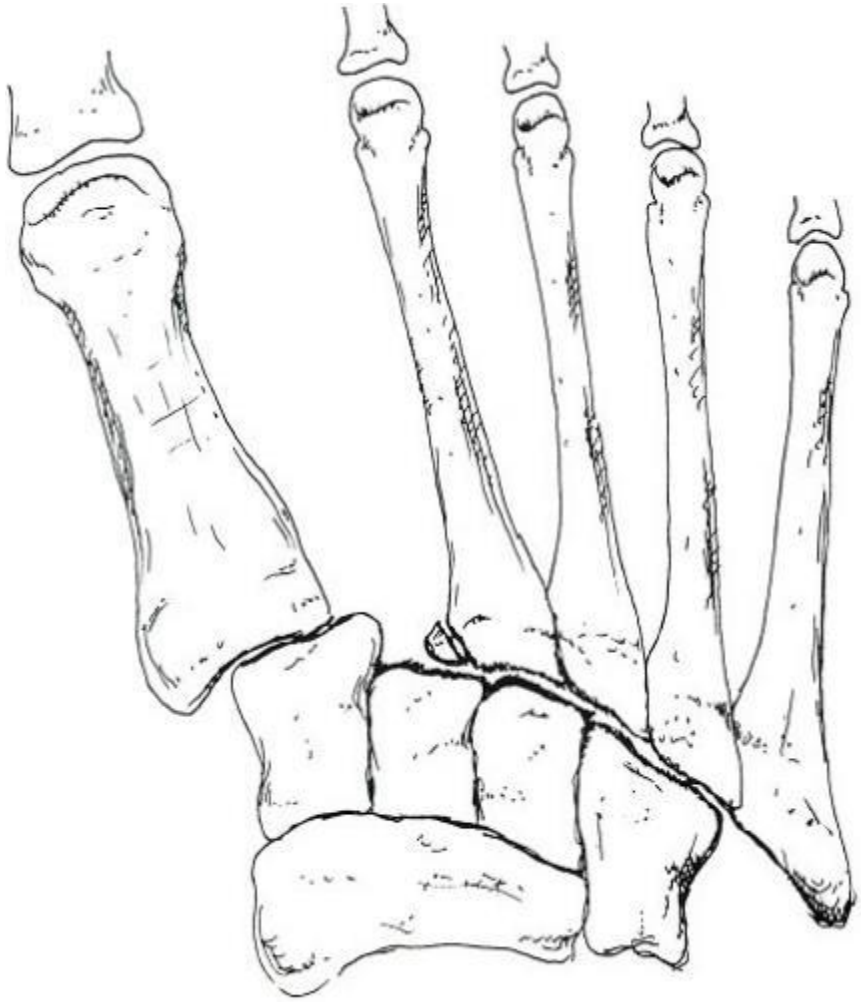
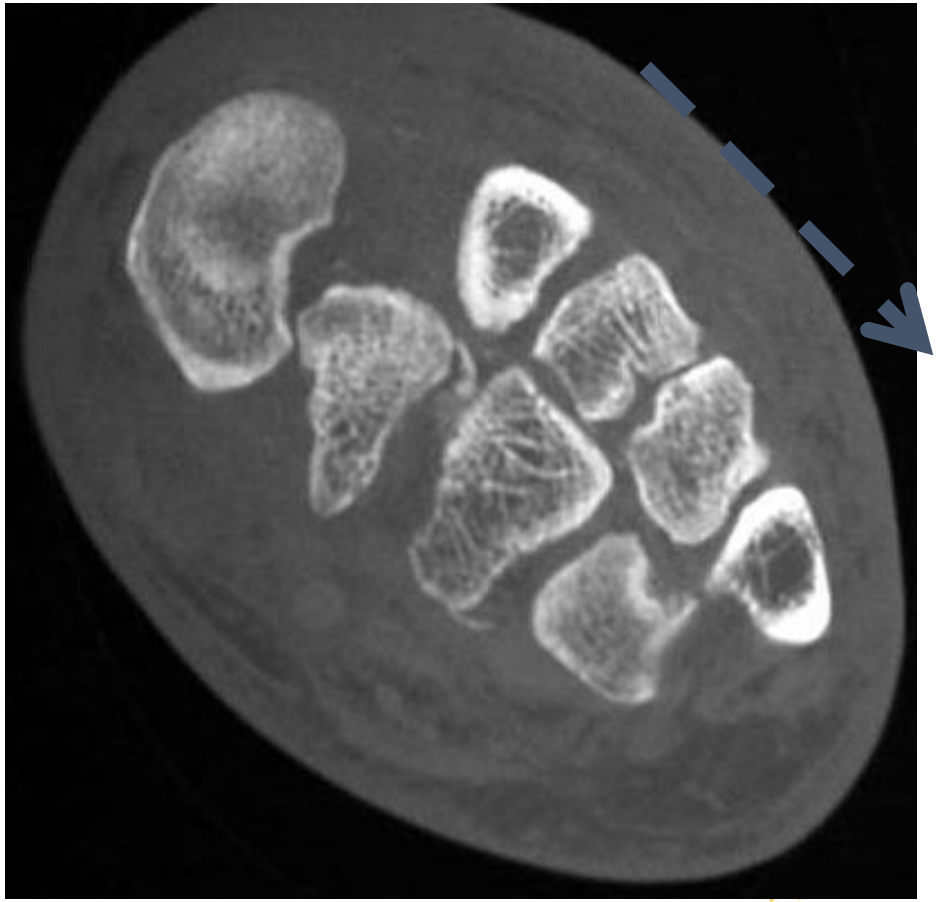
Lisfranc's Ligament



Fleck Sign



What Hardcastle Classification?



Lisfranc's Treatment

Talar Fractures

- **Talar anatomy**:
  - No muscular attachments
  - 60% of talus cover by articular cartilage
  - 7 articular facets
  - Blood supply is concern

- **Classification / Injuries include**:
  - Berndt-Hardy = Osteochondral talar dome fractures
  - Hawkins = Talar neck fractures (50%)
    - *Aviator's astragulus*
  - Sneppen = Talar body fractures

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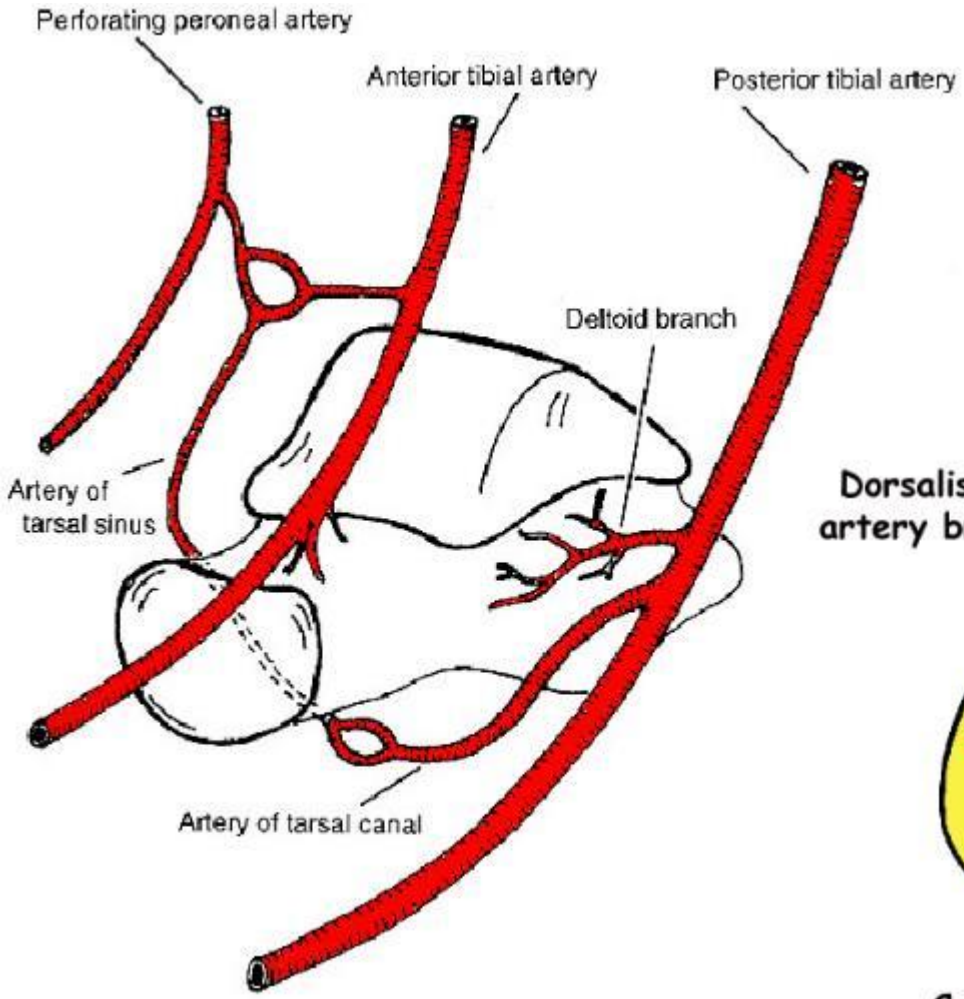
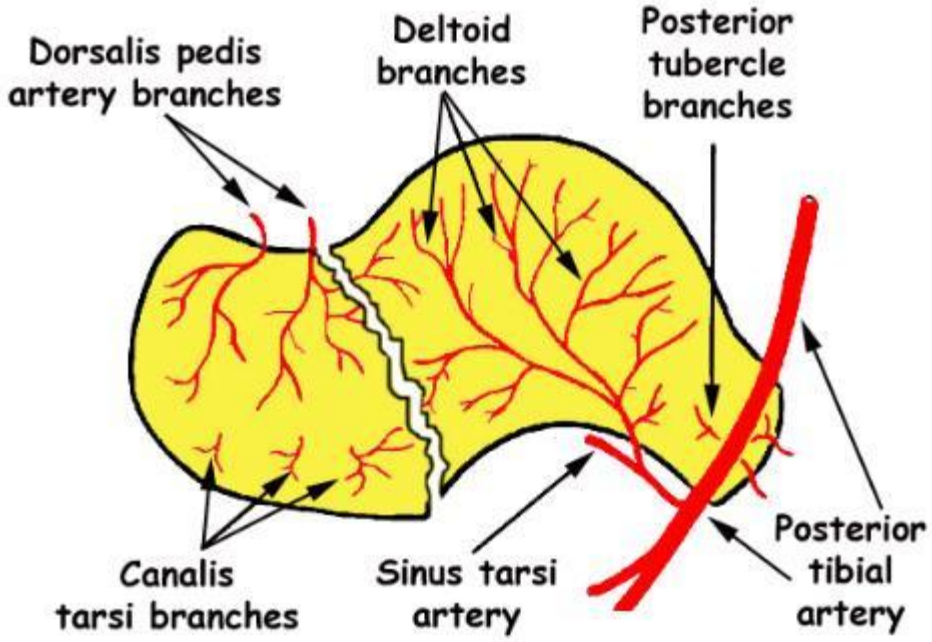
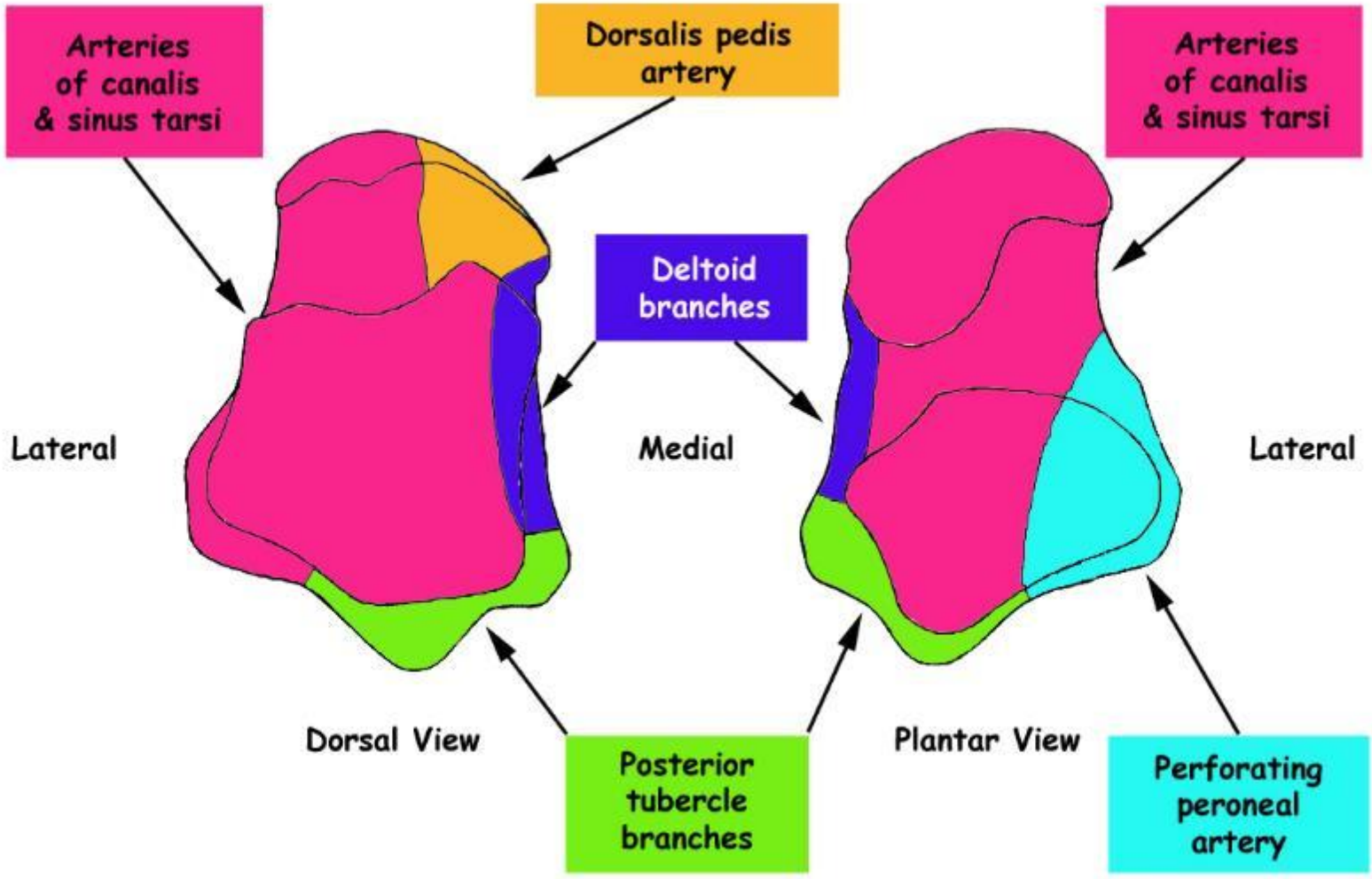
Talar Blood Supply





Talar Blood Supply



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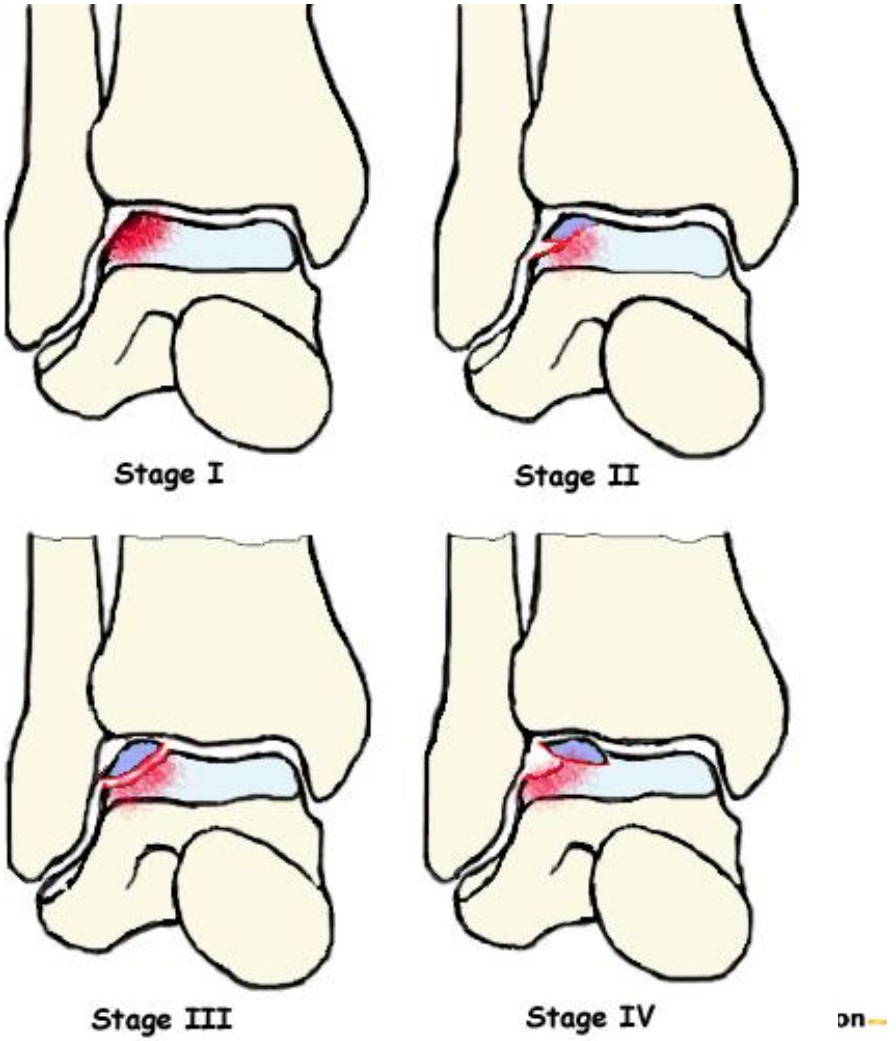
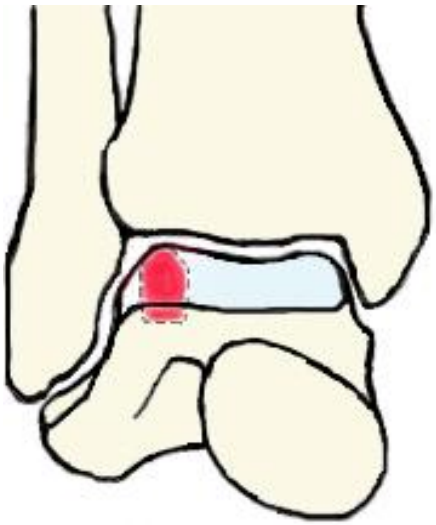
Talar Dome Lesions

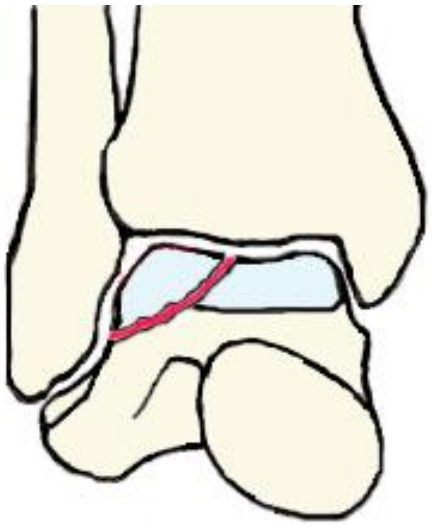
- Berndt & Harty Classification
  - **Stage I**: compression of subchondral bone
  - **Stage II**: partially detached osteochondral fragment
  - **Stage III**: completely detached osteochondral fragment remaining in defect
  - **Stage IV**: displaced osteochondral fragment



Berndt & Harty Classification

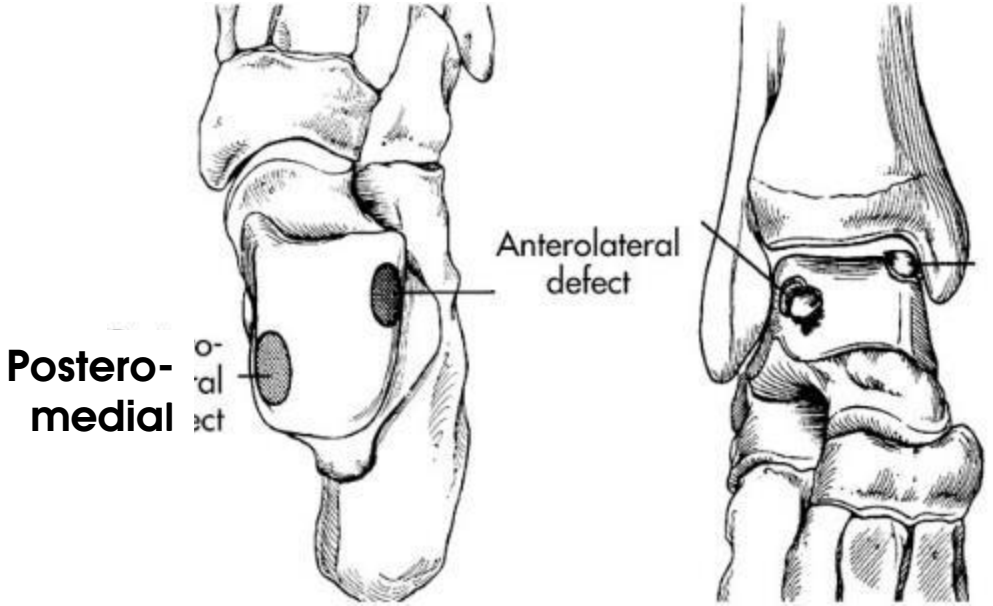
- Recently, two additions have been added
  - Stage V (2001 - Scranton & McDermott)
    - Large cyst below the subchondral bone
  - Stage VI (2004 – Steve Raikin)
    - Massive osteochondral defects of the talus
    - Lesion are greater than 3 cm3





MNEMONIC

- "**DIAL a PIMP**"
  - Dorsiflexion/inversion = Anterolateral Lesion
  - Plantarflexion/inversion = Posteromedial Lesions



What Stage?

Talar Neck Fractures

- **Hawkins' Classification (1970)**
- **(Canale & Kelly (1978) modification Type IV)**
  - **Type I**: non-displaced vertical fracture of the talar neck, body of the talus retains its normal position in the STJ and ankle joint
  - **Type II**: vertical fracture of talar neck with STJ subluxation or dislocation. (2 of blood supply gone)
  - **Type III**: vertical fracture of the talar neck with STJ and ankle joint dislocation. All three sources of blood supply are disrupted.
  - **Type IV**: vertical fracture of the talar neck with STJ, ankle and talonavicular joint dislocation. All three sources of blood supply are disrupted.

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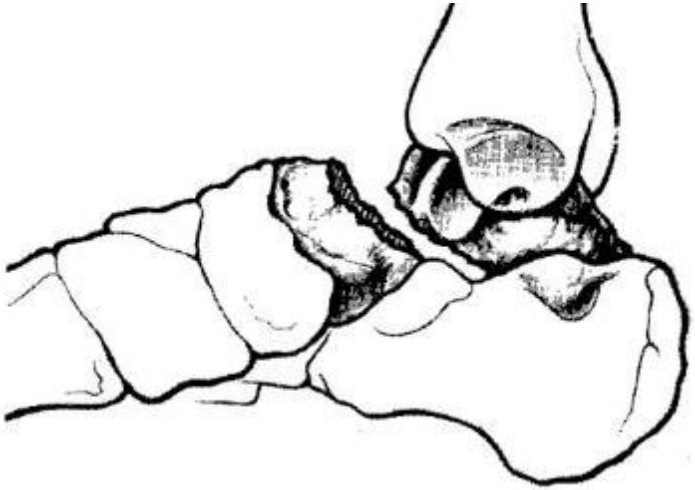
Hawkins' Classification

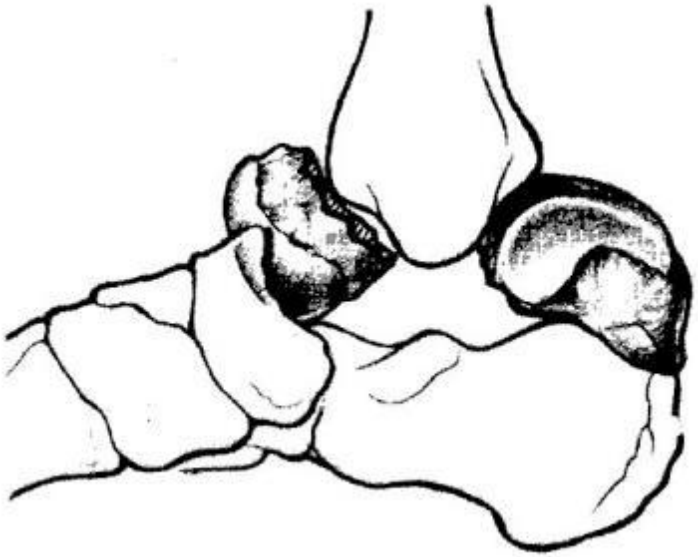
Type 1

Type 2



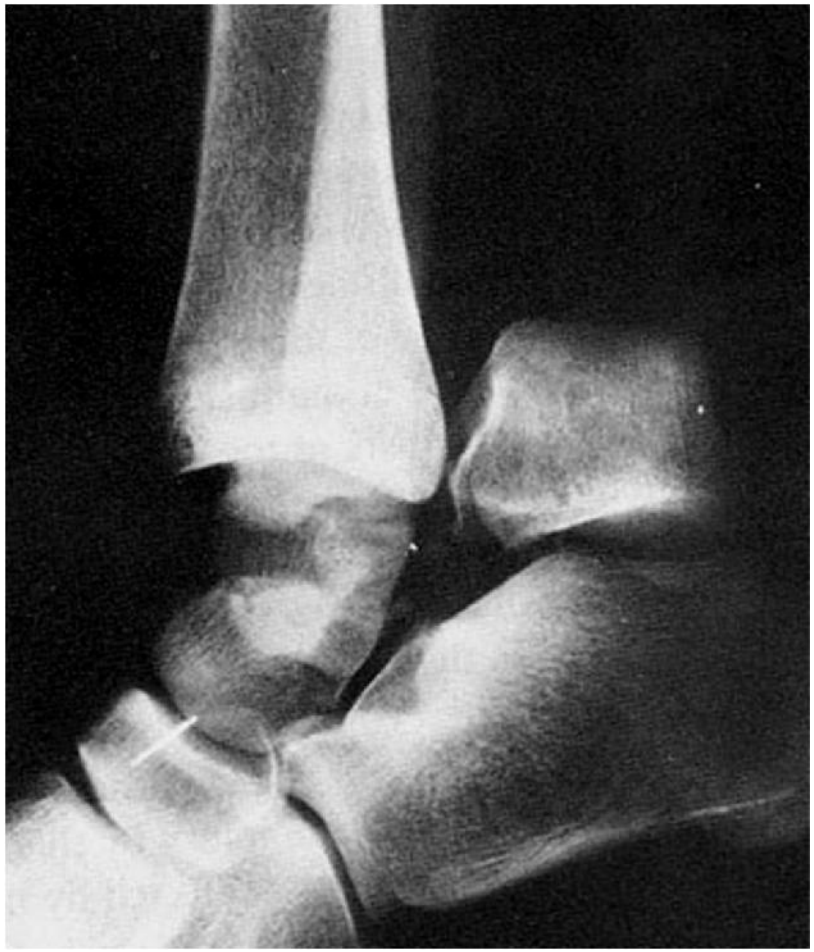
Type 3

Type 4



What Stage Hawkins?

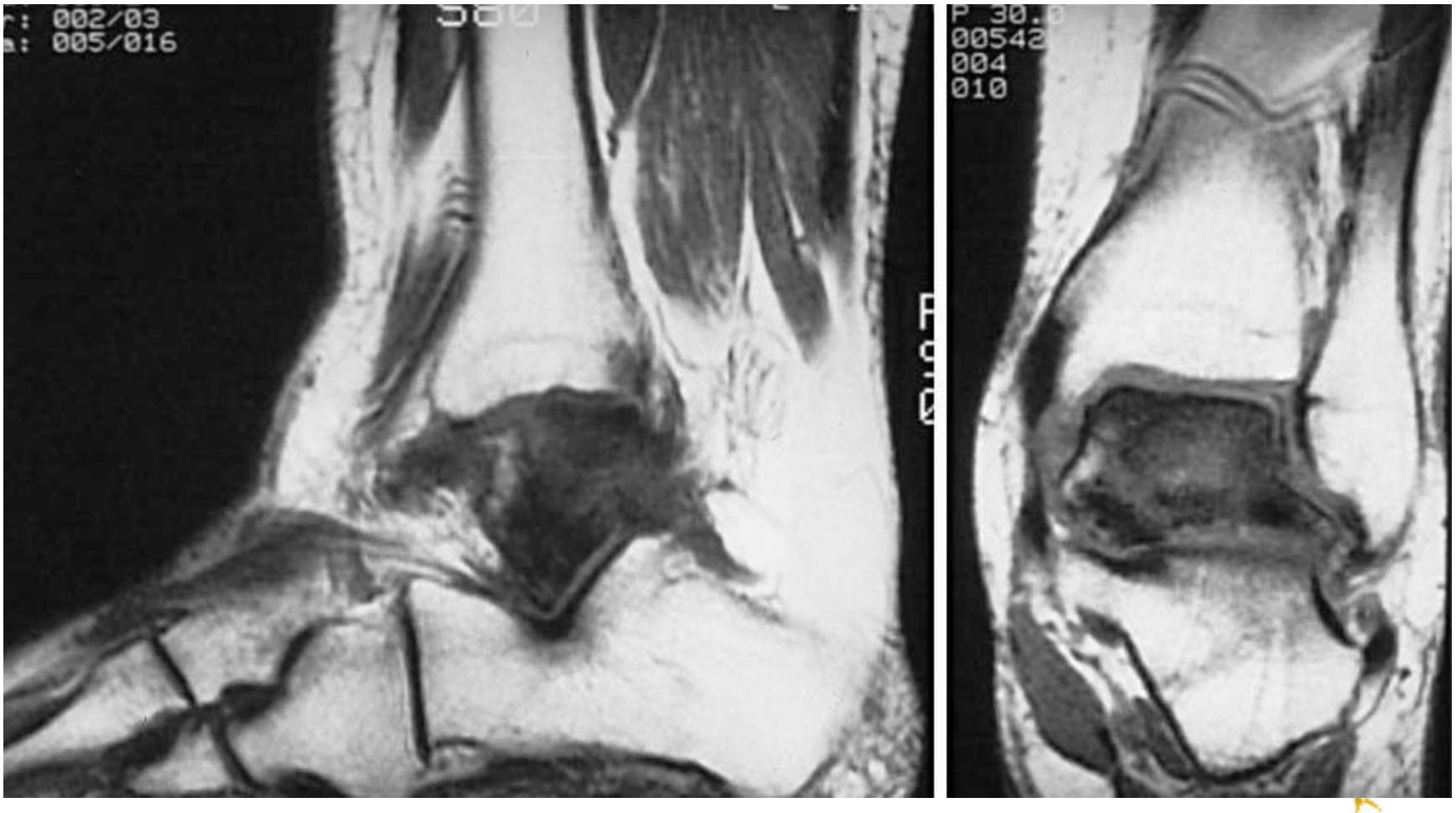
What Stage Hawkin's?



Incidence of AVN & STJ Arthritis

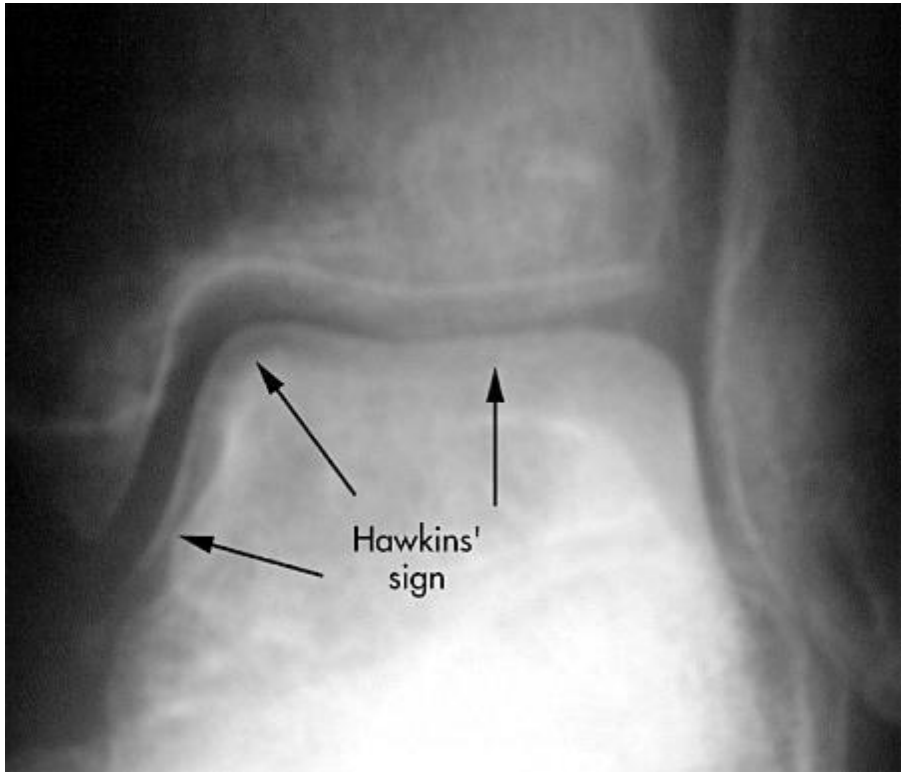
	AVN	STJ Arthritis
•**Type I**	0-10 %	RARE
•**Type II**	20-40%	60-75%
•**Type III**	70-100%	80-100%
•**Type IV**	100%	100%

AVN of Talus



Hawkins' Sign

- Noted 6 to 8 weeks after injury
- Disuse osteopenia appears as subchondral atrophy in the dome of the talus on the AP radiograph.
- This appearance, known as "*Hawkins' sign*", means that the talus is vascular, making the diagnosis of AVN unlikely.
- Hawkins' Sign = GOOD

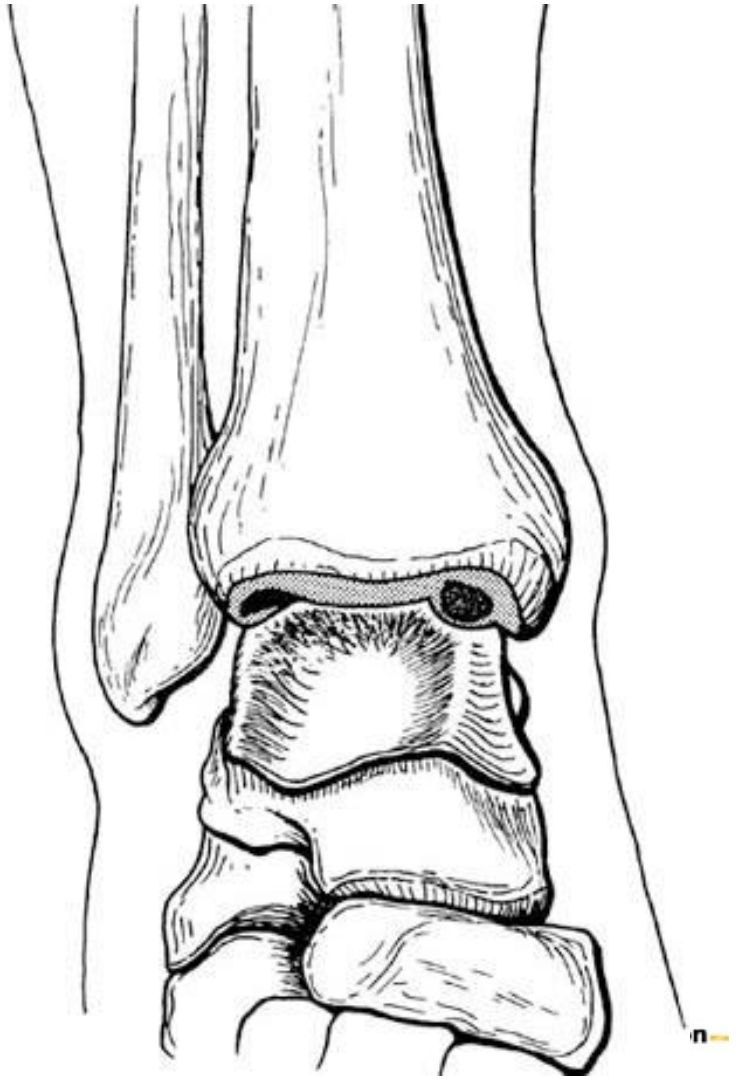


Talar Body Fractures

- **Sneppen Classification**
  - **Group I**: transchondral or compression fracture
  - **Group II**: shearing fractures
    - Type I: coronal or sagittal fracture
    - Type II: horizontal fracture
  - **Group III**: fracture of the posterior tubercle
  - **Group IV**: fracture of lateral process of talus
  - **Group V**: crush fracture of the talar body

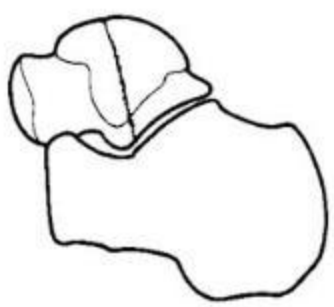
Talar Body Fractures

- **Group I**:
  - Transchondral or compression fracture of the talar dome
  - Includes osteochondritis dessicans of the talus
  - Berndt-Harty type injury

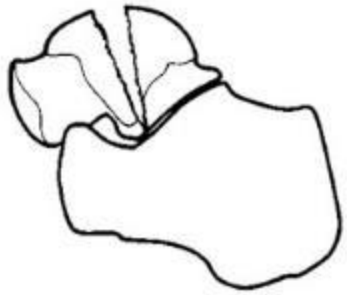


Talar Body Fractures

- **Group II**: shearing fractures involving the entire talar body
  - Type I: coronal or sagittal fracture
    - Type IA: non-displaced
    - Type IB: displacement of trochlear articular surface
    - Type IC: displacement of trochlear articular surface with associated STJ dislocation
    - Type ID: total dislocation of the talar body



Type IA



Type IB

Type IC

Type ID

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Talar Body Fractures

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Talar Body Fractures

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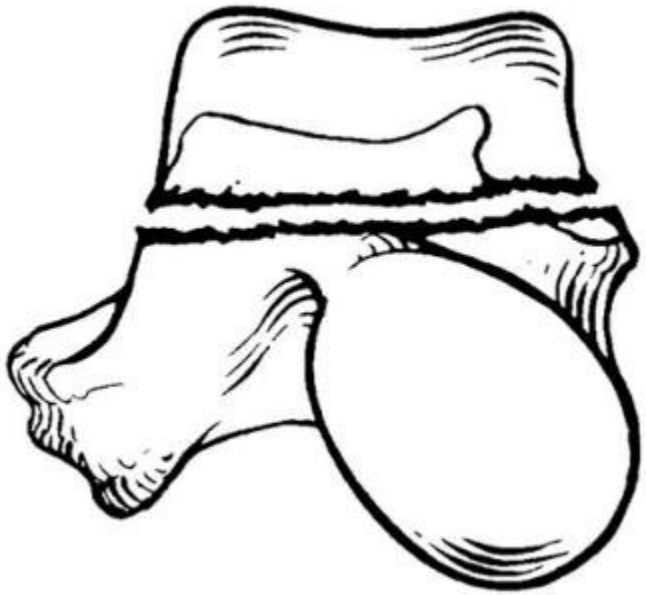
    - Type ID: total dislocation of the talar body

Talar Body Fractures

- **Group II**: shearing fractures involving the entire talar body
  - Type II: horizontal fracture
    - Type IIA: non-displaced
    - Type IIB: displaced

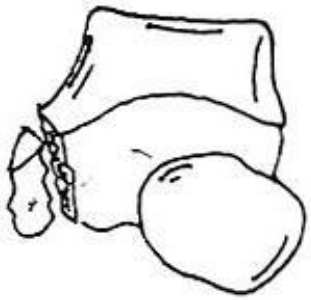


Talar Body Fractures

- **Group III**: fracture of the posterior tubercle of talus
  - Note: Os Trigonium present ~ 10% population
- **Group IV**: fracture of lateral process of talus
- **Group V**: crush fracture of the talar body

Group III:
Posterior Tubercle Fractures

Group IV:
Lateral Process Fractures



Group V:
Crush Fractures

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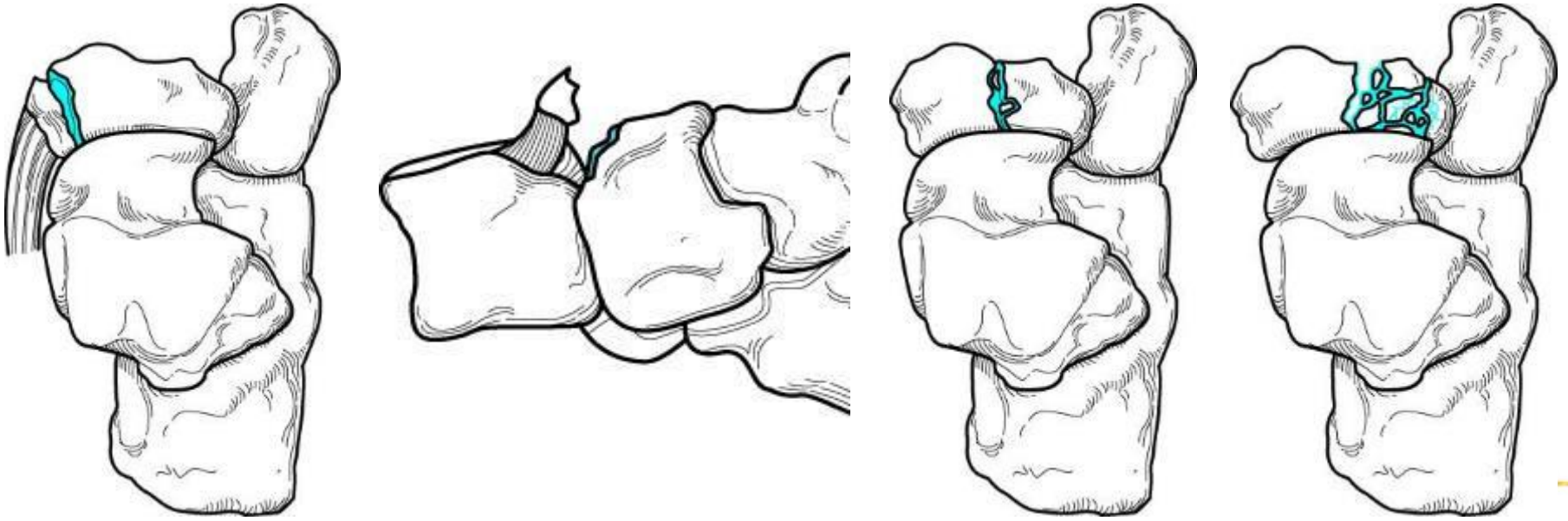
Talar Body Fractures

- **Group III**: fracture of the posterior tubercle of talus
- **Group IV**: fracture of lateral process of talus
- **Group V**: crush fracture of the talar body

Navicular Fracture

- **Watson & Jones Classification**
  - **Type I**: tuberosity fracture (associated with “nutcracker syndrome”)
  - **Type II**: dorsal lip fracture (most common type - 47%)
  - **Type IIIA**: transverse body fracture, non-displaced
  - **Type IIIB**: transverse body fracture, displaced
  - **Type IV**: stress fracture



Navicular Fracture

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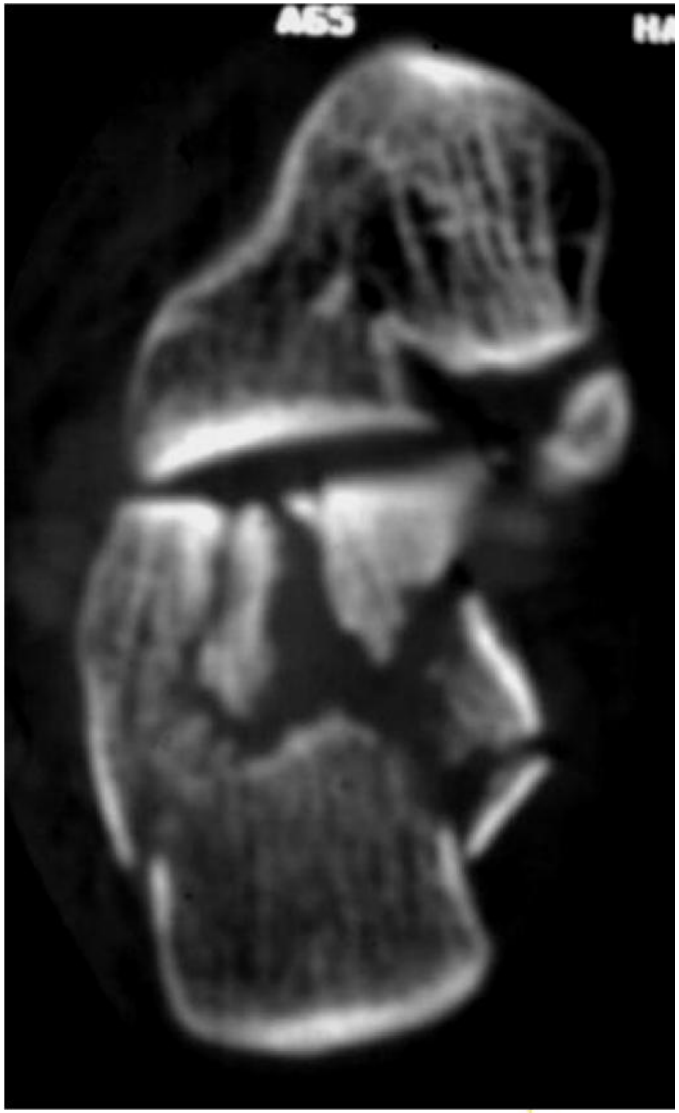
  - **Type IIIA**: transverse body fracture, non-displaced
  - **Type IIIB**: transverse body fracture, displaced
  - **Type IV**: stress fracture

What is the Type?

Calcaneal Fractures

- Most commonly as a result of a fall from a height
  - 75%-80% of these fractures occur from falls from a height greater than 3 feet
- **Most commonly fractured tarsal bone**
  - Represents 60% of all major tarsal injury
- However only 2% of all body fractures
- 55-75% are intra-articular in nature
- 90% occur in males 30-49



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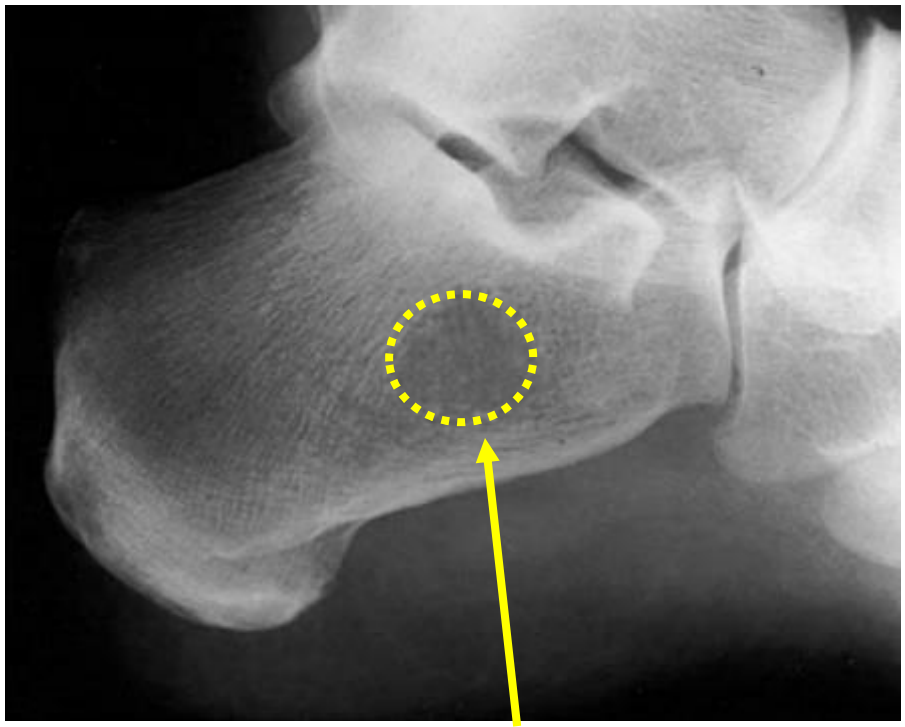
Introduction: Statistics

- 26% have associated extremity fracture
- 10% have spinal injury
  - L1 most common
- *7-15% are bilateral*
- 2% occur as open fracture
- 2-5% incidence of compartment syndrome

Calcaneal Anatomy

- **Neutral triangle**
  - Known as "*Ward's triangle*"
  - Represents the entrance of medullary vessels
  - Lies just beneath the crucial angle of Gissane
  - Considered to be the weakest portion of the calcaneus
- Trabecular patterns
  - Traction
    - inferior surface
  - Compression
    - radiate from superior articular facets
    - "Thalamic" portion of calcaneus



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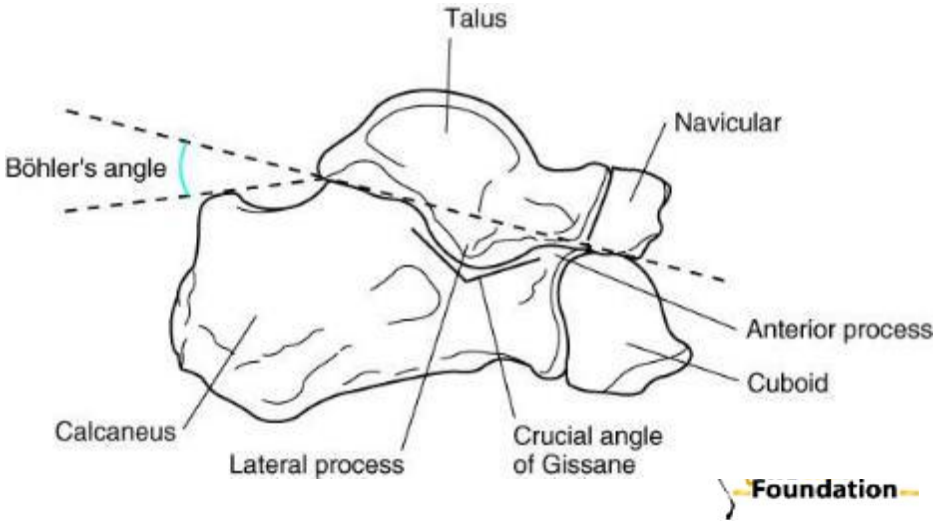
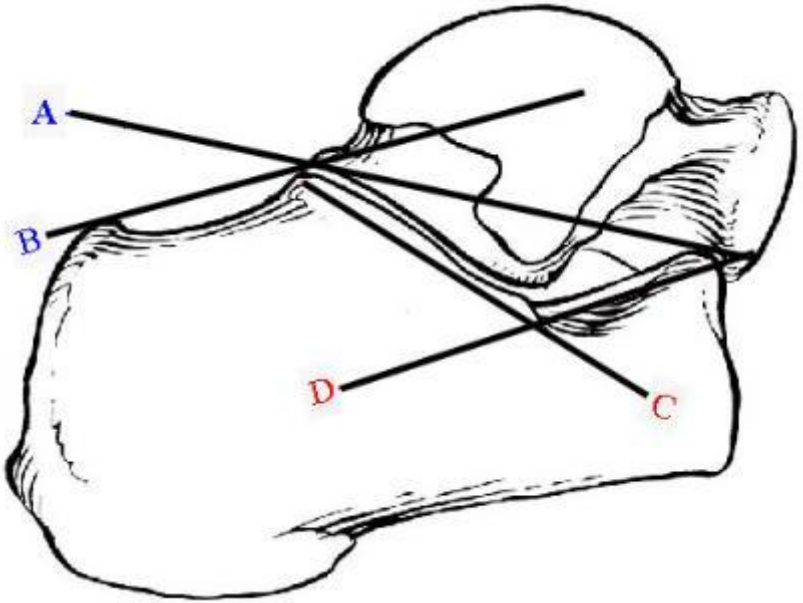
Radiographic Examination

- **Böhler's angle**
  - Normal: 25-40 degrees
  - In a joint depression fracture, decreases less than 20 degrees
- **Crucial angle of Gissane**
  - Normal: 125-140 degrees
  - In a joint depression fracture, increases greater than 145 degrees
- **Calcaneal compression angle**
  - Normal: 20-40 degrees
  - In a joint depression fracture, decreases less than 20 degrees



Radiographic Angles

- **Line A**: superior portion of the posterior facet to anterior process of the calcaneus
- **Line B**: Posterior bursal projection to superior portion of the posterior facet
- **Line C**: superior thalamic portion of the posterior facet
- **Line D**: inferior portion of the thalamic portion to the anterior process of the calcaneus



Classifications

- **Rowe classification (1963)**
  - 146 patients, 154 fractures, 5 types
  - Radiographic classification
  - Most commonly used classification
  - More useful classification for extra-articular fractures
- **Essex-Lopresti classification**
  - Radiographic classification
  - Replaces Rowe Types IV and V fractures
  - Two types
    - Tongue type
    - Joint depression
- **Saunders classification**
  - CT classification
  - 4 types

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Calcaneal Fractures

- **Rowe Classification**
  - **Type IA**: fracture of the medial tubercle
  - **Type IB**: fracture of sustentaculum tali
  - **Type IC**: fracture of the anterior process
  - **Type IIA**: beak fracture (no Achilles involvement)
  - **Type IIB**: tendo-Achilles avulsion fracture
  - **Type III**: extra-articular body fracture
  - **Type IV**: fracture involving the STJ (intra-articular) without joint depression
  - **Type VA**: comminuted, intra-articular fractures with central depression
  - **Type VB**: comminuted fractures with severe joint depression

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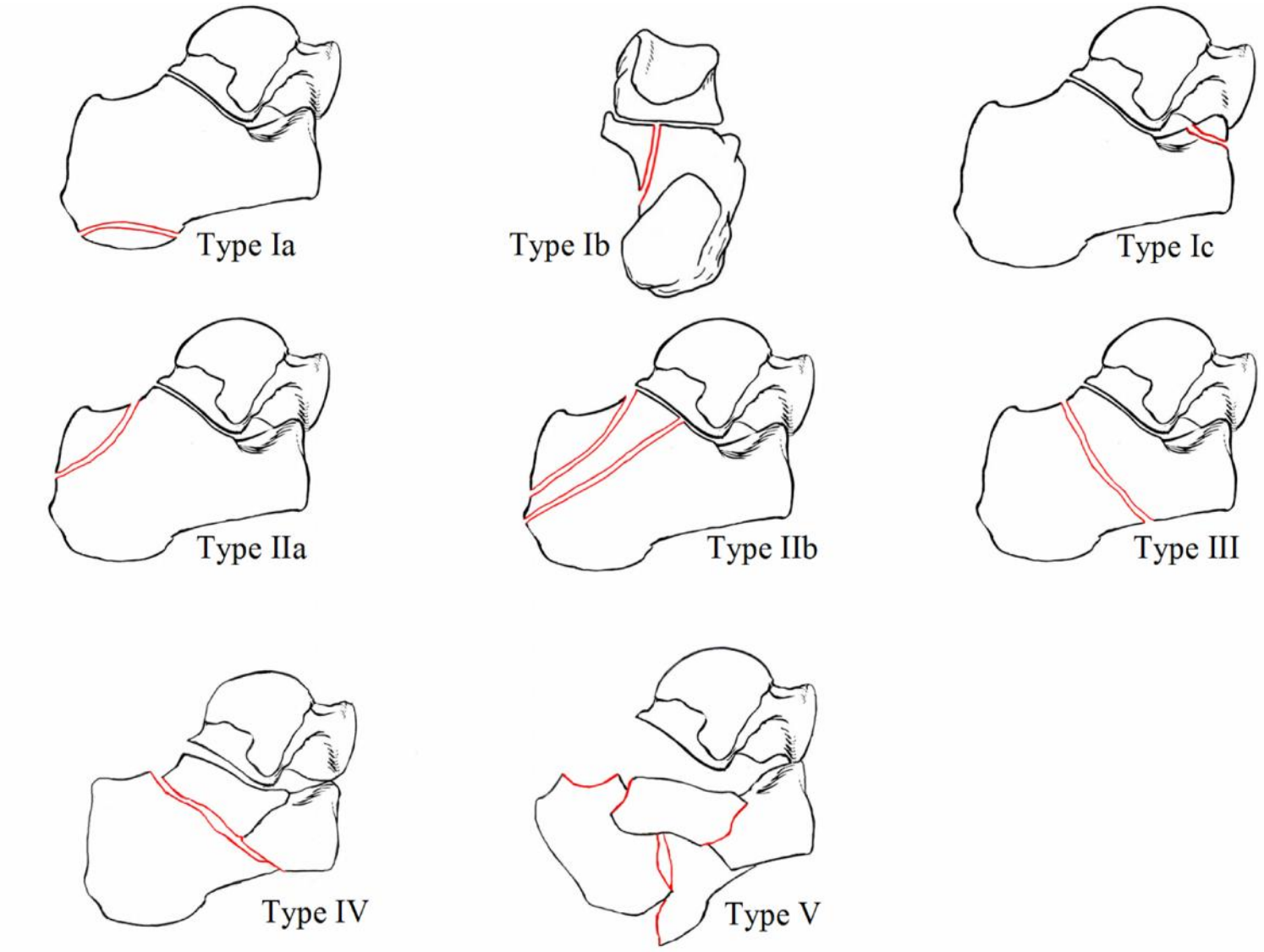
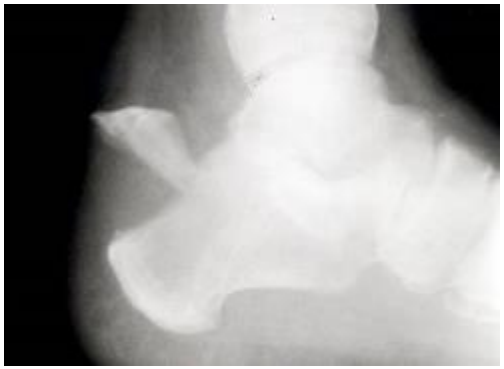
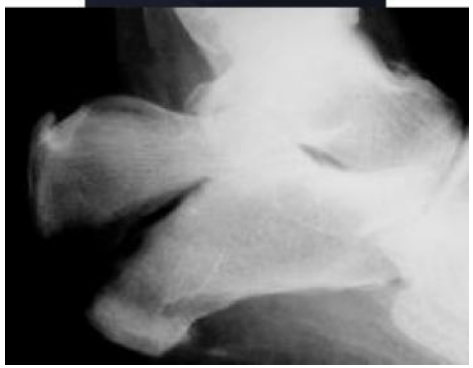
Rowe Classification



Rowe Classification





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Rowe Type Ia

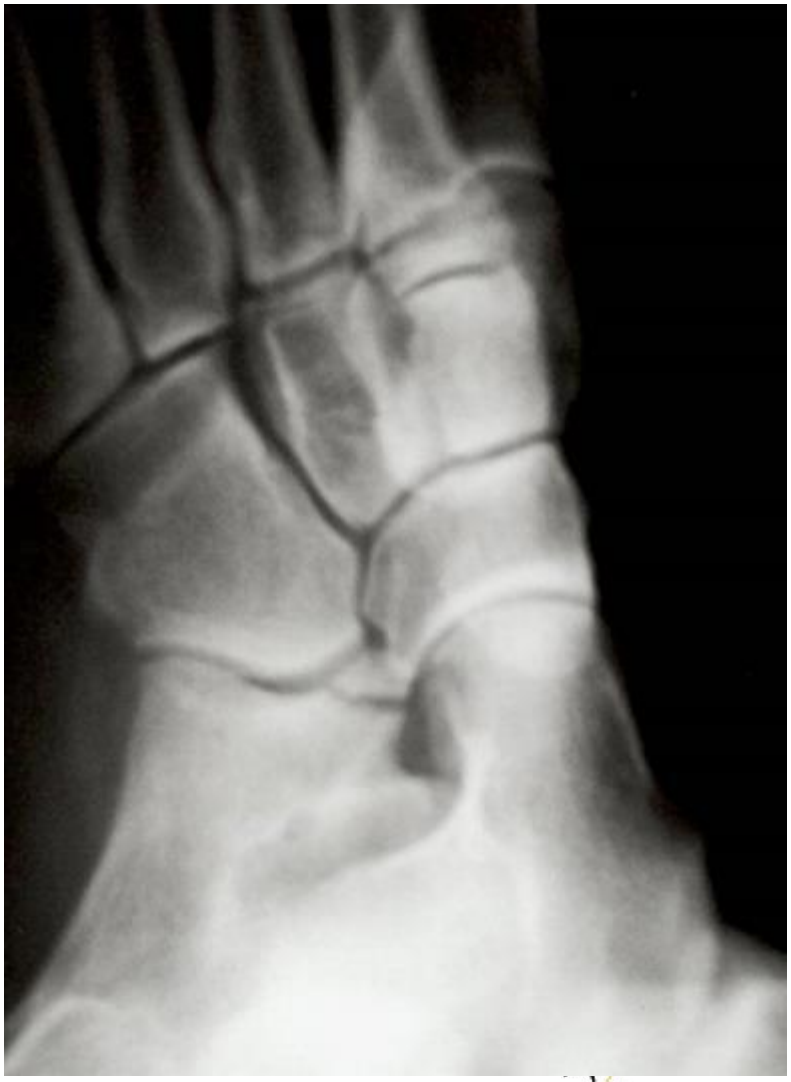
- Calcaneal tuberosity fracture (either medial or lateral)
- Mechanism of injury:
  - Usually the result forceful heel strike in valgus or varus position shearing medial or lateral tuberosity.
- Treatment:
  - Closed reduction and casting reported as adequate treatment.
- Not common fractures

Rowe Type Ib

- Sustentaculum tali fracture
- Mechanism of injury:
  - Fall on inverted foot, talar shearing force causes fracture
- Should be categorized as intra-articular since middle facet is involved
- Treatment:
  - Since the FHL and deltoid ligaments support rarely allows for displacement, the injury is usually treated with NWB
- Axial calcaneal view best displays fracture

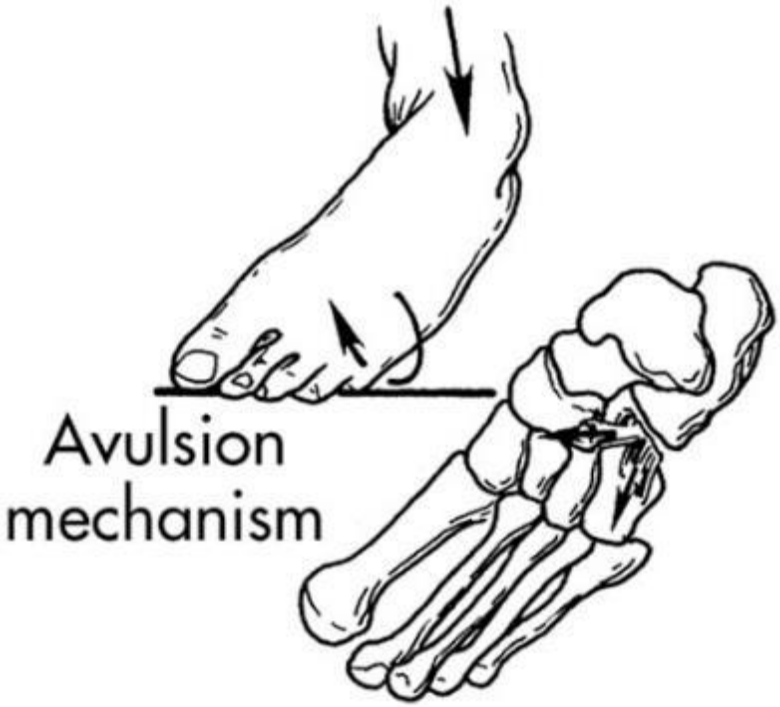
Rowe Type Ic

- Fracture of the anterior process of the calcaneus
  - Bifurcate Ligament
- May involve the CC joint if large
- Os calcaneal secondarium can be confused with fracture
- Degan Classification System



Rowe Type Ic

- Three mechanisms of injury are reported:
  - *Inversion and plantarflexion*
  - Dorsiflexion impaction (impaction against cuboid)
  - Forefoot abduction against fixed rearfoot (usually supination)



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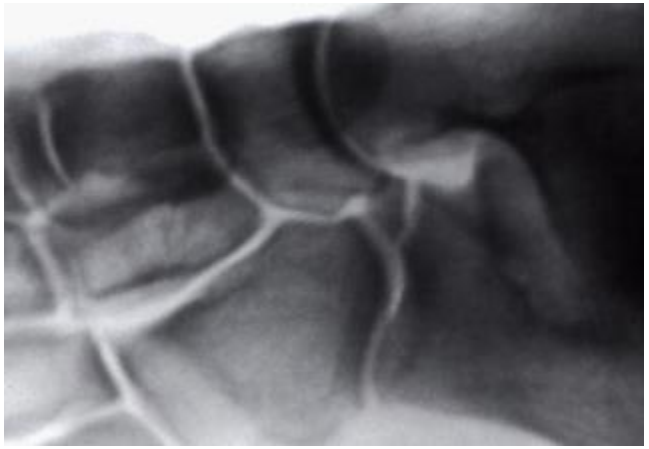
Rowe Type Ic

- Can use the **Degan classification**
  - **Type I**: Non-displaced fracture, usually only involving the anterior process (extra-articular)
  - **Type II**: Displaced fracture that does not involve the articular surface (extra-articular)
  - **Type III**: Large, displaced fracture fragment that involves the calcaneocuboid joint (intra-articular)



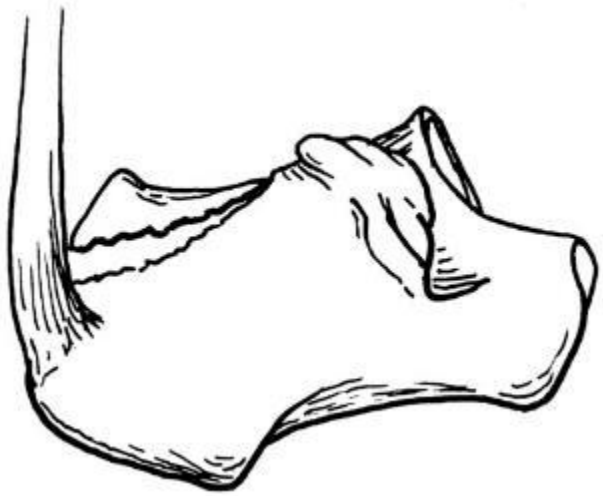
Rowe Type Ic

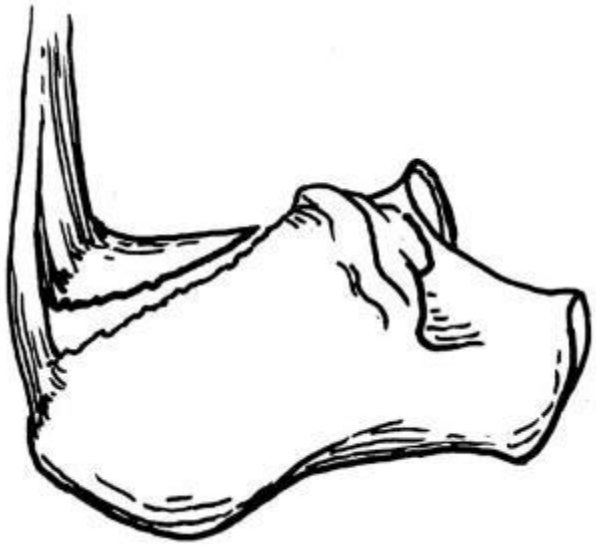
- **Treatment**:
  - If non-displaced or small fragments, than 3-4 weeks NWB cast with early ROM
  - If displaced, large fragments or involves greater than 25% of intra-articular fragment , than ORIF
  - Excision of fracture fragment: usually after 1 year of conservative care

Usually takes an extended period of time for full relief no matter what treatment employed

Rowe Type 2

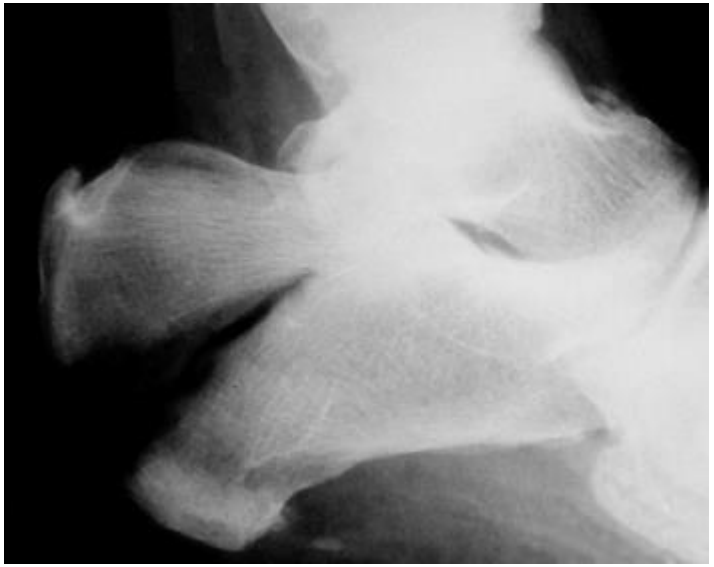
- **Two types**:
  - Type 2a represents a “beak fracture”
  - Type 2b is an “avulsion fracture”
- **Mechanism of injury**:
  - Avulsion fractures result of forceful contraction of Triceps Surae with foot in fixed or forced dorsiflexed position
- The fracture is typically oblique in nature and the fragment can vary in size and displacement
- Both fractures are extra-articular
- Some argue that “beak fractures” may not exist at all or may only be present in direct trauma situations





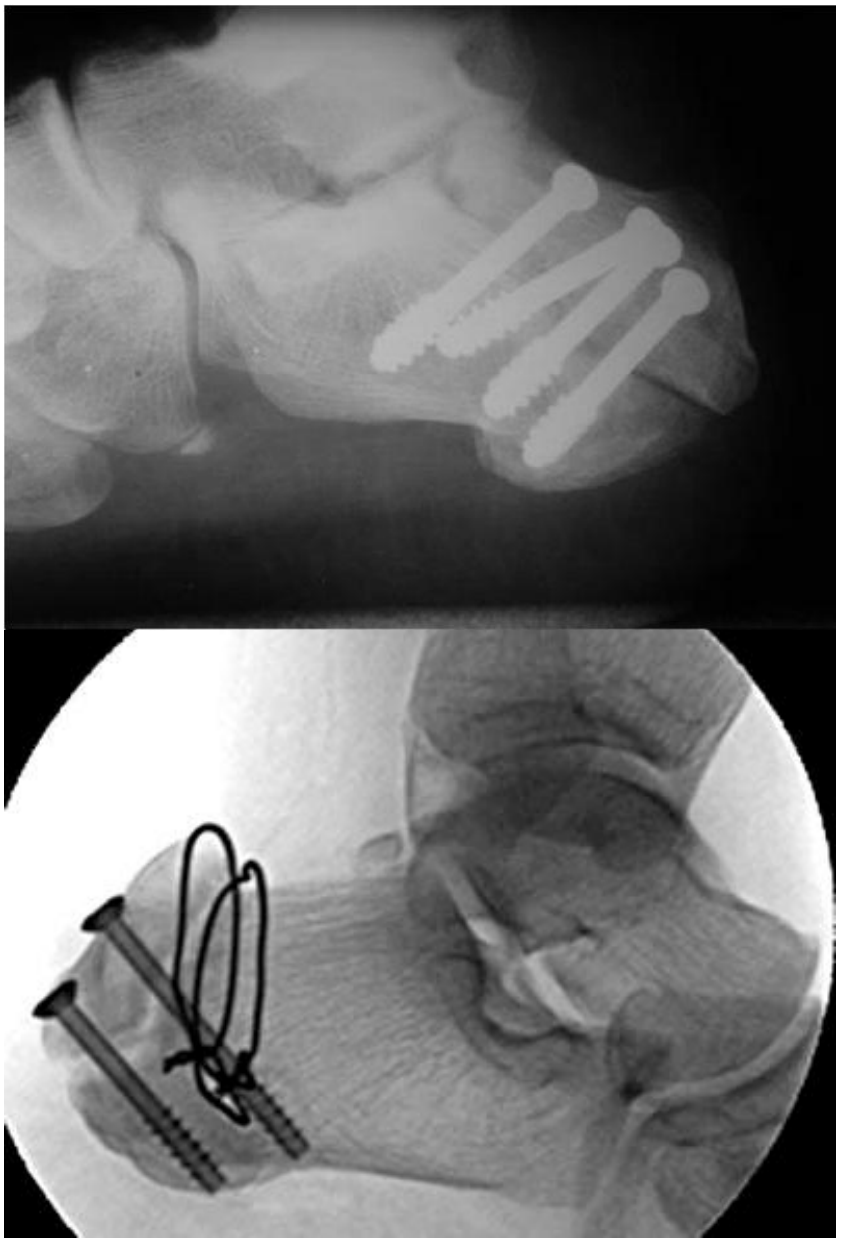
Foundation

Rowe Type 2



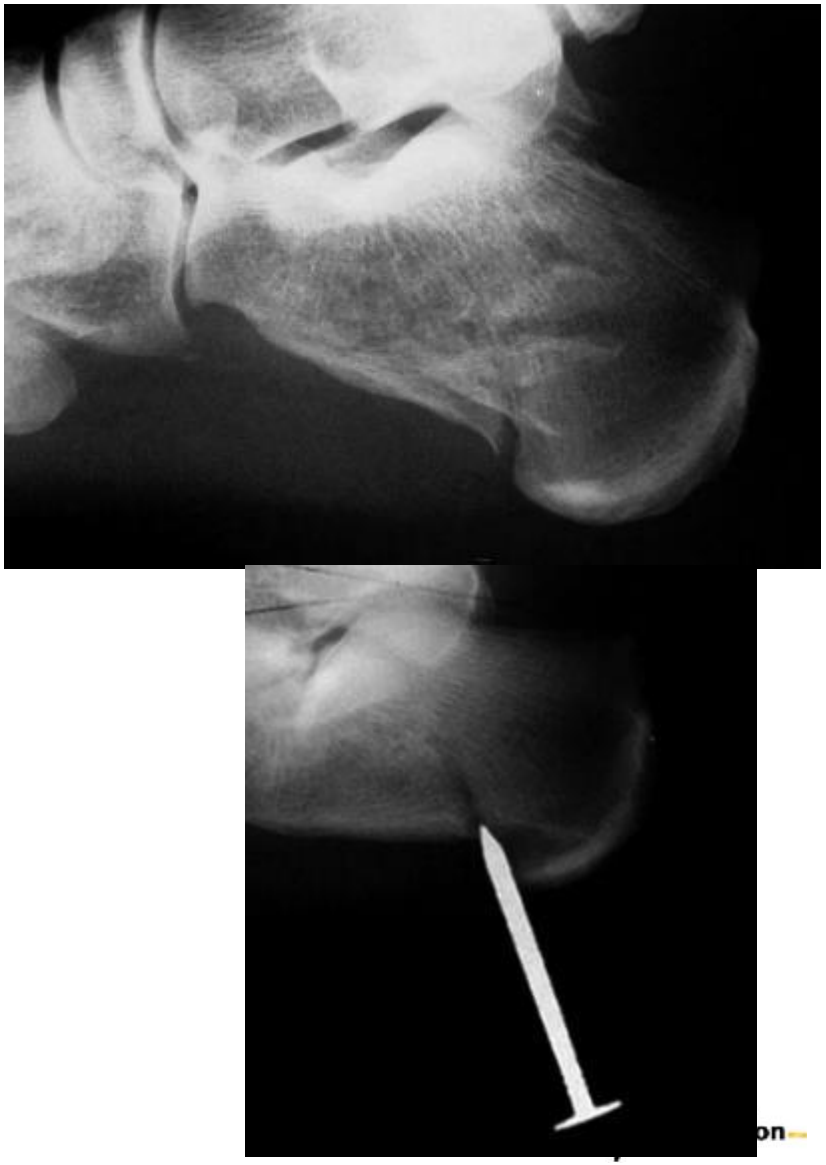
Rowe Type 2

- **Treatment**:
  - If non-displaced, than NWB cast immobilization for 6-8 weeks in equinus
  - Should attempt closed reduction to maintain Achilles function
  - If displaced or non-reducible , than ORIF is employed
  - Displaced Type IIb fractures require ORIF followed by above-the-knee casting for 6-8 weeks



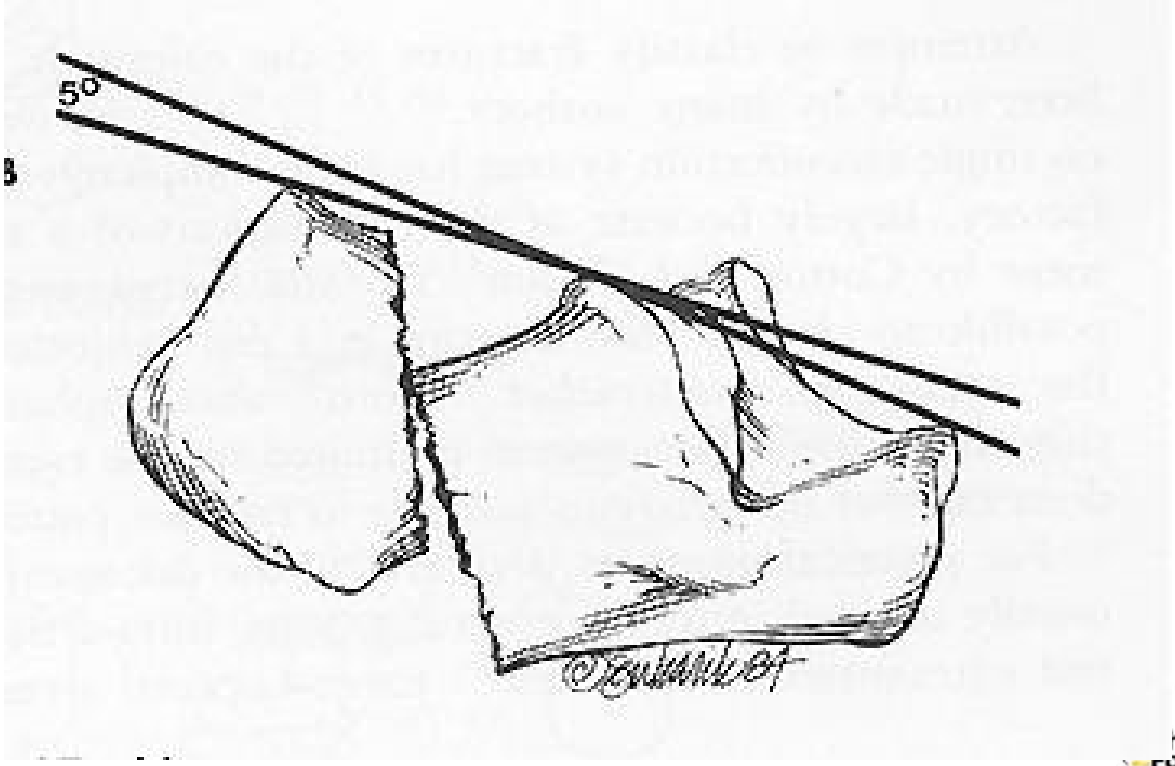
Rowe Type III

- Any fracture of the calcaneal body not involving the CC or ST joints.
- **Mechanism**: fall from height
- Fracture often runs posterior-medial to anterior-lateral
- **Treatment**:
  - If non-displaced fracture
  - Non weight-bearing 8 weeks
  - Early ROM



Rowe Type III

- Treatment:
  - Usually is non-displaced fracture
- Tuberosity fragment displacement
  - Reduce Bohler's angle with Steinman pin, similar to Essex-Lopresti maneuver.



Calcaneal Fractures

- **Essex-Lopresti Classification**
  - Replaces Rowe Type IV and V

- Two types of fractures
  - Type A (Tongue Type) Fracture
  - Type B (Joint Depression) Fracture

- Depends on vector of force

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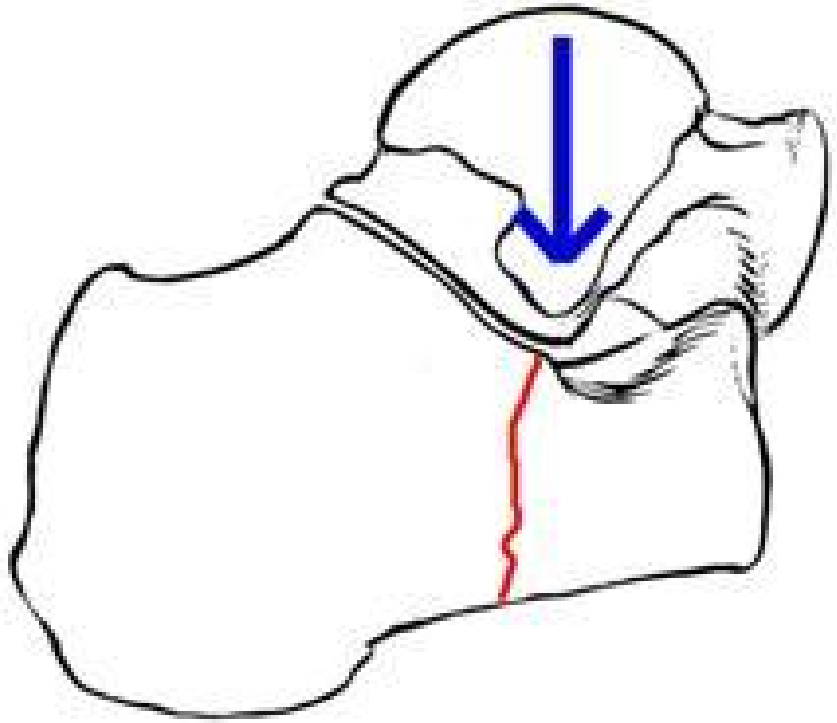
Type A (Tongue Type) Fracture

- *Vertical force*
- Talus carries the force into the STJ, sharp spur of talus is driven inferiorly into the crucial ankle, splitting it along the lateral cortex
- Secondary fracture line extends to posterior border of the tuberosity



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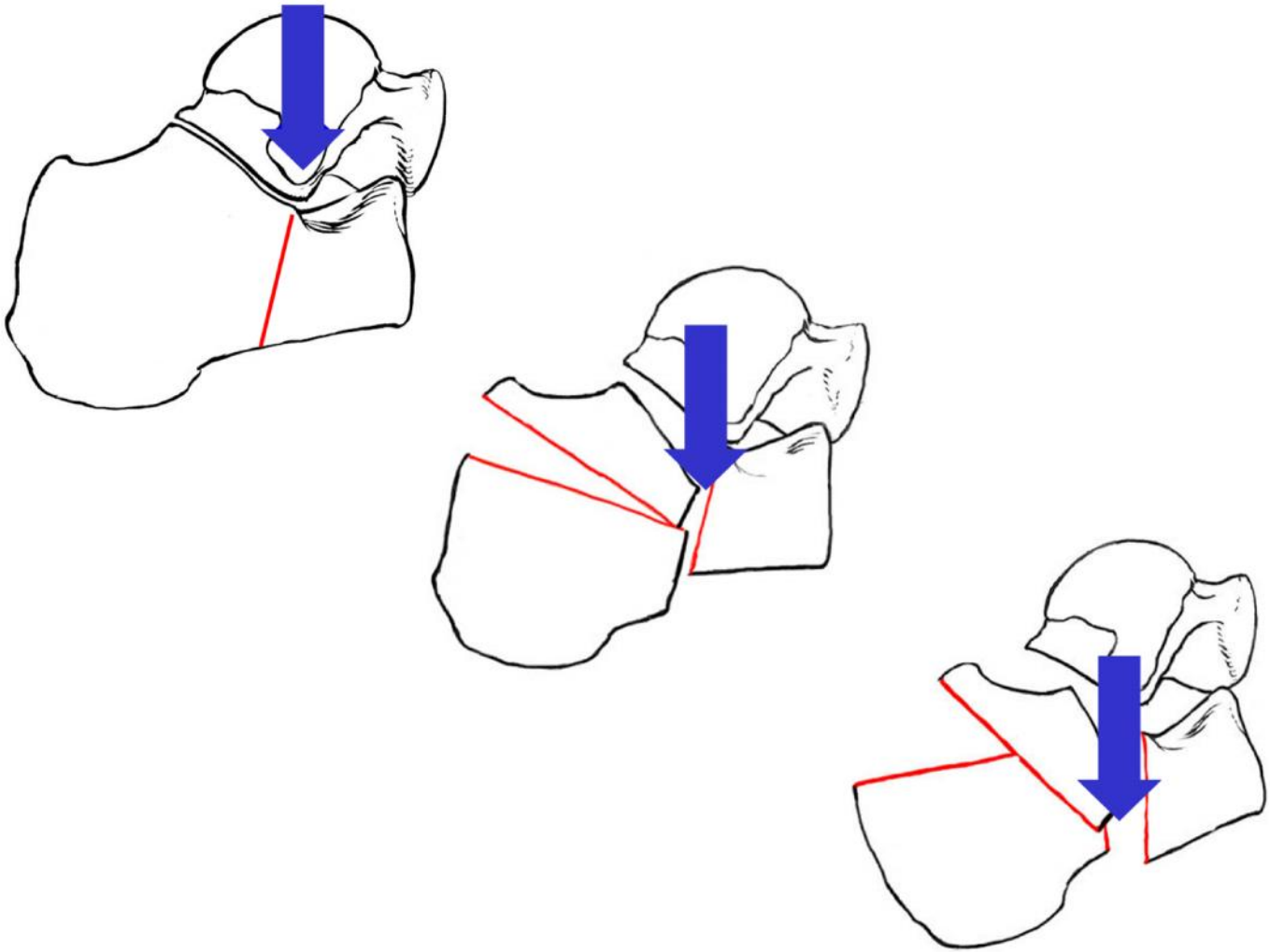
Type A (Tongue Type) Fracture



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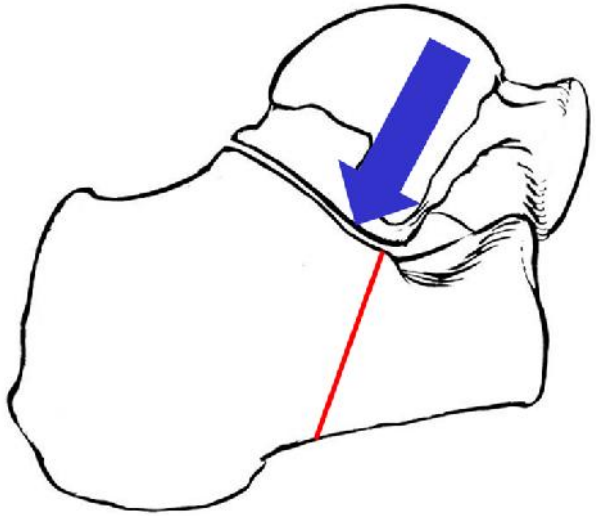
Type B (Joint Depression) Fracture

- *Posterior force*
- Primary fracture divides calcaneus into medial and lateral fragments
- The medial fragment includes the sustentaculum talus and medial portion of posterior facet of STJ
- The lateral fragment includes the lateral portion of the posterior facet and remaining body of calcaneus
- The lateral talar process acts like a wedge causing separation and depression of posterior facet into body of calcaneus
- Lateral wall fracture occurs with lateral cortical extension or with distal extension into the CC joint.



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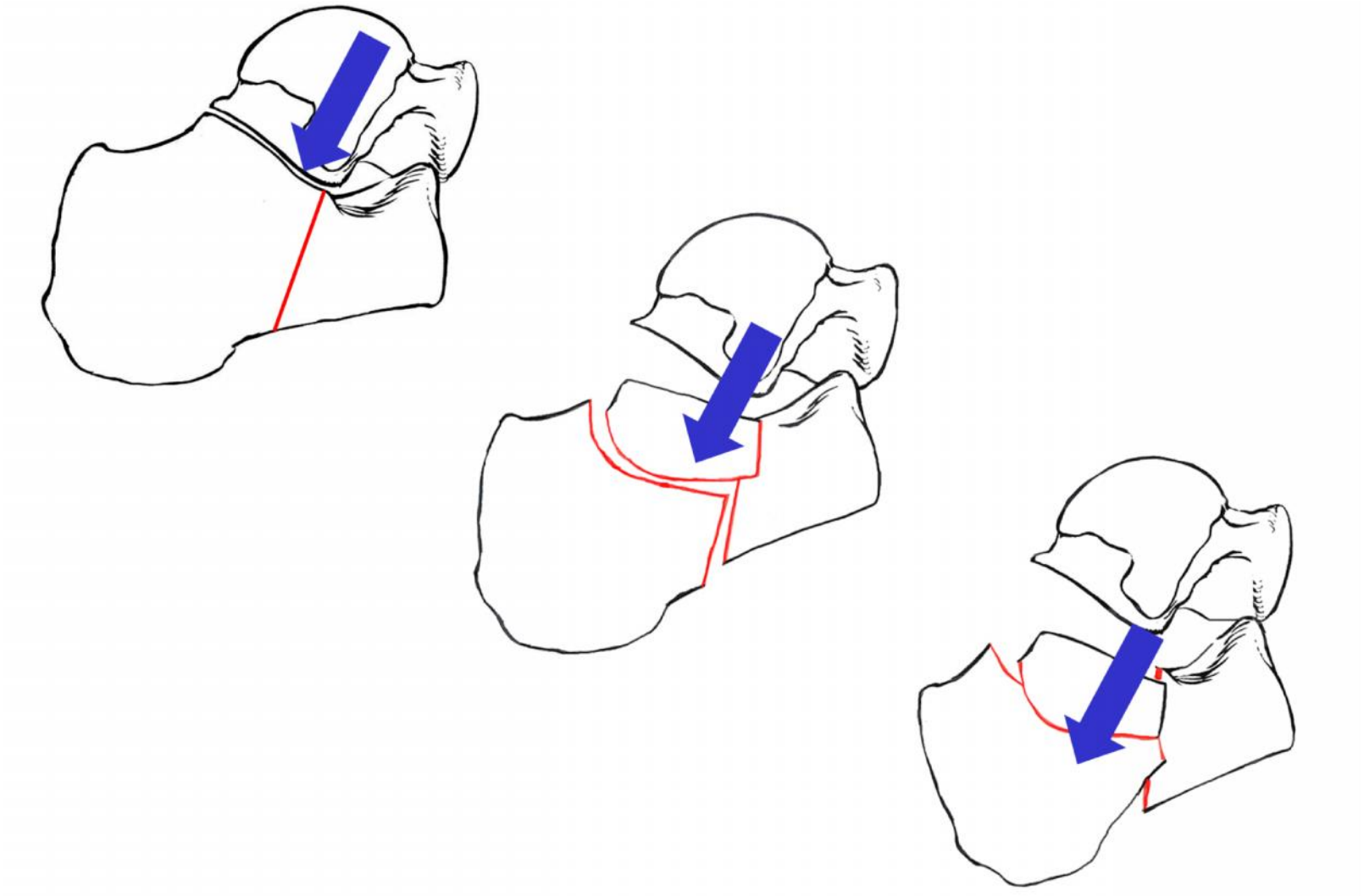
Type B (Joint Depression) Fracture



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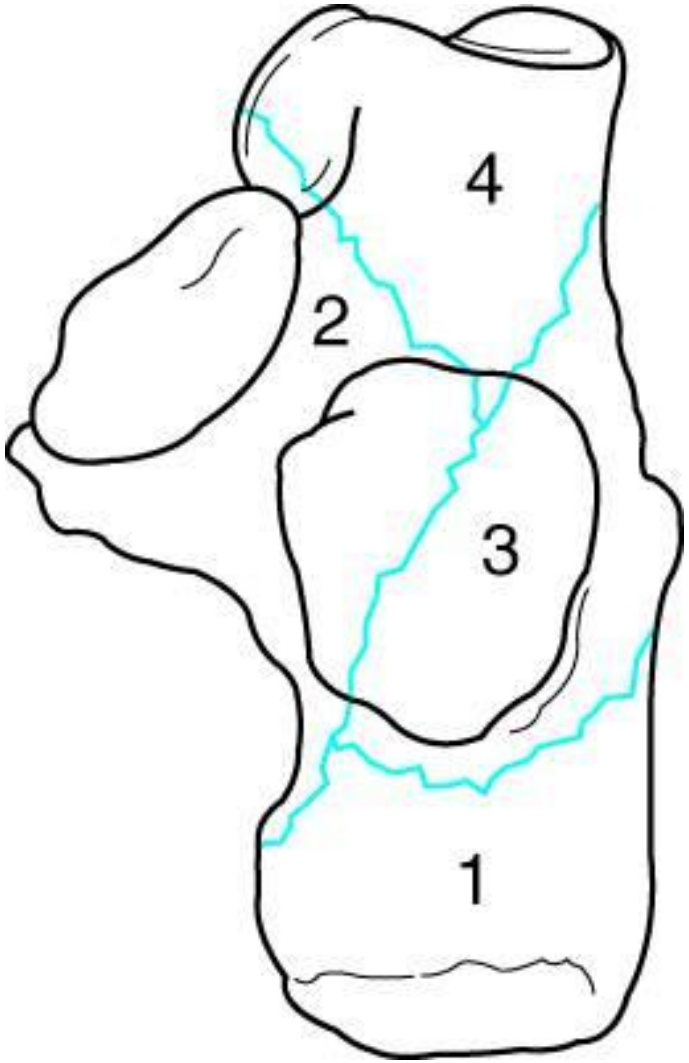
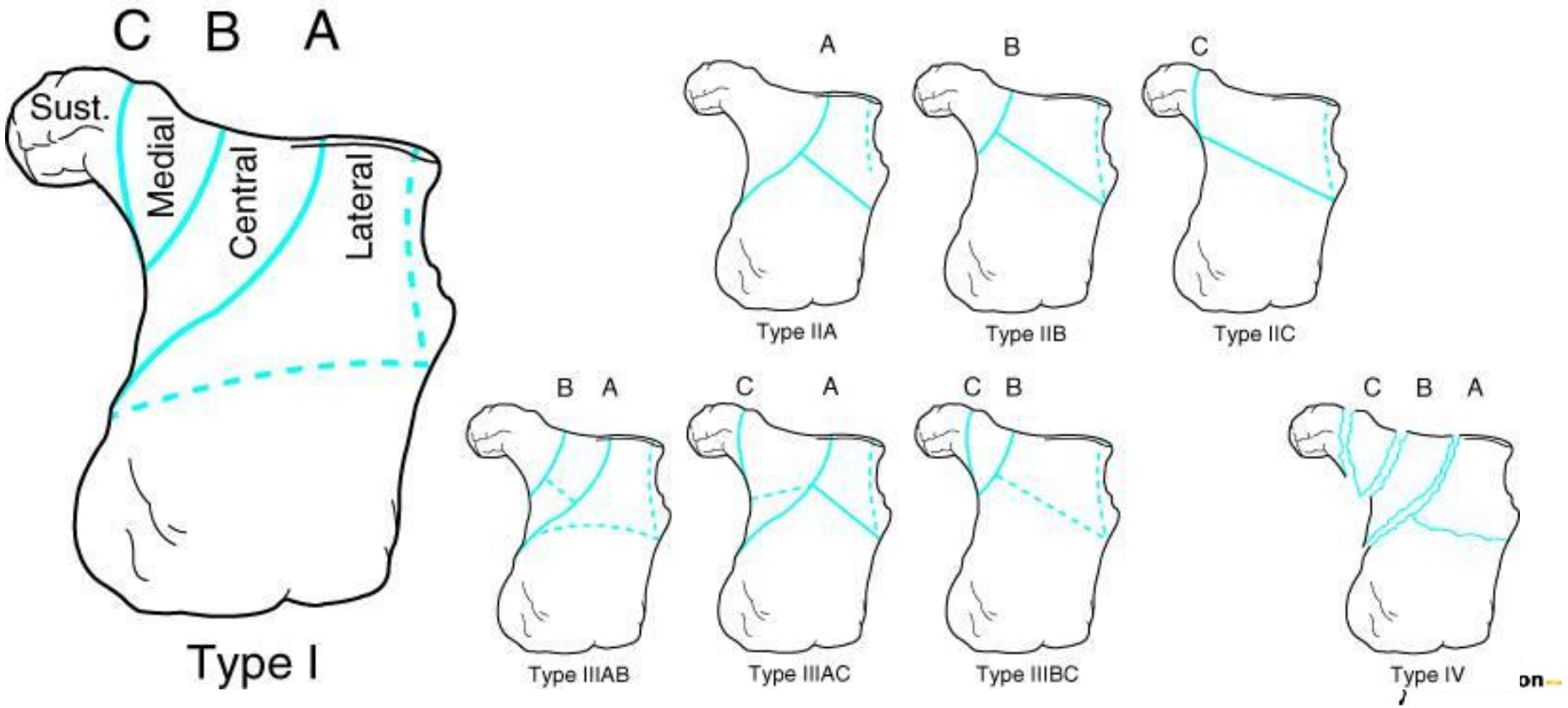
4 Parts of All Intra-Articular Calcaneal Fractures



- Tuberosity fragment
- Sustentacular fragment
- Posterior facet fragment (superior lateral fragment)
- Anterior lateral fragment

Sanders' Classification

- Sanders' Classification (1992)
- Based on CT axial and coronal plane images
- 4 fracture types

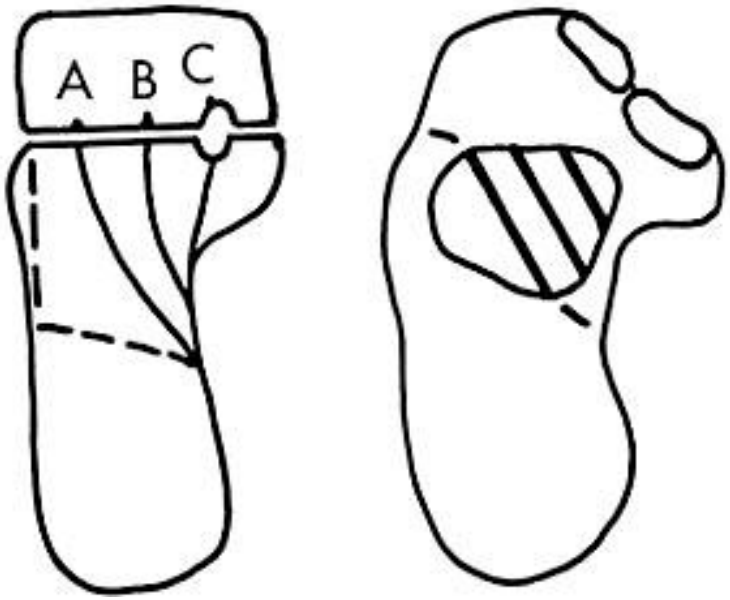


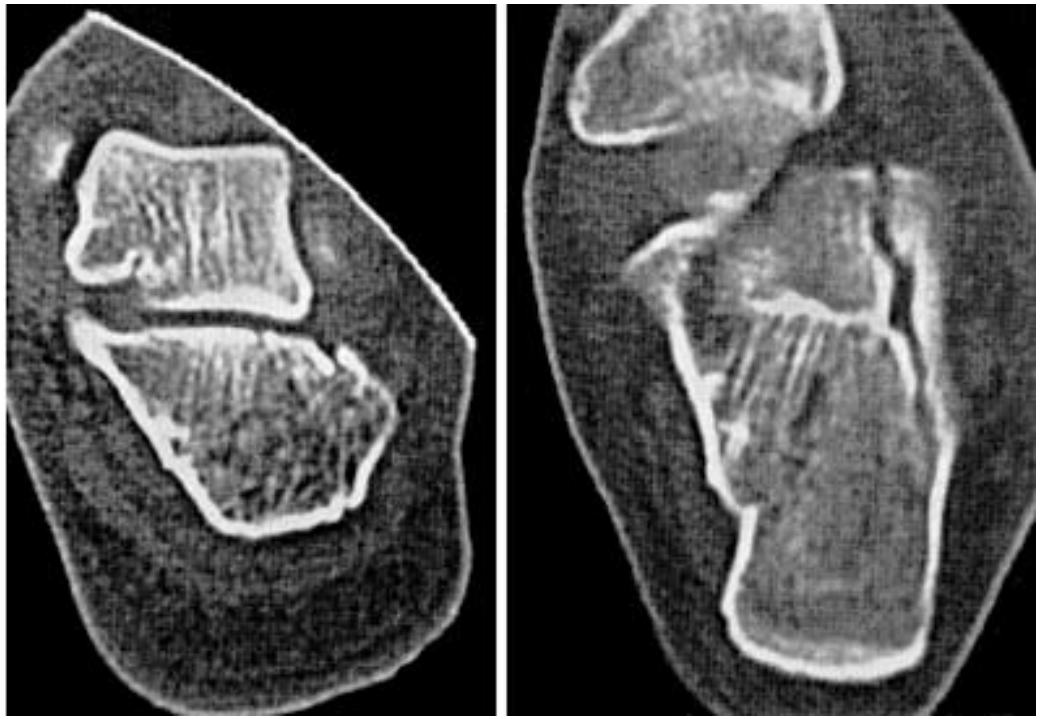
Sanders' Classification

- Use the inferior aspect of talus to divide into 3 columns
  - **Type I**: non-displaced
  - **Type II**: 2 part posterior facet fracture (one fracture line)
    - (A): fracture through lateral column
    - (B): fracture through central column
    - (C): fracture through medial column
  - **Type III**: 3 part posterior facet fracture with central depression (2 fracture lines)
    - (AB): fracture through the lateral and central columns
    - (AC): fracture through lateral and medial columns
    - (BC): fracture through central and medial columns
  - **Type IV**: 4 part posterior facet fracture

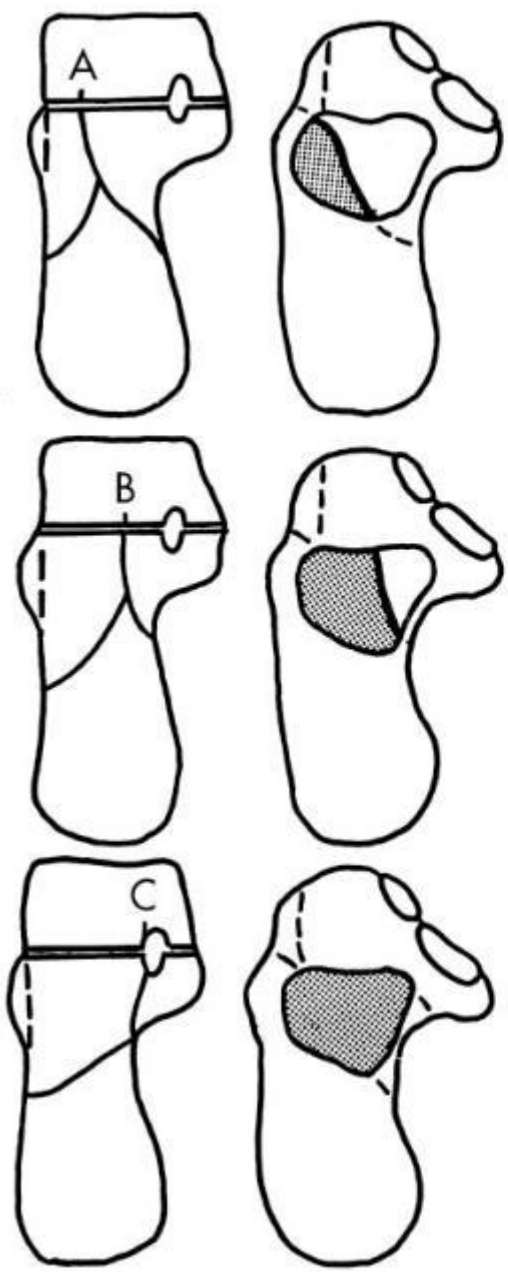
The Goldfarb Foundation

Sanders' Classification

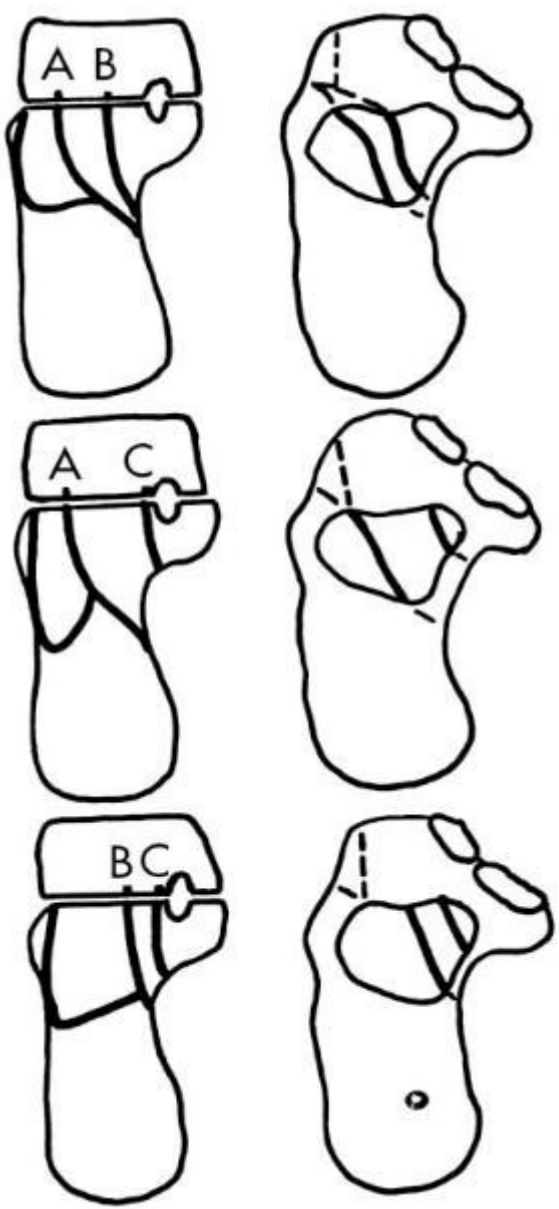




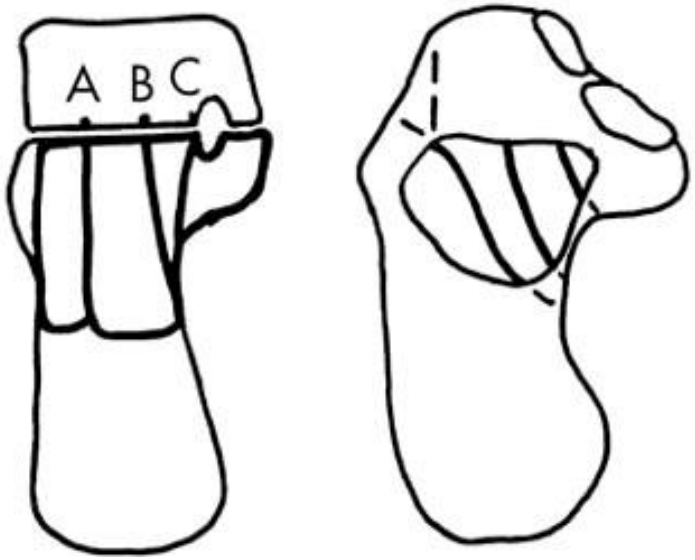
Sanders' Type II

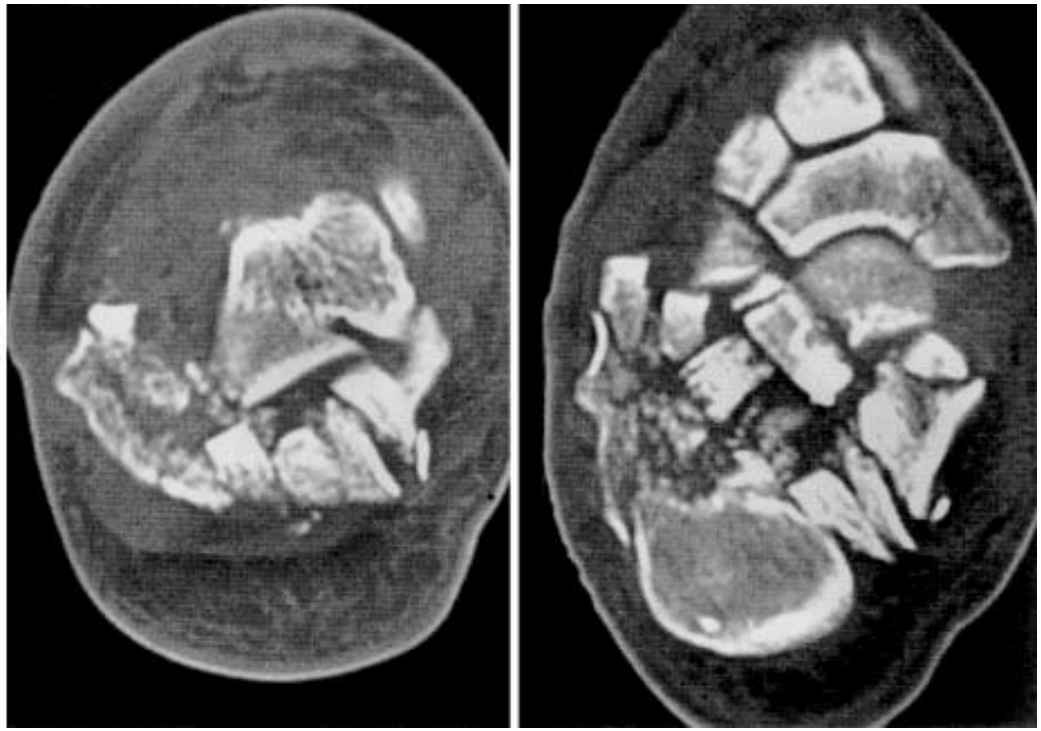


Sanders' Type III



Sanders' Type IV



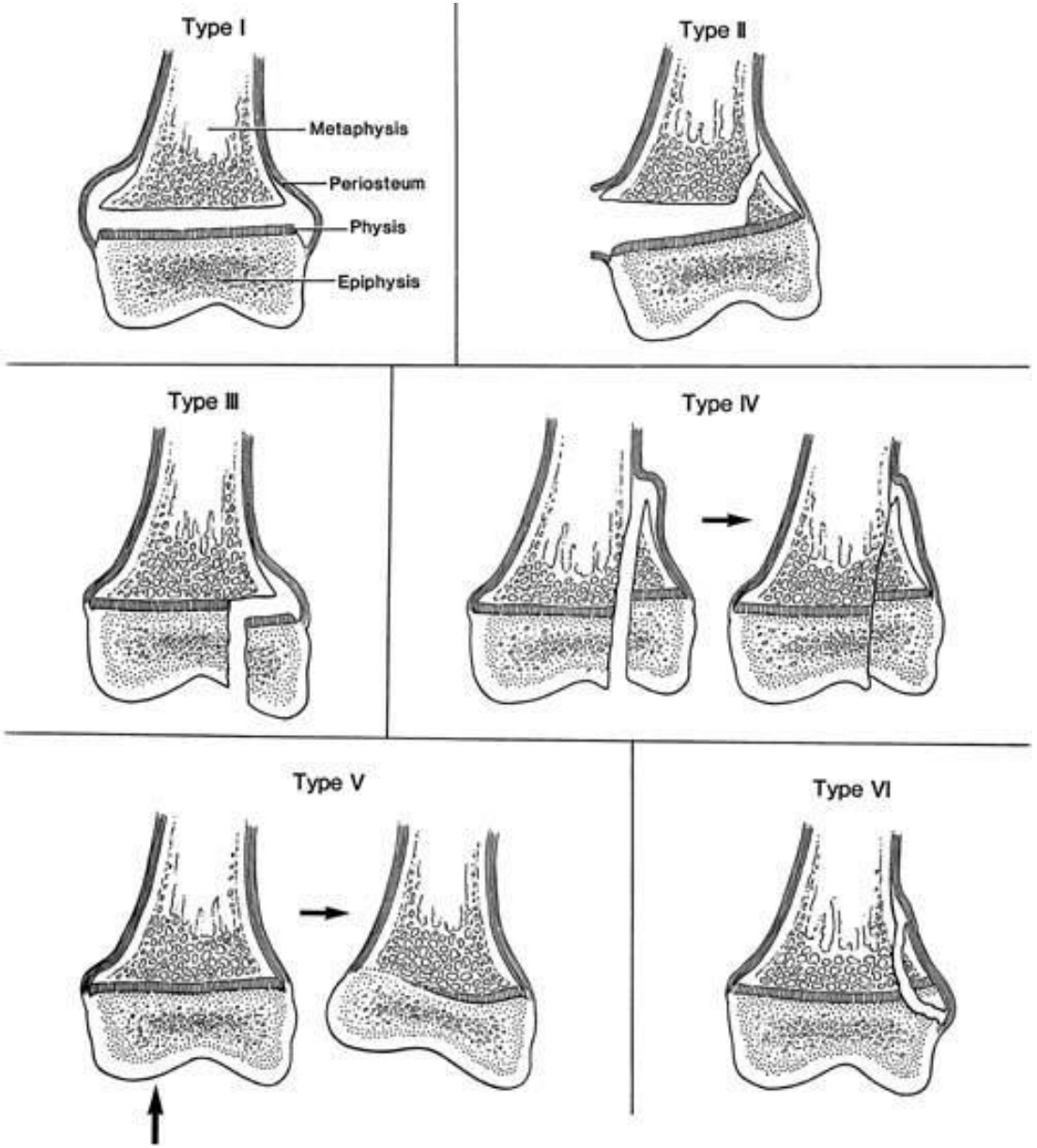


Epiphyseal Fractures

- **Salter-Harris Classification**
  - **Type I**: separation of the epiphysis without osseous fractures
  - **Type II**: fracture the epiphyseal plate progressing into the metaphysis proximally, leaving a metaphyseal spike called the "*Thurston-Holland sign*"
  - **Type III**: epiphyseal plate fracture propagating distally through the epiphysis, usually creating an intra-articular fracture
  - **Type IV**: fracture line transverse through the metaphysis, epiphyseal plate and epiphysis
  - **Type V**: crush injury to epiphyseal plate
  - **Type VI**: (Rang's addition) avulsion of peri-chondral ring
  - **Type VII**: (Odgen's addition) avulsion fracture of the epiphysis without involvement of the physis

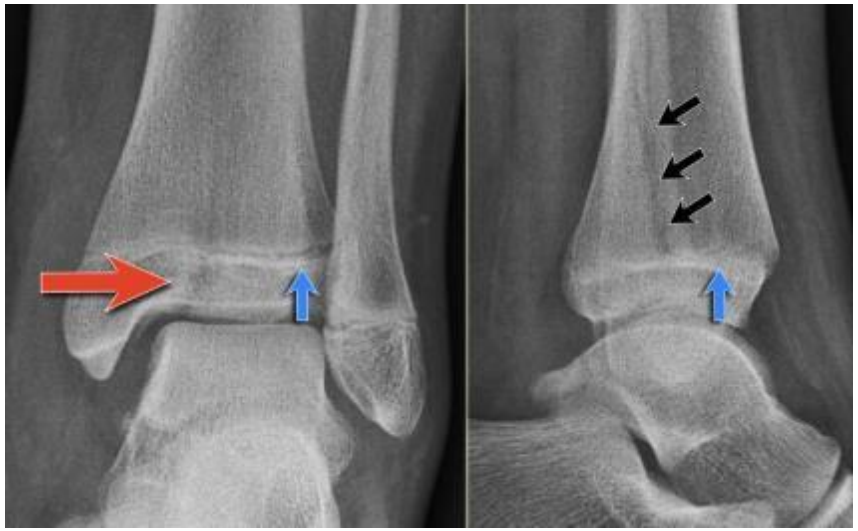
The Foundation

Salter-Harris Classification



Triplane Fracture

- Appears as…
  - SH 2 on Lateral XR
  - SH 3 on AP XR
- Occurs in younger kids (12-15yo) prior to physis closure with lateral physis last to close, most vulnerable



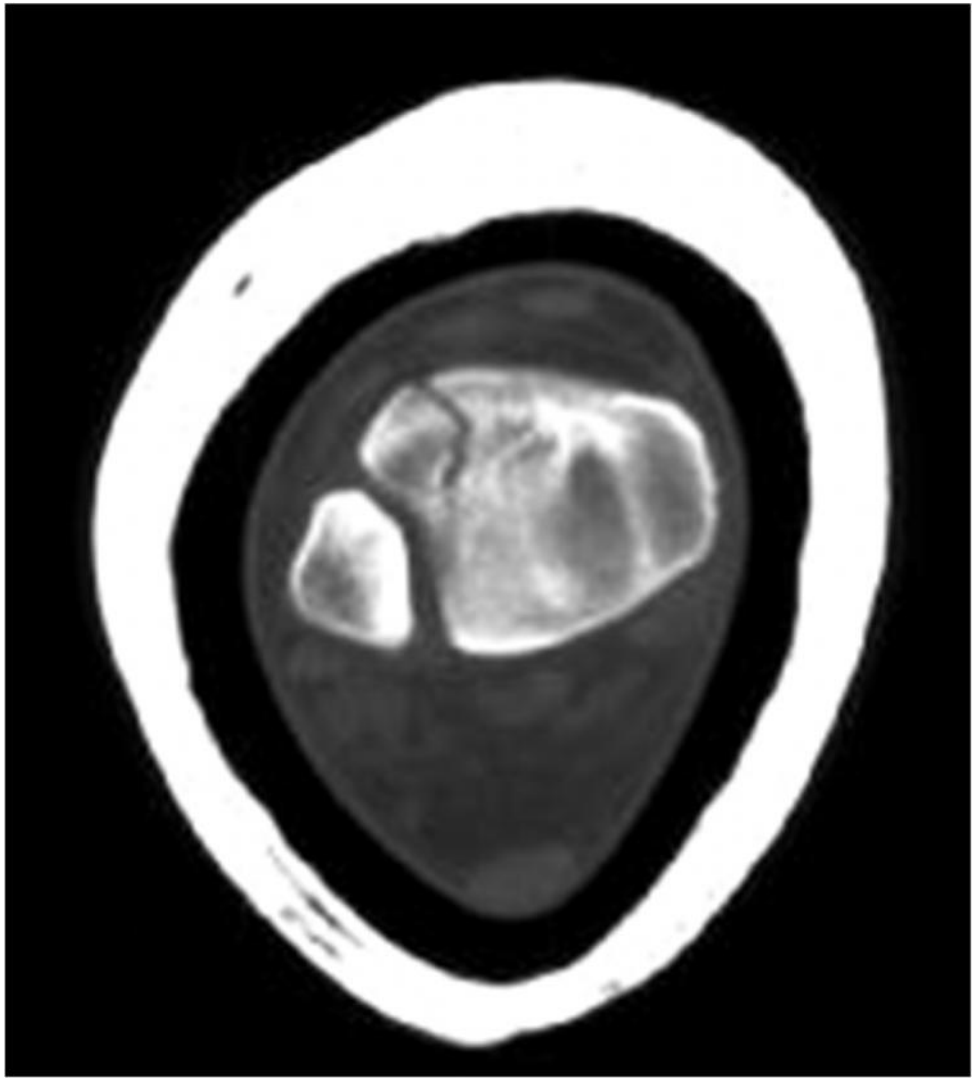
Ankle Fractures

- Two classification schemes are most commonly employed when dealing with ankle fractures.
  - Danis-Weber Classification
    - Based on location of fibular fracture
  - Lauge-Hansen Classification

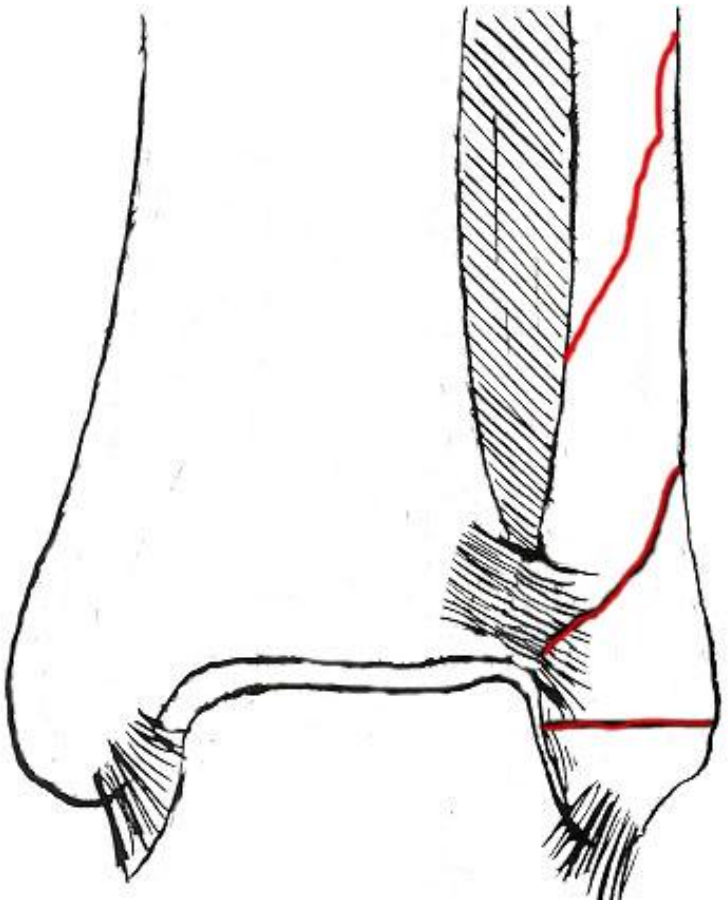
Maisonneuve Fracture

Volkmann's Fracture

Tillaux Fracture



Danis-Weber Classification



- **Danis-Weber A**:
  - Transverse fracture **below** the level of the joint
  - Implies syndesmosis intact
- **Danis-Weber B**:
  - Spiral or oblique fracture **at** the level of the joint
- **Danis-Weber C**:
  - Fracture **above** the level of the joint
  - Implies syndesmosis disrupted

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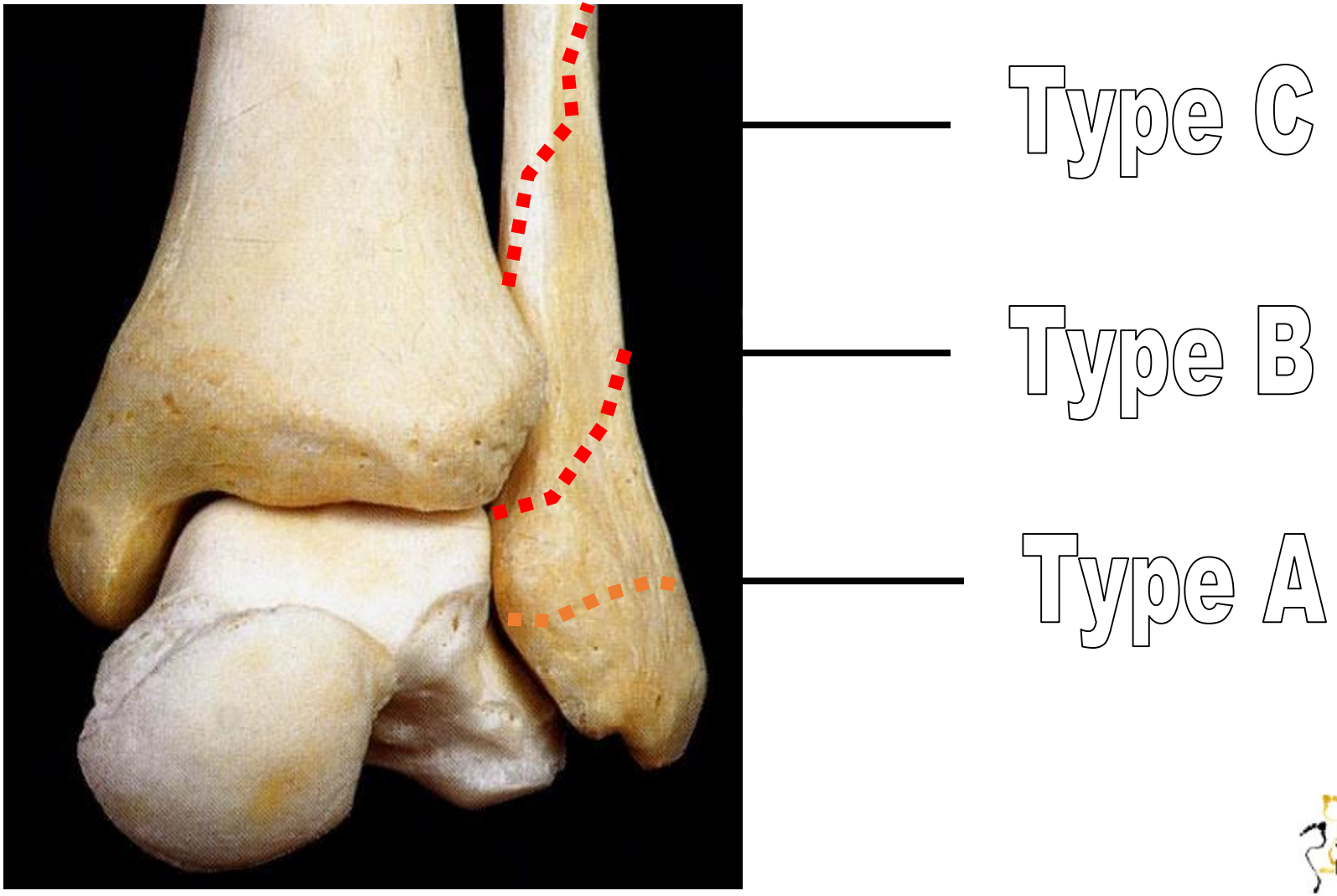
Danis-Weber Classification



Lauge Hansen Classification

- Accurately predicts mechanism of injury in **95%** of ankle fractures.
  - Only **5%** of ankle fractures do not fit into this classification system.
- Two word classification system:
  - First word = "***position***" of foot at time of injury
  - Second word = "***motion***" of foot at time of injury

5 Basic Patterns of Injury

- Supination-adduction
- Pronation-abduction
- Supination-eversion (SER)
  - Most common type
  - Occurs about 60% of time
- Pronation-eversion (PER)
- Pronation-dorsiflexion
  - Least common type
  - Only occurs in less than 5% of injuries

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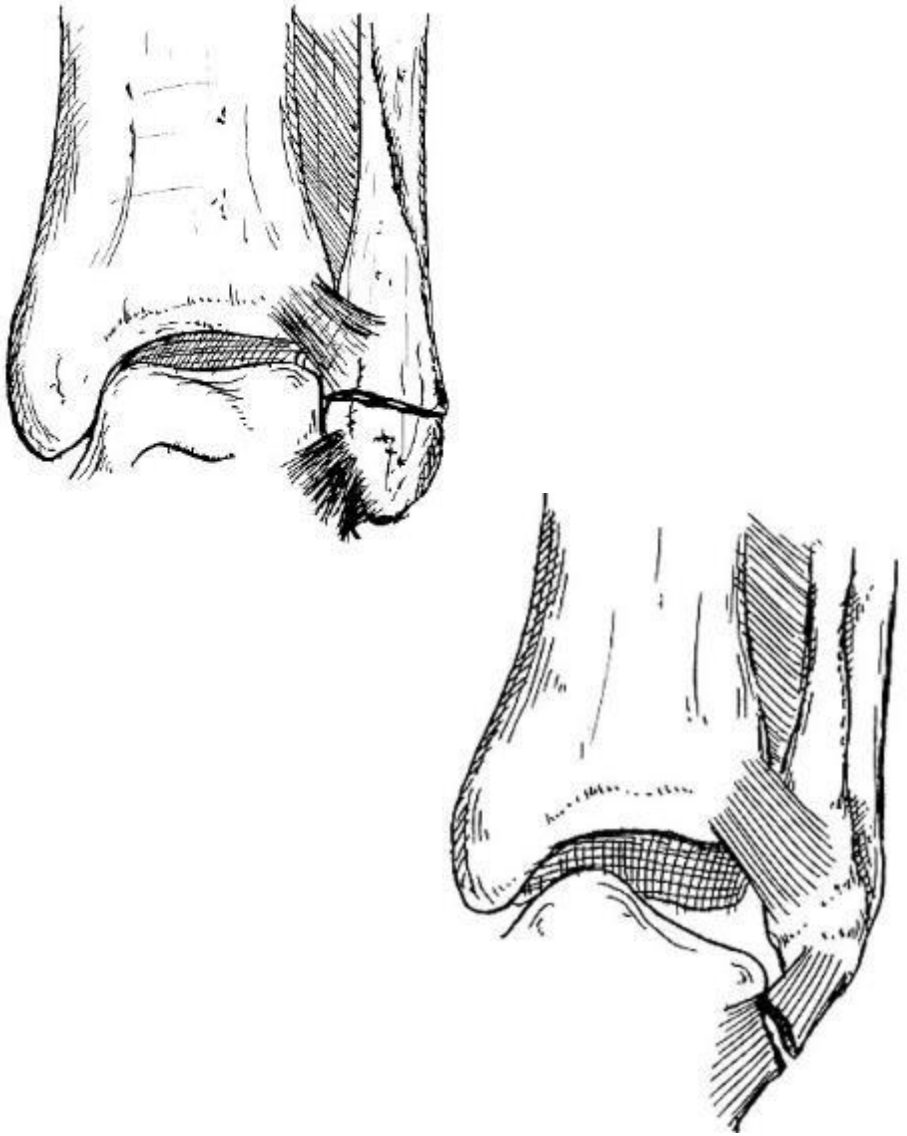
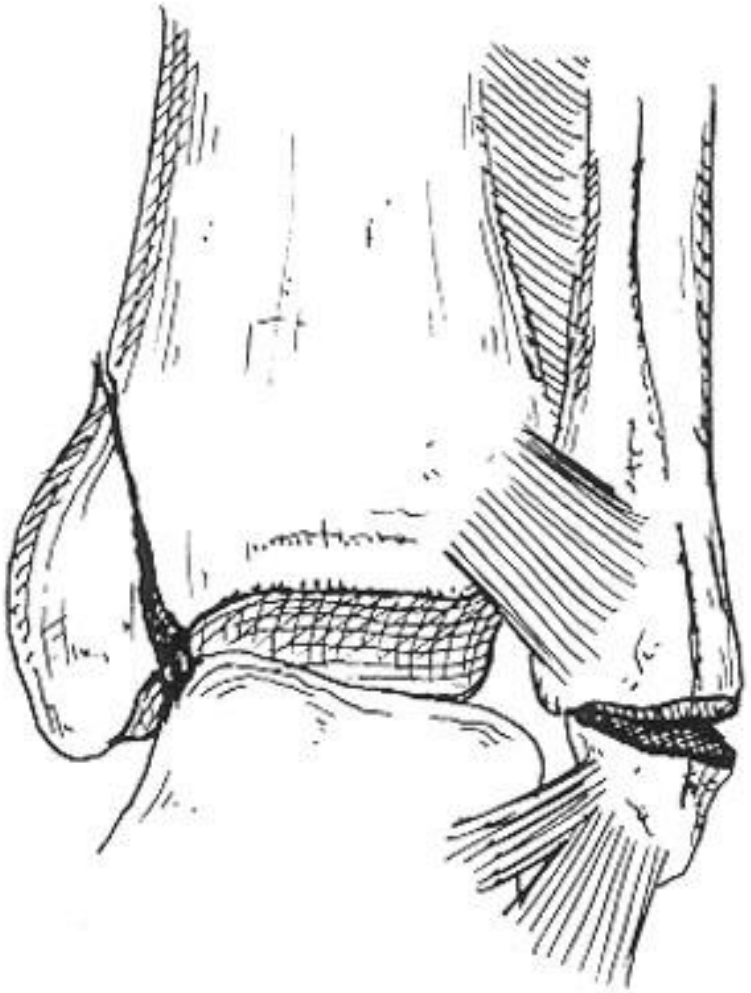
Sup.-Add. Stage I

- Occurs at the level of the fibula
- Two things can happen:
  - Transverse fracture of distal fibula (**Hallmark**)
  - Rupture of lateral collateral ligaments
    - noted by increased clear space laterally



Sup.-Add. Stage II

- Talus no longer constrained on lateral side and drive into medial malleolus, thereby shearing off medial malleolus.
  - Vertical fracture of tibial medial malleolus (**Hallmark**)



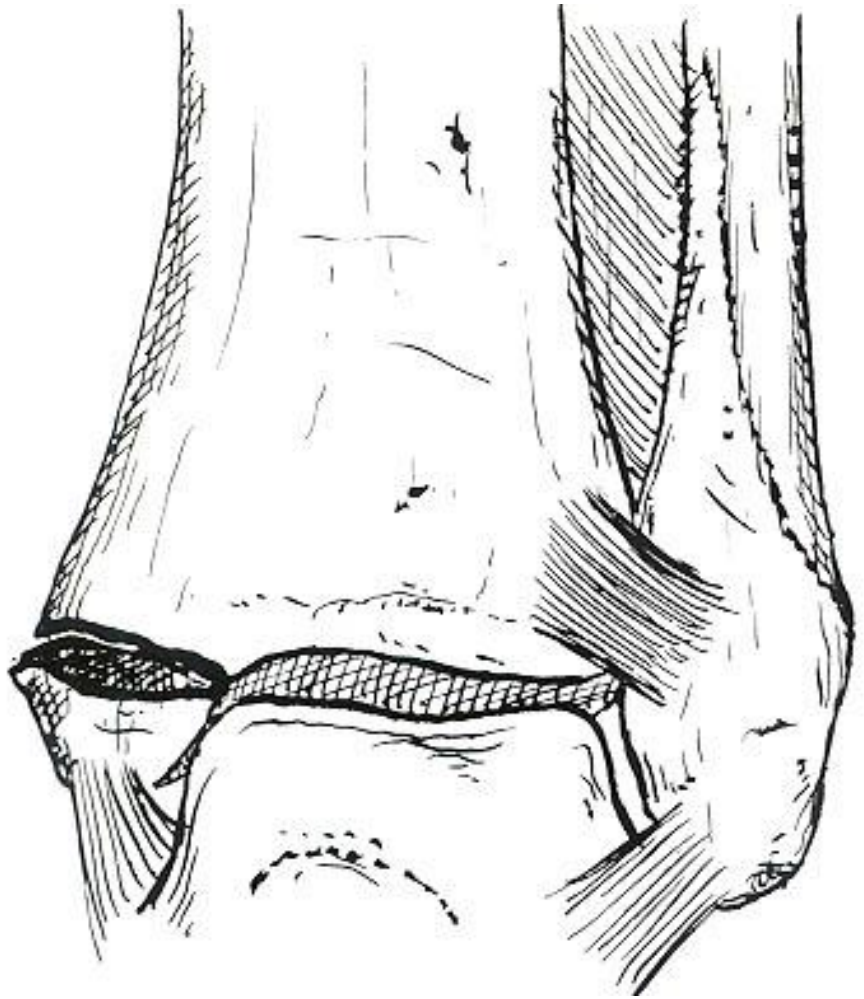
The Foundation

Supination-Adduction Summary

- Hallmark Fractures:
  - Stage I: transverse fracture of distal fibula
  - Stage II: vertical fracture of medial malleolus
- Characteristics of supination-adduction injury:
  - Stage I Sup-Add injury is a "*lateral ankle sprain*"
  - No disruption of syndesmosis
  - Best prognosis of any ankle fracture
  - Often no ORIF needed

Pron.-Abd. Stage I

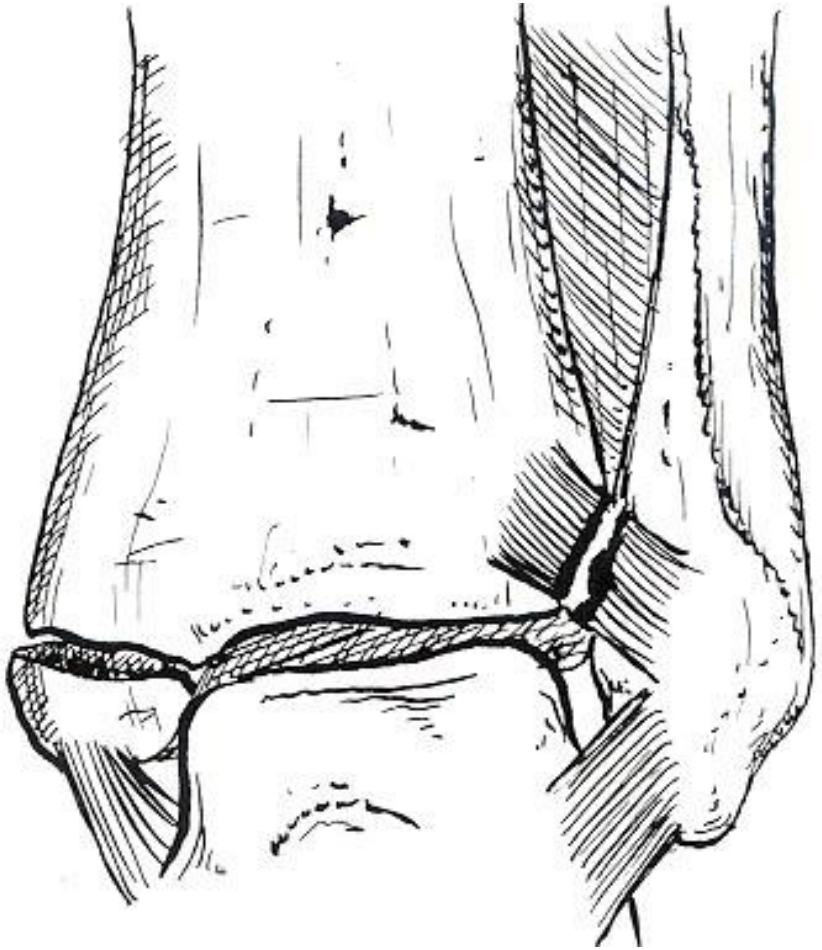
- Two presentations:
  - Transverse fracture of medial malleolus
  - Rupture of deltoid ligaments
    - evidence by increased medial clear space



The Foundation

Pron.-Abd. Stage II

- Talus no longer constrained by deltoid ligaments makes contact with fibula
  - Get partial or complete rupture of anterior and posterior tibiofibular ligaments



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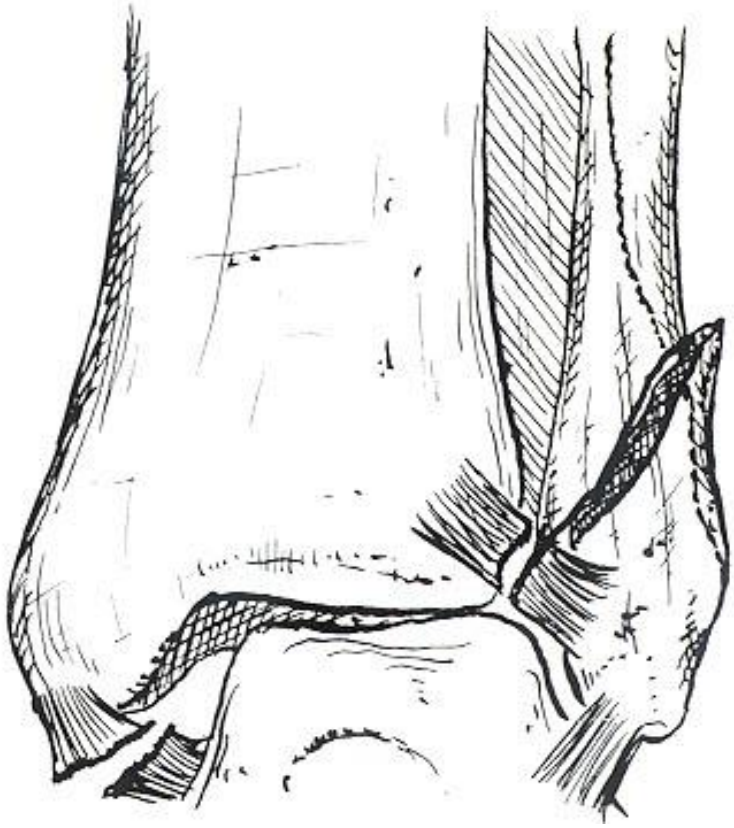
Pron.-Abd. Stage III

- Short oblique fibular fracture ("Hallmark Fracture")
- AP view: fracture begins at joint line on medial side of the fibula then goes high on lateral side of fibula (short oblique)
- Lateral view: fracture looks like transverse fracture
- Hallmark fracture is a "*bend type*" fracture



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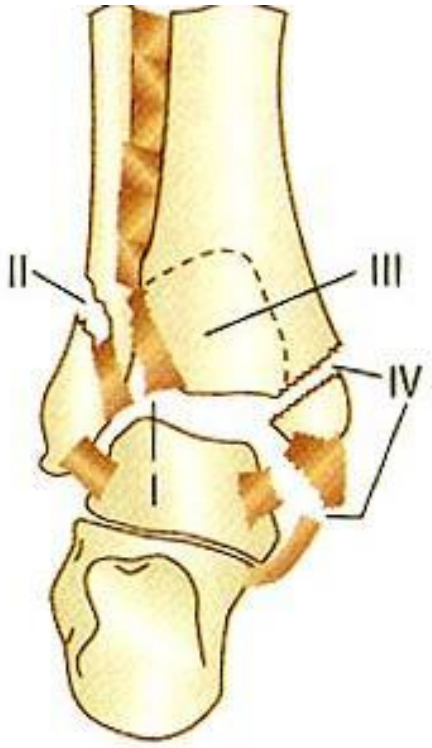
Pronation-Abduction Summary

- Is a Weber B fracture of the fibula
- Stage I:
  - Transverse fracture of medial malleolus
  - Rupture of deltoids ligaments
- Stage II:
  - Partial or complete rupture of anterior and posterior syndemosis (tibiofibular ligaments)
- Stage III:
  - Short oblique fibular fracture at level of syndesmosis (Hallmark Fracture)

The Foundation

Supination-Eversion (SER)

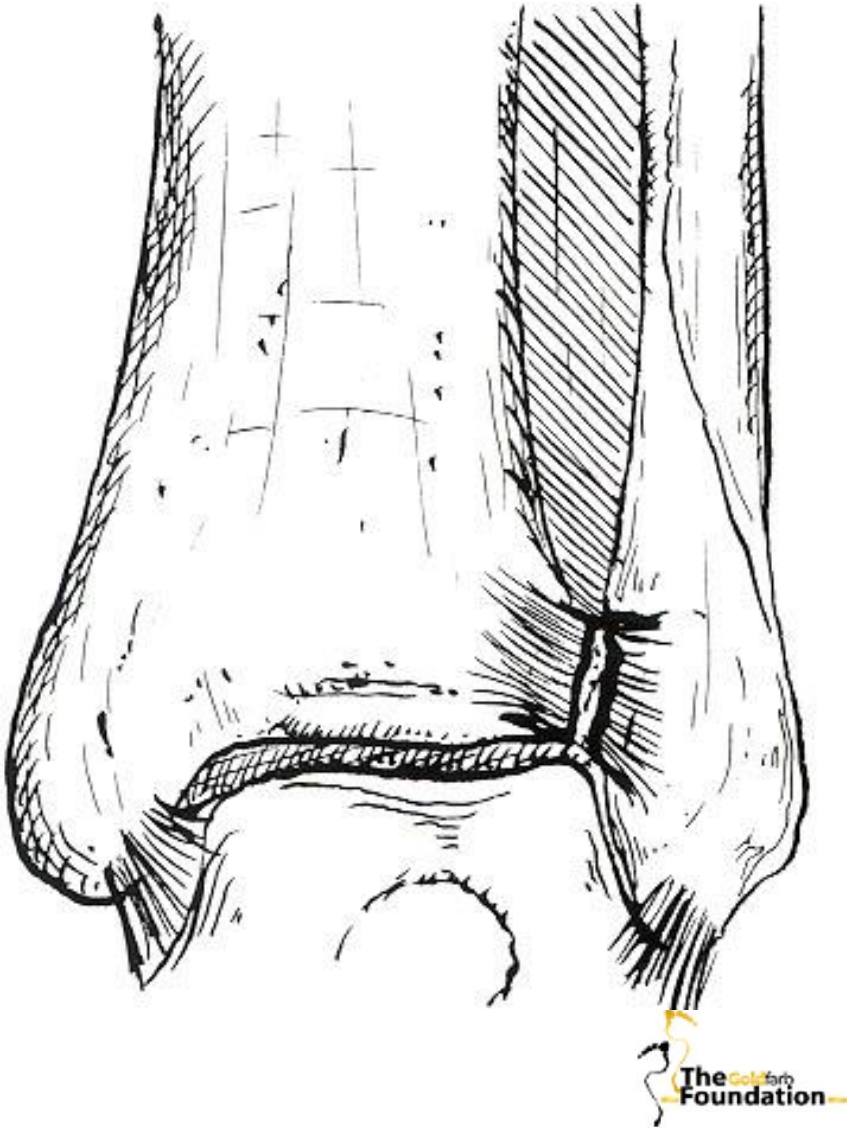


Supination-external rotation stages I-IV

- The injury occurs in four stages:
  - Begins antero-laterally
  - Goes through fibular
  - Goes through the posterior malleolus
  - End at the medial malleolus

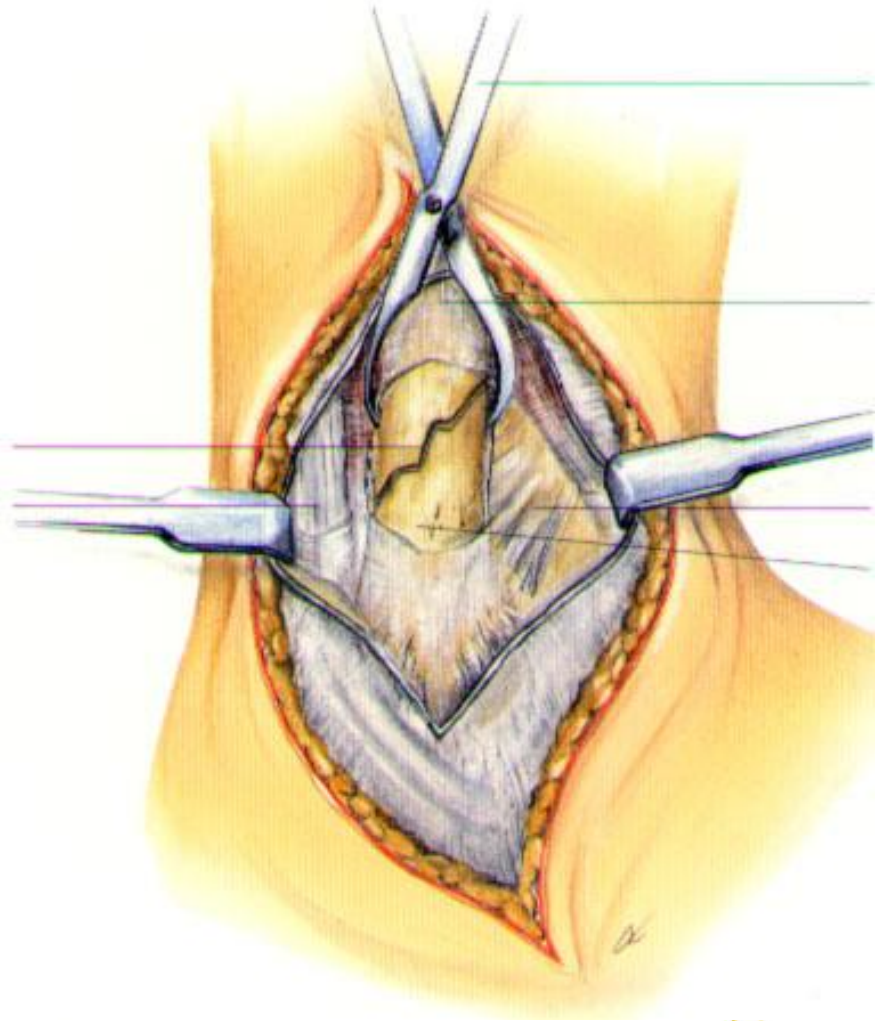
SER Stage I

- Begins antero-laterally
  - disruption of distal anterior tibio-fibular ligament
  - avulsion fracture of tubercle of Chaput on this tibia ("***Tillaux fracture***")
  - avulsion fracture off the fibula ("***Wagstaffe fracture***")



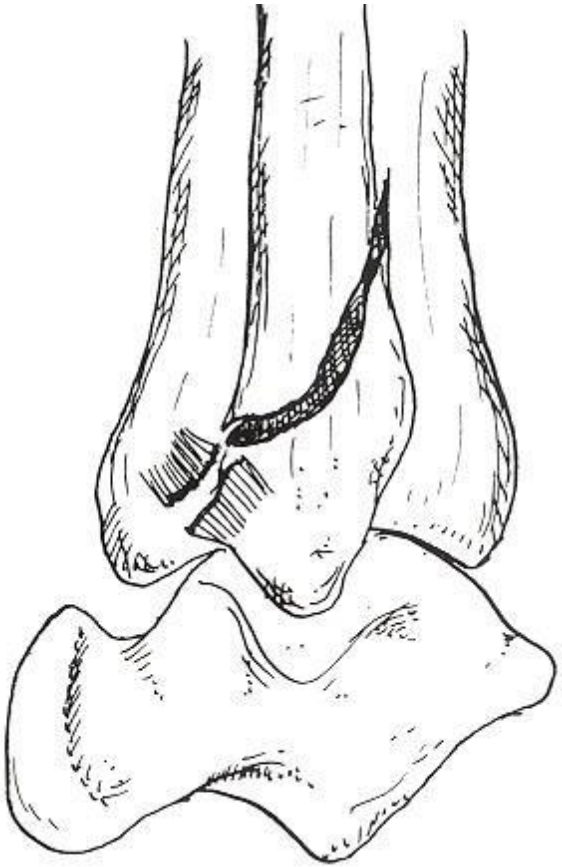
SER Stage II

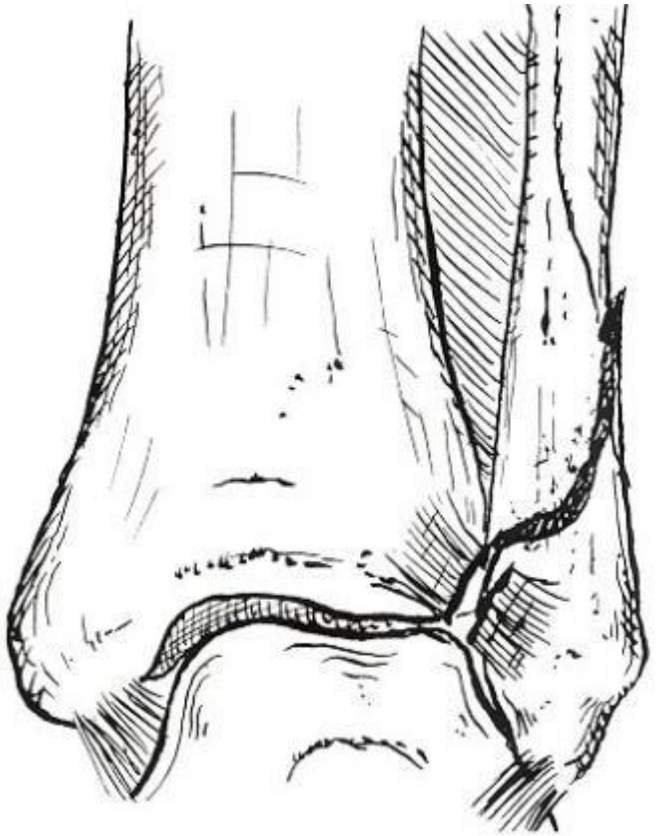
- Hallmark fracture:
  - short spiral oblique fibular fracture
  - begins “at” level of ankle joint
  - Is a Weber B fibula fracture



The Foundation

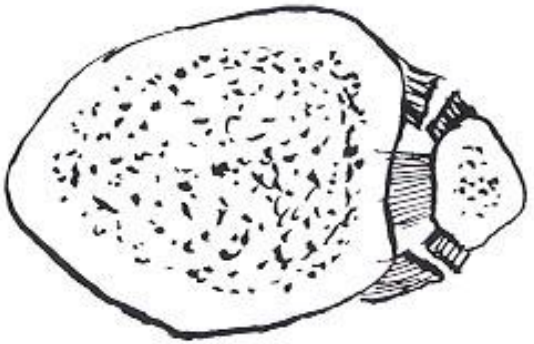
SER Stage II





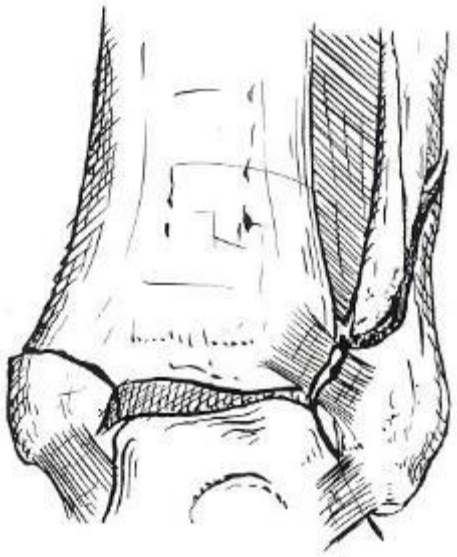
SER Stage III

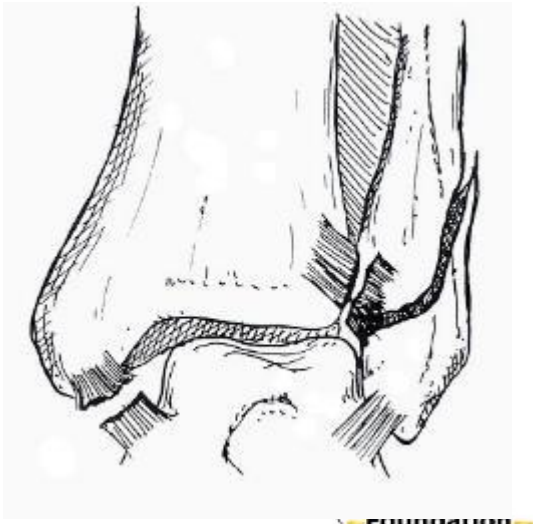
- Posterior malleolus disruption
- Either osseous or soft tissue injury
  - Osseous:
    - Volkmann's fracture
    - Avulsion fracture off posterior malleolus via posterior distal tibiofibular ligament
  - Soft tissue:
    - Rupture of posterior tibiofibular ligament



SER Stage IV

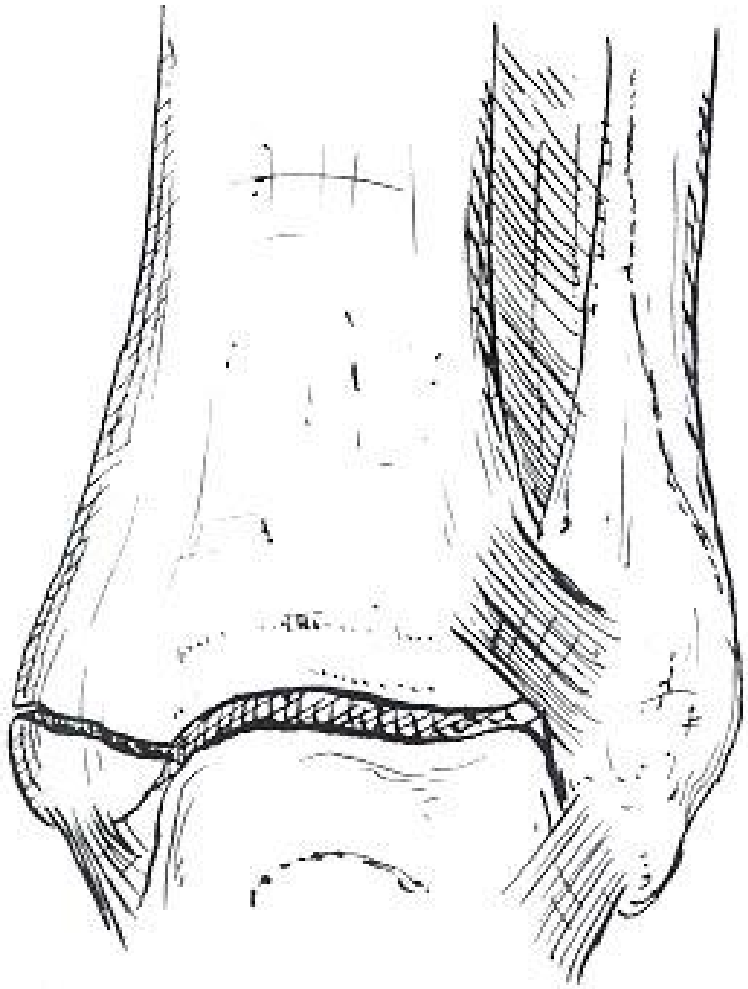
- Talus not constrained so talus hits medial malleolus (transverse direction)
  - Transverse medial malleolar fracture
  - Rupture of deltoid ligaments evidence by greater medial clear space





PER Stage I

- Get medial disruption with either:
  - Avulsion fracture of medial malleolus (transverse)
  - Rupture of deltoid ligaments
    - evident by medial clear space



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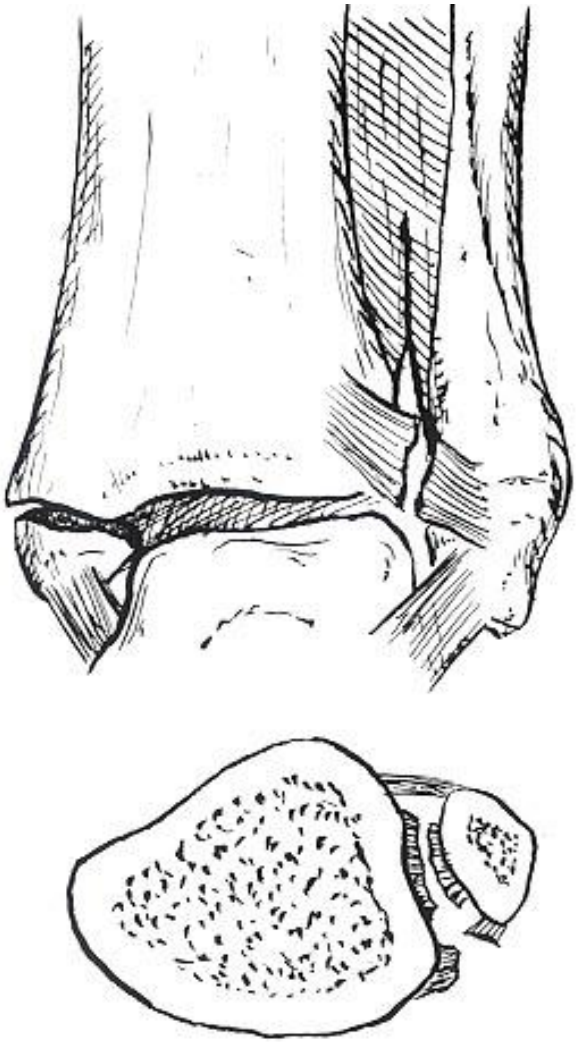
PER Stage II

- Disruption of distal anterior tibiofibular ligament
  - Tillaux fracture:
    - avulsion piece from tubercle of Chaput
  - Wagstaffe fracture:
    - avulsion piece from fibula



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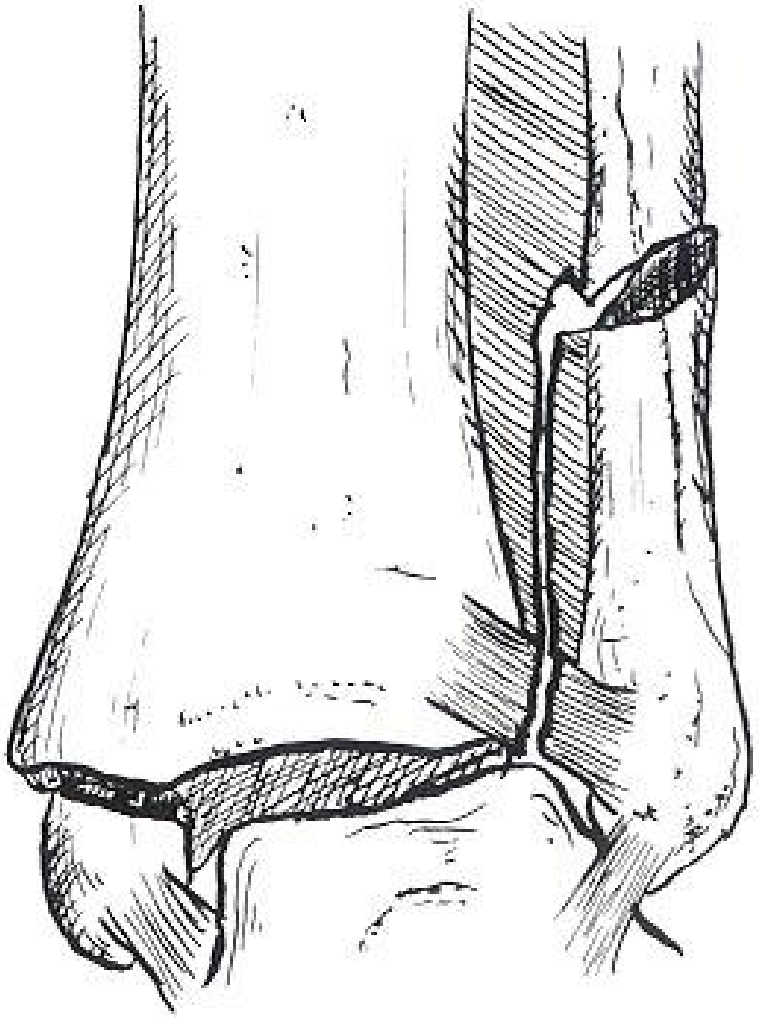
PER Stage III

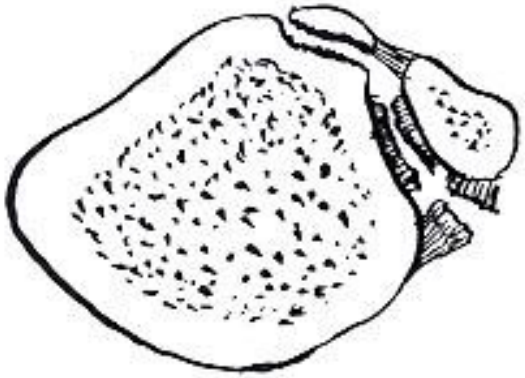
- Talus externally rotates about lateral axis pushes on fibula
- High fibular fracture (Hallmark fracture)
- Rupture of the interosseous membrane
- Fibular fracture begins above the syndesmosis
- Is a Weber C fibula fracture
  - Fibular fracture is usually short oblique
  - May be spiral or butterfly

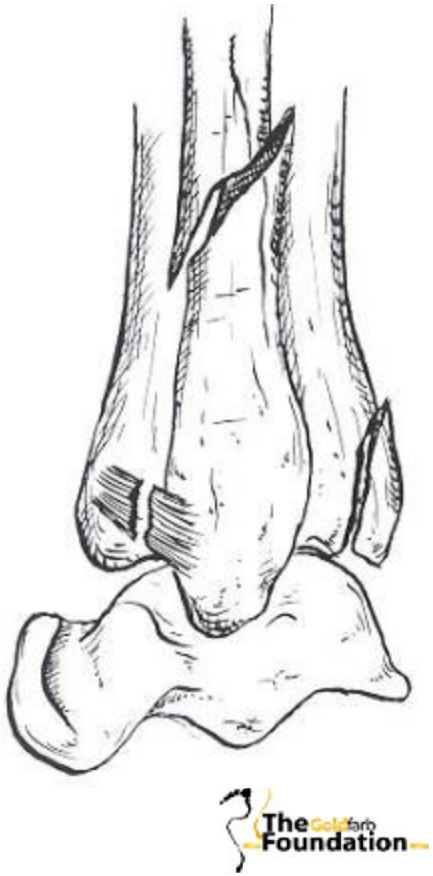


The Foundation

PER Stage IV

- Posterior disruption of posterior malleolus with either:
  - Volkmanns fracture
  - Rupture of distal posterior tibiofibular ligament
- Associated fracture with a PER fracture is a “Maisonneuve fracture” or high fibular fracture



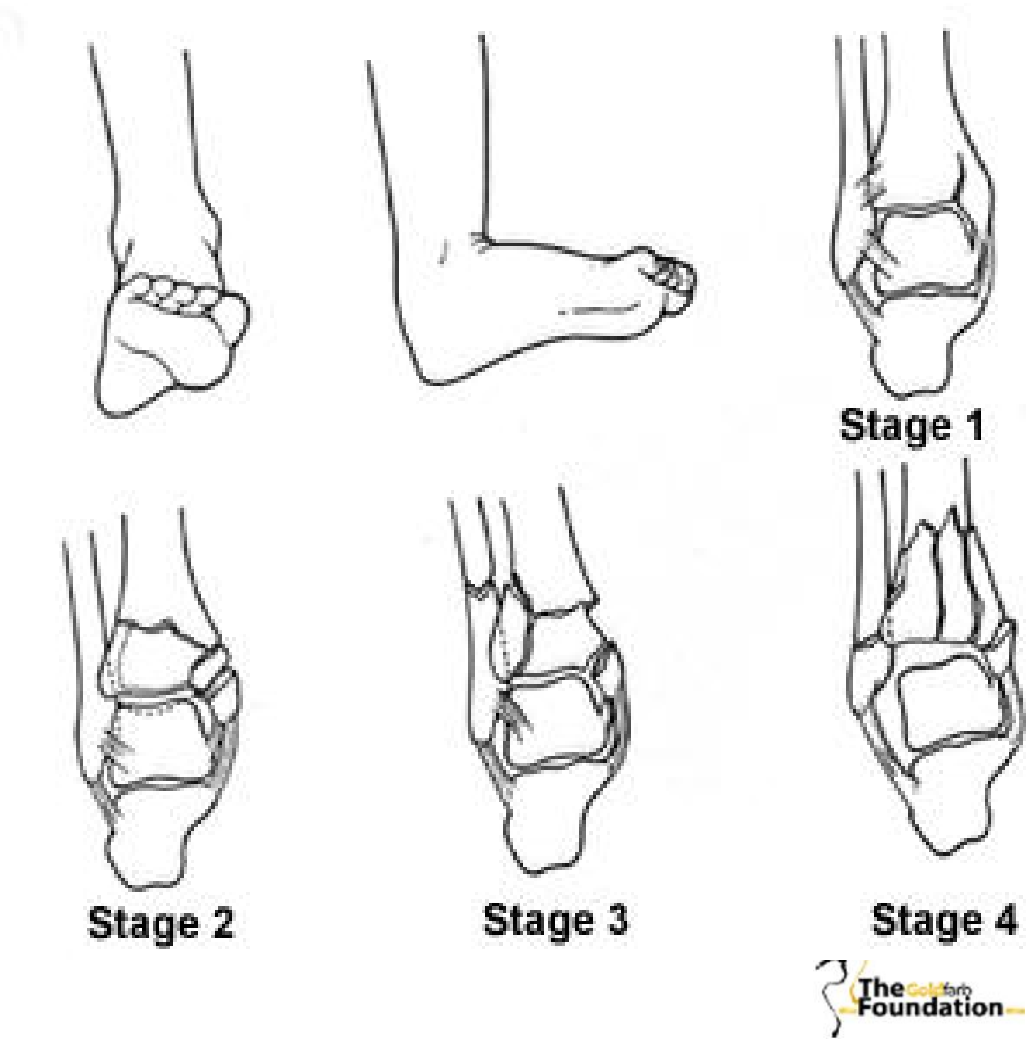


Pronation-Dorsiflexion

- Least common type of Lauge-Hausen classification.
- Occurs in 4 stages:
  - Stage I: fracture of medial malleolus
  - Stage II: fracture of anterior tibial tip
  - Stage III: supramalleolar fracture of fibula
  - Stage IV: transverse fracture of posterior aspect of tibia

Pronation-Dorsiflexion

1. Fracture of the medial malleolus
2. Fracture of the anterior margin of tibia
3. Supramalleolar fracture of the fibula
4. Transverse fracture of the posterior tibial surface

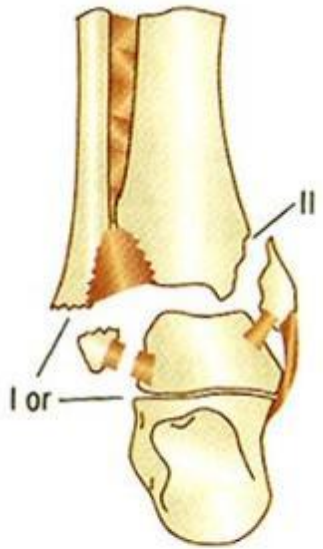


Lauge-Hansen Classification

- Supination-Adduction
  - Stage I: Transverse avulsion fracture of fibula at or below the ankle joint level or rupture of the lateral collateral ligament
  - Stage II: Oblique to vertical fracture of medial malleolus
- Pronation-Abduction
  - Stage I: Transverse avulsion fracture of the medial malleolus or rupture of the deltoid ligament
  - Stage II: Rupture AITFL and PITFL or a Tillaux-Chaput fracture or Wagstaffe fracture
  - Stage III: Short oblique fracture of the fibula beginning at the level of the syndesmosis
- Supination-External Rotation
  - Stage I: Rupture of AITFL or a Tillaux-Chaput fracture or Wagstaffe fracture
  - Stage II: Spiral/oblique fracture of fibula beginning at the syndesmosis
  - Stage III: Rupture of the PITFL or an avulsion fracture of the posterior malleolus
  - Stage IV: Transverse fracture of medial malleolus or rupture of deltoid ligament
- Pronation-External Rotation
  - Stage I: Transverse fracture of medial malleolus of rupture of deltoid ligament
  - Stage II: Tillaux-Chaput or Wagstaffe fracture or rupture of AITFL and rupture of interosseous membrane
  - Stage III: High spiral oblique fracture, proximal extent of fracture is dependent on how high interosseous membrane is ruptured (Maisonneuve Fracture)
  - Stage IV: Rupture of PITFL or avulsion fracture of posterior malleolus

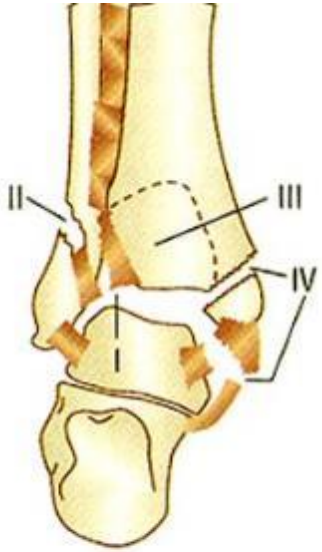
The Foundation

HALLMARK



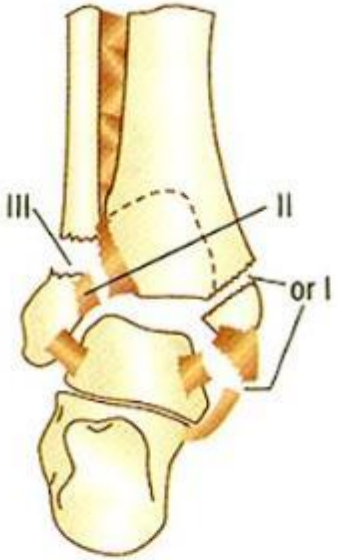
Supination-adduction
stages I and II

HALLMARK



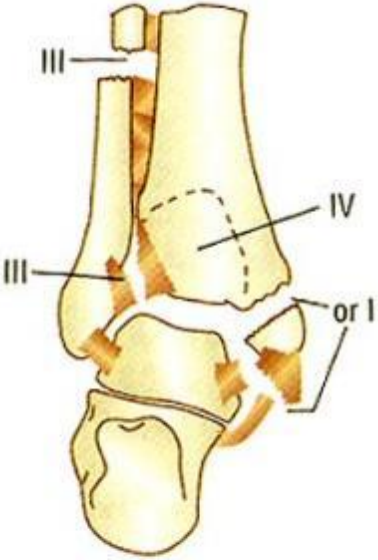
Supination-external
rotation stages I-IV

HALLMARK



Pronation-abduction
stages I-III

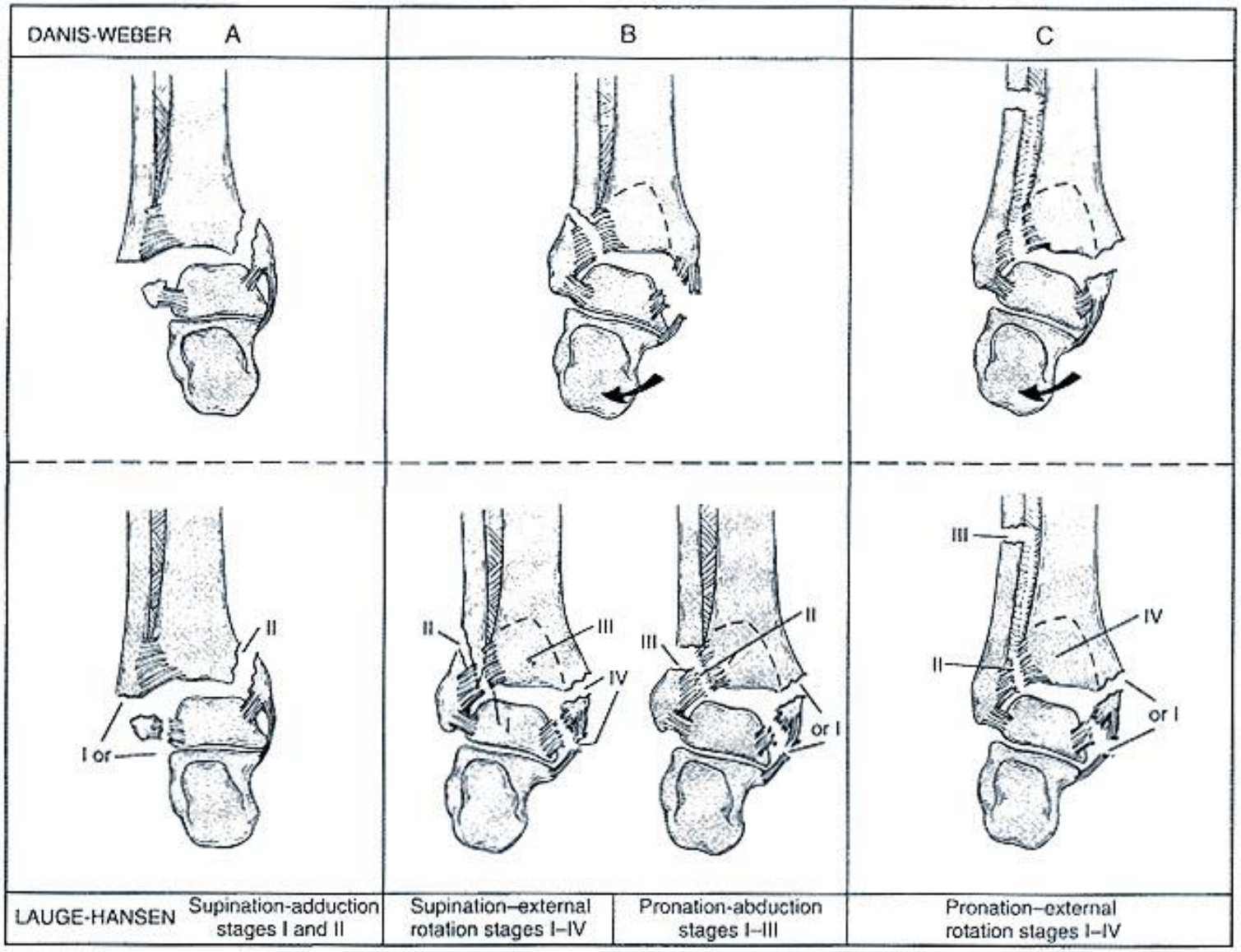
HALLMARK



Pronation-external
rotation stages I-IV

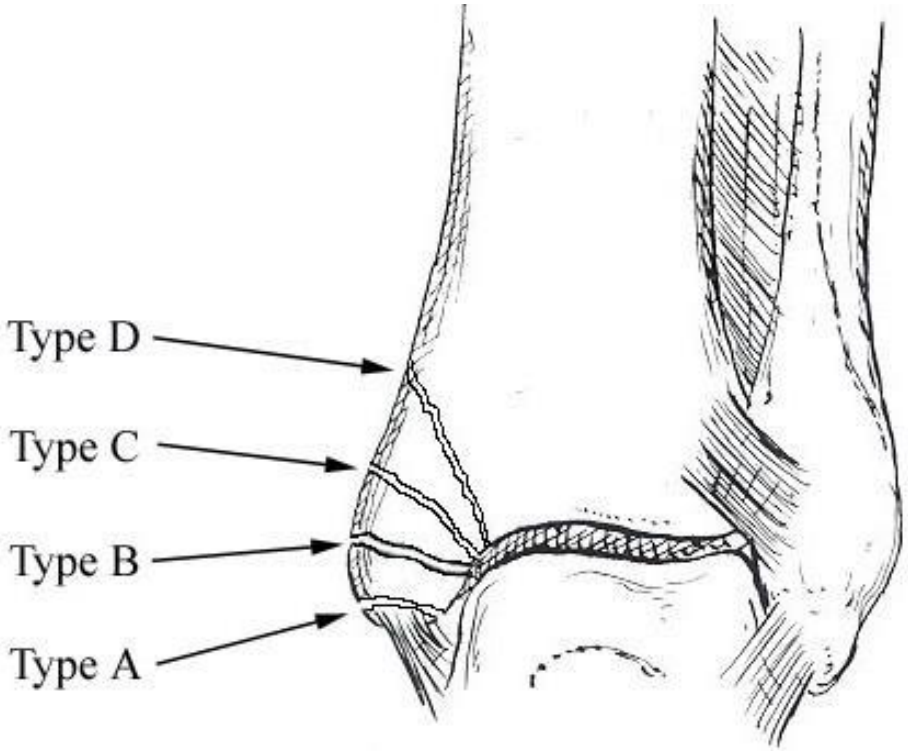
The Foundation

Lauge-Hansen Classification



Medial Malleolar Fractures

- **Mueller Classification**
  - **Type A**: avulsion of tip of medial malleolus
  - **Type B**: transverse avulsion at the level of the ankle joint
  - **Type C**: oblique fracture
  - **Type D**: vertical orientation



Pilon Fracture

- Pilon fracture are different than ankle fractures
- Get impaction injury of the anterior tibia, as well as, a fracture of the distal fibula
- Occurs more commonly in skiing accidents
- Most common classifications:
  - Rüedi and Allgöwer's classification (1979)
    - 3 types
  - Müller (AO/OTA) (1990):
    - 4-3 A/B/C
      - 4 = tib/fib
      - 3 = distal 1/3rd
      - A/B/D = extra-articular / partial articular / completely articular

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Incidence of Pilon Fractures

- Extremely rare fracture
- Pilon fractures account for less 1% of **all** lower extremity fractures.
- They account for 7-10% of all tibia fractures.
- 20-25% occur as open fractures.
- 30-50% have associated injuries.
- Males are more commonly affected.
- They occur over a broad age range.
- However, uncommon in children and in elderly patients.
- The average patient age is 35 to 40 years.
- These injuries most commonly result from motor vehicle accidents or falls from heights.

Pilon Fracture

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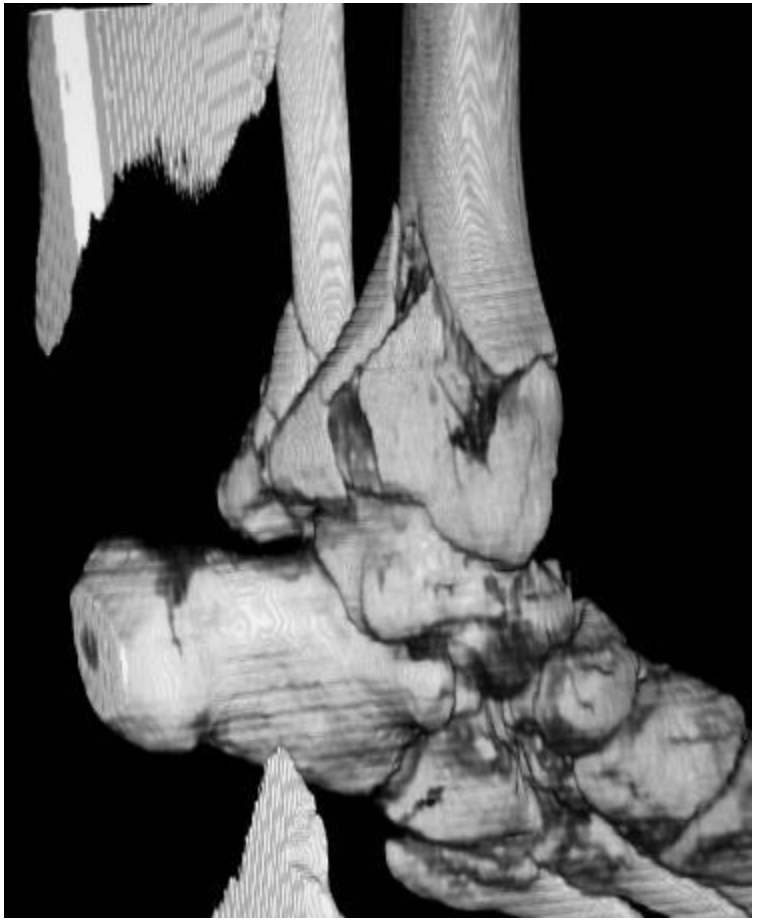
Diagnostic Modalities



- Standard radiographs are necessary for fracture fragment evaluation.
- Computed tomography (CT) is required for surgical reconstruction.
  - If possible 3-D reconstruction are extremely helpful.

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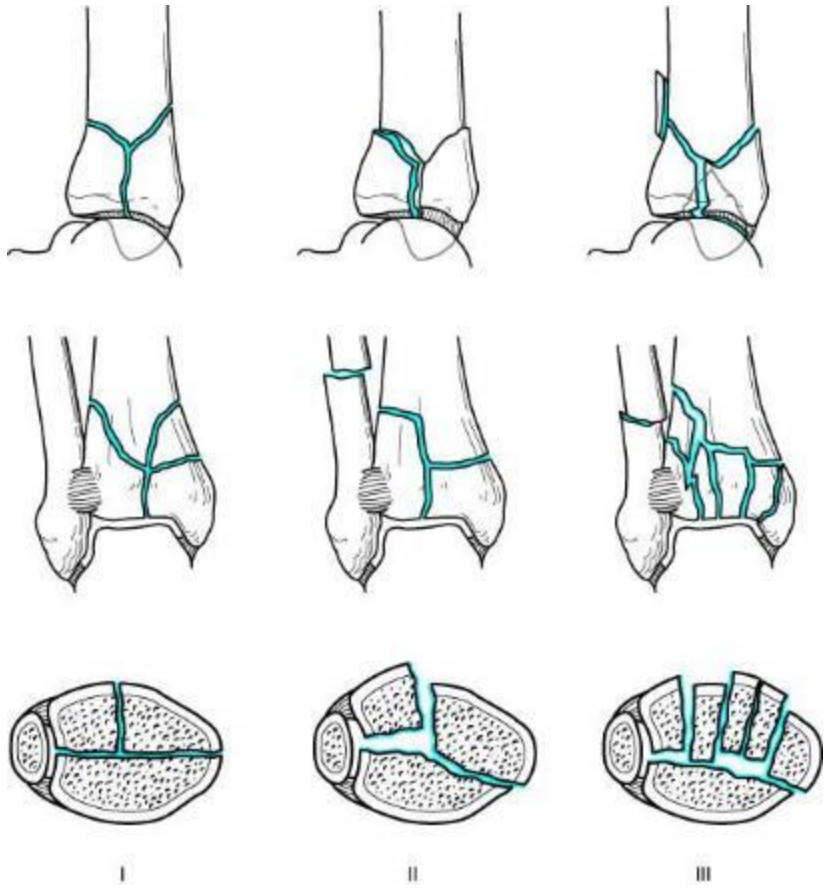
Rüedi and Allgöwer's

- **Type I**: is a non-displaced cleavage fracture of the joint
- **Type II**: consists of a displaced but moderately comminuted fracture
- **Type III**: is a highly comminuted and displaced fracture



Rüedi and Allgöwer's

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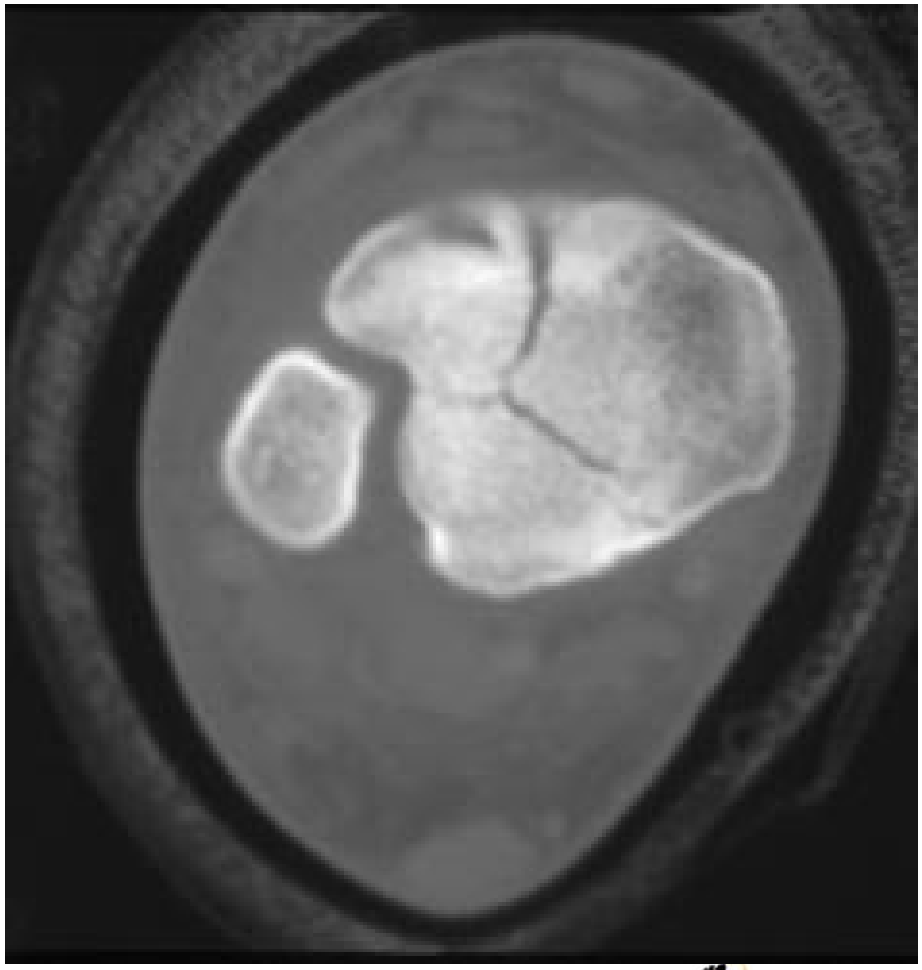
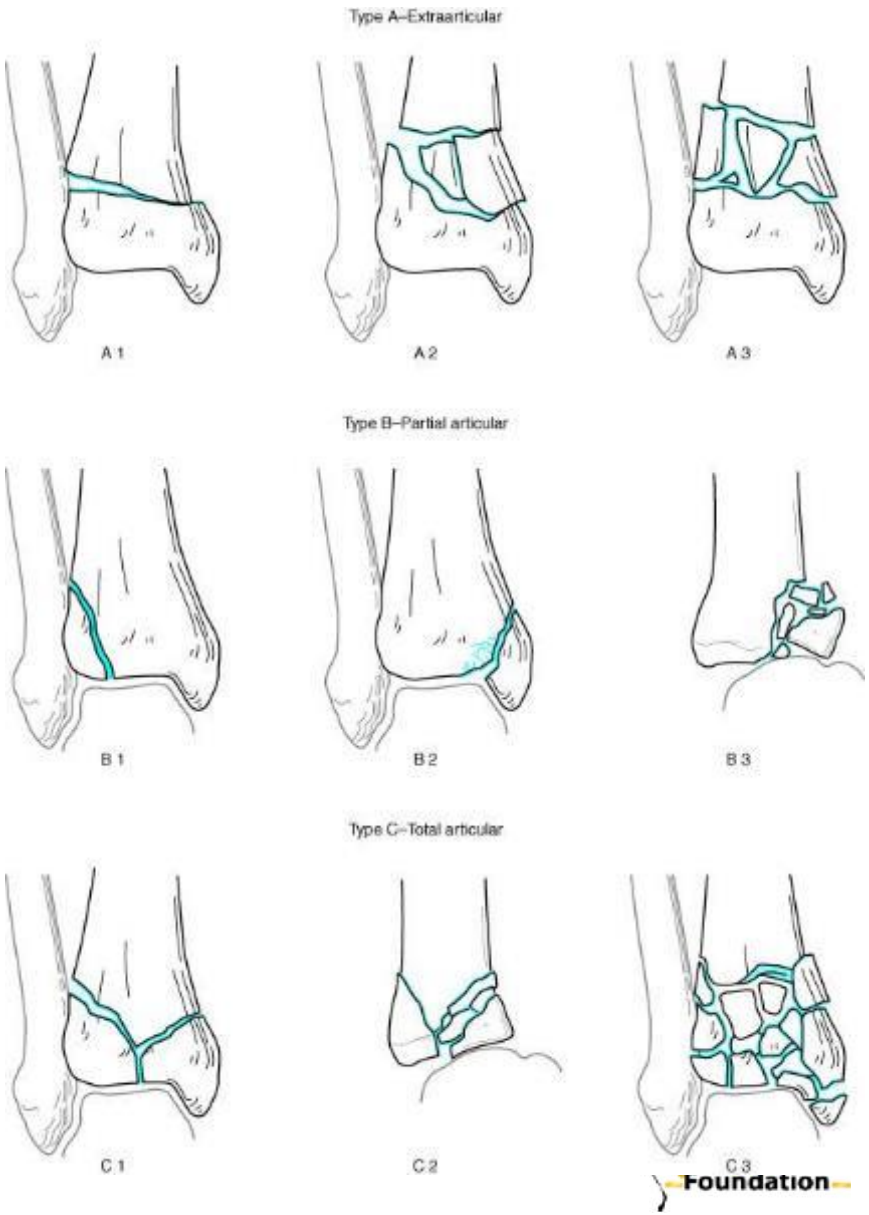


AO/OTA Classification

Type A: Extra-articular

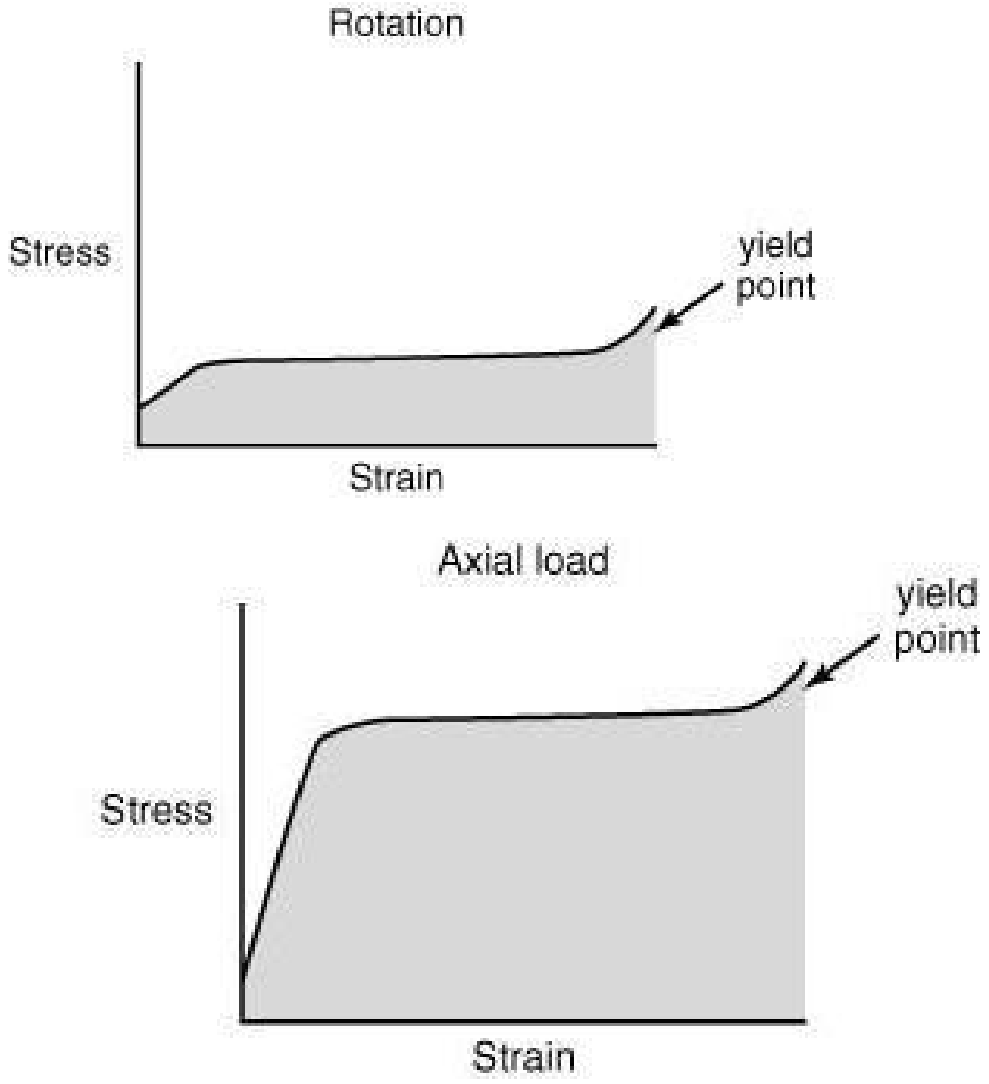
Type B: Partial articular

Type C: Intra-articular



What Type Pilon Fracture?

Pilon Fractures



- Ankle (malleolar) fractures are caused predominately by rotation
- Tibial plafond fractures are caused predominantly by axial loading
- Are high-energy injuries

Rotation versus Axial Load

Rotation

- Slow rate of loading
- Little energy released at failure (yield point)
- Translational displacement of the talus
- Little comminution
- Minimal soft tissue injury

Axial Load

- Rapid rate of loading
- Large amount of energy released
- Proximal displacement of the talus
- Severe comminution
- Severe soft tissue injury

Mechanism of Injury

- Two distinct and separate mechanisms exist.
- **Low energy**:
  - Usually produced by rotational forces
  - Pronation-dorsiflexion mechanism
  - Common in sporting injuries, such as skiing ("boot-top fracture")
- **High energy**:
  - Produced by axial compression forces
  - Usually comminuted fragments
  - Common in MVA and falls from heights

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