Closed Reduction, Traction, and Casting Techniques

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March 2014

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Contents

- Closed Reduction Principles & Anesthesia options
- Splinting Principles
- Common Closed Reductions
- Casting Principles
  - Complications
- Traction Principles
  - Complications
  - Halo Application

Closed Reduction Principles

- Identify need for closed reduction
  - Most displaced fractures should be reduced to minimize soft tissue complications & injury
    - Includes injuries ultimately treated with surgery
    - Various resources for acceptable non-operative fracture alignment parameters
      - Find & utilize a reliable source

Closed Reduction Principles

- Prior to reduction
  - H&P
    - Define injury & host factors
      - Trauma ABC's first
    - Evaluate skin, compartments & neurovascular status
      - Urgent/Emergent reduction
        - » Dysvascular distal limb, significant skin tenting
    - Organize/customize appropriate team for:
      - Sedation need
      - Reduction & immobilization assistance
      - Post reduction imaging

Closed Reduction Principles

- Reduction maneuver specific for fracture location & pattern
- Goals:
  - Restore length, alignment & rotation
- Immobilize joint above & below
- Quality post reduction radiographs

Anesthesia

- Adequate analgesia & muscle relaxation/fatigue are critical for success
- Determine goals of reduction & plan
- Customize anesthesia for each patient & injury combination

Anesthesia Options

IV Sedation

- Versed: 0.5-1 mg q 3 min (5mg max)
- Morphine : 0.1 mg/kg
- Demerol: 1- 2 mg/kg (150 mg max)
- Ketamine

  - Beware of pulmonary complications with deep conscious sedation
    - Anesthesia service/ED/trauma team usually administering at most institutions
  - Pulse oximeter & careful monitoring recommended

Pros

Potential better relaxation

Versatile for many anatomic locations

Limited memory of reduction

Cons

Non-paralyzed muscle relaxation

Cardio/pulmonary complications

-over sedation

Anesthesia Options

Hematoma Block

-Aspirate fracture hematoma & place 10cc of Lidocaine at fracture site

Pros

Efficient

Usually effective

Useful for distal radius & hand

Cons

Can be less reliable than other methods.

Theoretically converts closed fracture to open fracture

-No documented ↑ in infection

Anesthesia Options

Intra-articular Block

-Aspirate joint & place 10cc of Lidocaine (or equivalent local anesthesia) into joint

Pros

Efficient

Commonly effective

Useful for certain ankle/knee injuries

Cons

Can be less reliable than other methods

Intra-articular violation

Theoretically converts closed injury to open injury

-No documented ↑ in infection

Anesthesia Options

Bier Block

•Double tourniquet is inflated on proximal arm and venous system is filled with local

- Lidocaine preferred for fast onset
- Volume = 40cc
- Adults 2-3 mg/kg
- Children 1.5 mg/kg

If tourniquet is deflated after < 40 minutes then deflate for 3 seconds and re-inflate for 3 minutes - repeat twice

Pros

Good pain relief & relaxation,

Minimal premedication needed

Cons

Cardiac & CNS side effects (seizures)

Closed Reduction Principles

- Prepare immobilization prior to reduction
  - Splint pre-measured & ready for efficient application
  - Sling or knee immobilizer in close proximity
  - Have extra supplies close
  - Assistant or assistive device

(ex. Finger traps) available

Closed Reduction Principles

- Reduction requires *reversal* of mechanism of injury
  - Especially in children with intact periosteum
- The soft tissues may disrupt on the convex side & remain intact on the concave side

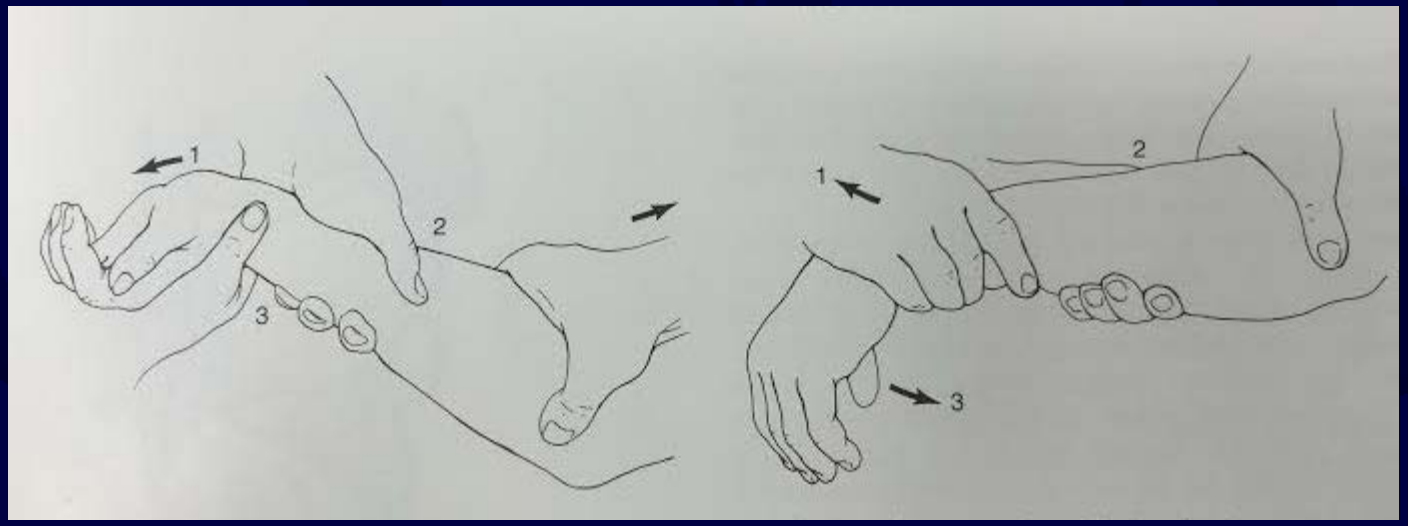


Figure from: Rockwood and Green: Fractures in Adults, 6th ed, Lippincott, 2006

Closed Reduction Principles

- Longitudinal *traction alone* may not allow the fragments to be disengaged & length re-established if there is an intact soft-tissue hinge
  - Especially in children with strong partially intact periosteum

Closed Reduction Principles

Reproduce fracture mechanism

↓

Traction to disengage fracture fragments

↓

Re-align fracture

***Angulation beyond 90˚ is potentially required

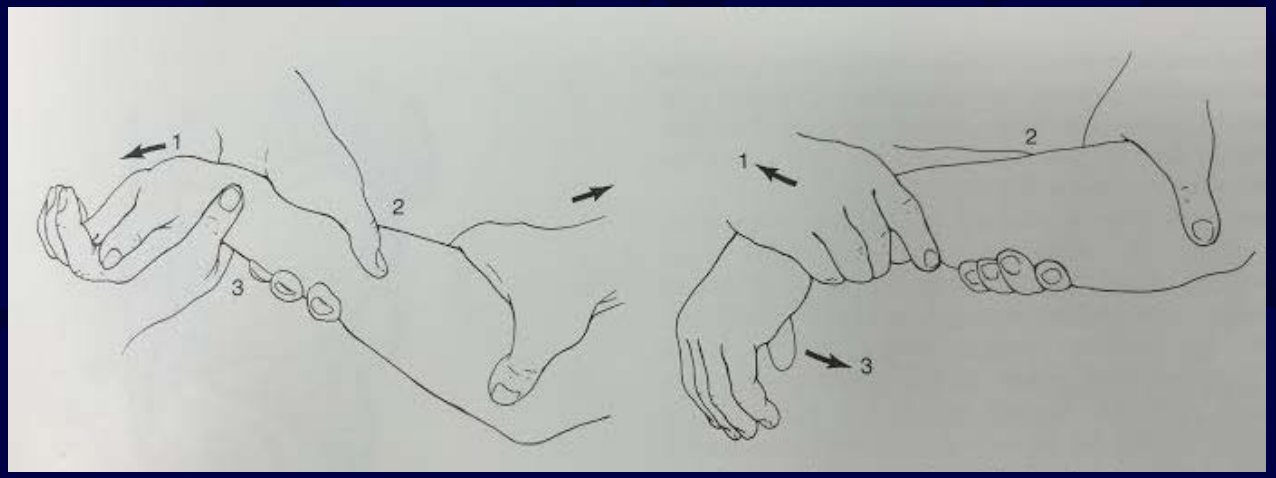


Figure from: Rockwood and Green: Fractures in Adults, 6th ed, Lippincott, 2006

Splinting Principles

- Splint must be molded to resist deforming forces
  - "Straight casts lead to crooked bones"
  - "Crooked casts lead to straight bones"

Splinting Principles

Three point contact (mold) is necessary to maintain closed reduction

Removal of any of the three forces results in loss of reduction

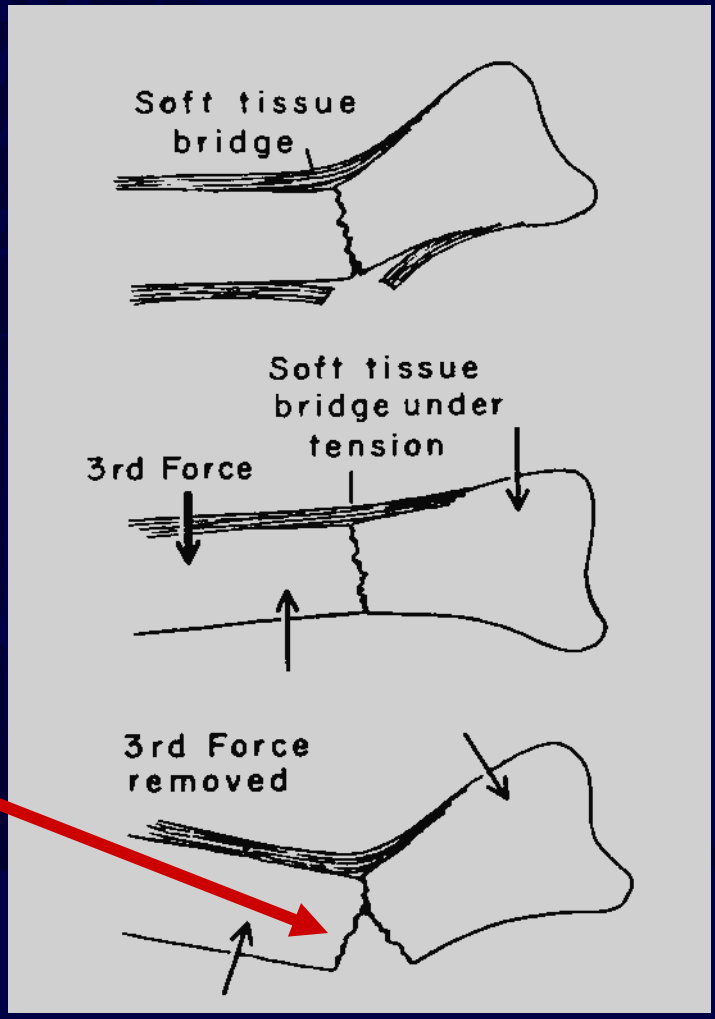


Figure from: Rockwood and Green: Fractures in Adults, 4th ed, Lippincott, 1996.

Splinting

- Non-circumferential
  - Permits swelling & soft tissue evaluation
- May use plaster or prefab fiberglass splints
  - Plaster
    - Best for customized mold
    - More versatile material
    - More reliable at maintaining reduction

Common Splinting Techniques

- Coaptation
- Posterior long arm
- Sugar-tong
- Ulnar gutter
- Volar/dorsal forearm
- Volar/dorsal hand
- Resting hand
- Thumb spica
- Posterior long leg
- Lateral long leg
- Posterior slab (ankle)
  - +/- U splint
  - +/- Foot plate
  - +/-Side struts
- “Bulky” Jones

Splint Choice

- Considerations when customizing for each patient & injury
  - Overall patient condition
    - Multi-trauma vs. isolated injury
  - Soft tissue envelope
  - Reduction stability
  - Future treatment plan
  - Experience

Splint Padding

- 3-4 layers thick under ALL types of splints
- Padding Problems
  - Too thin → skin pressure
  - Too thick → less fracture control (potential loss of reduction)

Unpadded fiber glass splint caused skin lesions

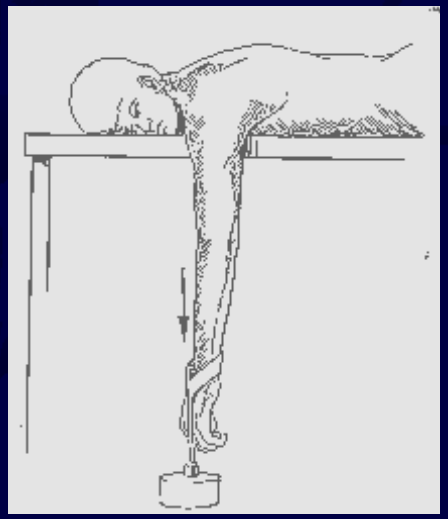
Common Closed Reductions

- Shoulder Dislocation
- Humeral Shaft
- Elbow Dislocation
- Forearm Fracture
- Distal Radius
- Hip Dislocation
- Femur Fracture
- Knee Dislocation
- Tibia Fracture
- Ankle Fracture
- Talus Fracture
- Calcaneus Fracture
- Midfoot Fracture Dislocation

Shoulder Dislocation

- **Relaxation key**
- Traction
  - Disengage humeral head from glenoid
- +/- gentle rotation
- Many described techniques
- Avoid iatrogenic fracture propagation
- Immobilization: Sling

Traction/Counter-Traction



Miltch Technique

Figures from Rockwood and Green, 5th ed.

Humeral Shaft

- Gravity traction +/- formal reduction maneuver
- <u>Immobilization:</u> Coaptation splint
  - Lateral splint extends over the deltoid
  - Medial splint into axilla & must be well padded (*ABD pad) to avoid skin breakdown
  - Elbow unsupported permitting gravity traction

Figure from Rockwood and Green, 4th ed.

Elbow Dislocation

- Traction, flexion & direct manual palpation of olecranon
  - Reduce medial/lateral displacement 1st
  - Address anterior/posterior next
  - Supination/pronation may assist reduction
- Cautious elbow range of motion after reduction
  - Can guide treatment plan
- Immobilization: Posterior long arm splint +/- sugar tong

Multi-directional traction

Manual pressure over olecranon

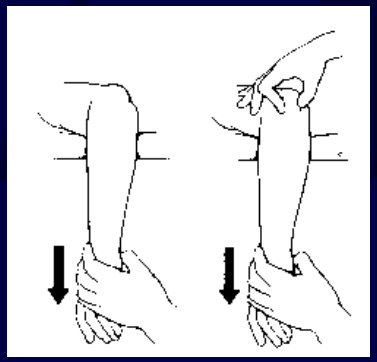


Figure from Rockwood and Green, 5th ed.

Forearm Fracture

- Traction
  - +/- need to significantly recreate the deformity
    - Especially in pediatric pts
- Immobilization = Sugar tong splint with 3 point mold
- Pediatric
  - Splint → Cast with nonop mgnt
- Adult
  - Almost always surgical thus temporizing until ORIF

-Splint around distal humerus to provide rotational control

-Extra padding at the elbow

Distal Radius

- Local or regional block
  - Hematoma/Bier
- Longitudinal traction
  - Finger Traps or manual
  - Fatigue muscles
- Exaggerate deformity
- Push distal fragment & pull hand for length & deformity reversal
- Immobilization: Volar/dorsal wrist splint, 3-point mold +/- elbow sugar tong

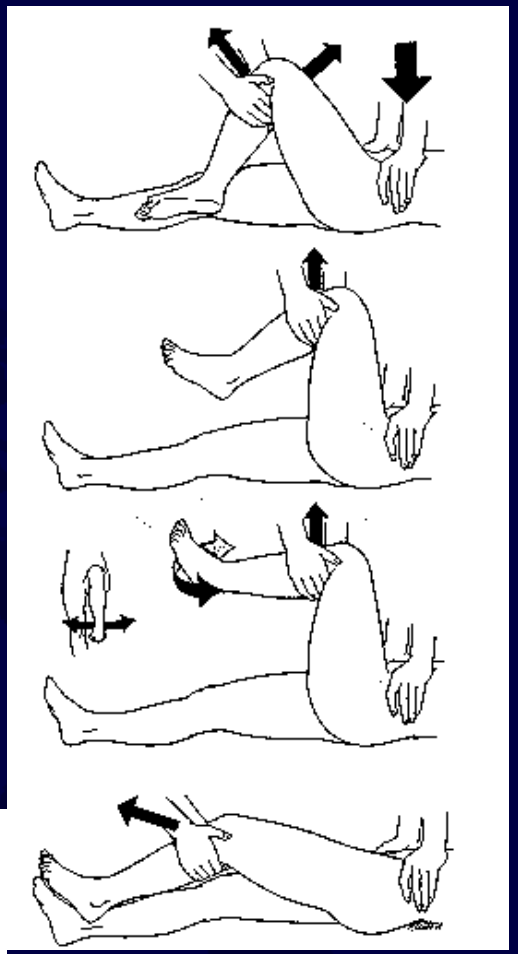
-Ulnar deviation to reestablish radial height & length
-Patient's thumb collinear with forearm

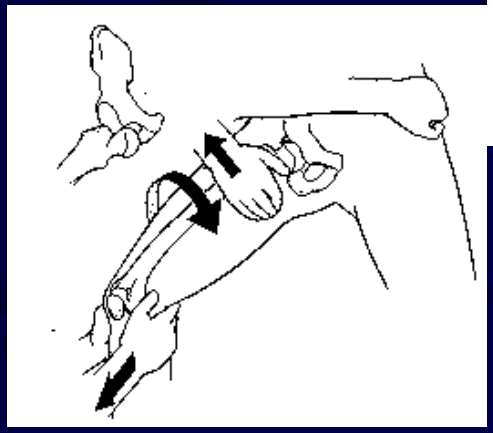
Volar directed distal force over Lister's tubercle

No finger pressure points on splint

Hip Dislocation

- IV Sedation (deep) with **Relaxation**
- *Posterior:* Flexion, traction, adduction and internal rotation
- *Anterior*: Traction, abduction, lateralization, rotation
- Gentle & atraumatic
- Reduction palpable & permit significantly improved ROM
- Immobilization: Knee immobilizer vs. Abduction pillow





Figures from Rockwood and Green, 5th ed.

Femur Fracture

- Traction
  - Skin vs. skeletal
    - See traction section of lecture
  - Temporizing until surgery
- Adult
  - Most Rx with surgery (IMN)
- Pediatric
  - Spica cast vs. IMN vs. plate
- Immobilization:
  - Traction vs. long leg splint
- Commonly in traveling traction upon ED arrival

Evaluate for groin and foot skin pressure lesions from traction device

Tibia Fracture

- Traction
  - +/- alignment correction
- Evaluate for compartment syndrome
- Adult
  - –Definitive Rx with IMN vs. ORIF vs. cast
- Pediatric
  - –Definitive Rx with IMN vs. ORIF vs. cast
- Immobilization = Posterior or lateral long leg splint vs. calcaneal traction
  - –Monitor soft tissues

Knee Dislocation

- Emergent Reduction
  - Vascular injury common
- Traction with gentle flexion/extension after varus/valgus correction
- Check Pulse/ABI
  - Comprehensive NV exam
- Monitor compartments

- Immobilization = Knee Immobilizer

  +/- ExFix until surgical reconstruction

Ankle Fracture

- Traction with deformity correction
  - Bend knee to relax gastroc/soleus complex
  - Posterior & lateral dislocation
    - +/- Quiggly Maneuver
    - Posterolateral to anterormedial directed mold
  - Medial
    - Traction reduction
    - Medial to lateral directed mold
  - Customize mold to specific fracture/dislocation
- Immobilization:
  - U Splint
    - +/-Posterior slab splint
    - +/- Foot plate
    - +/- Side struts

Quigley Maneuver: Knee flexion & leg external rotation, foot supination & adduction for reduction

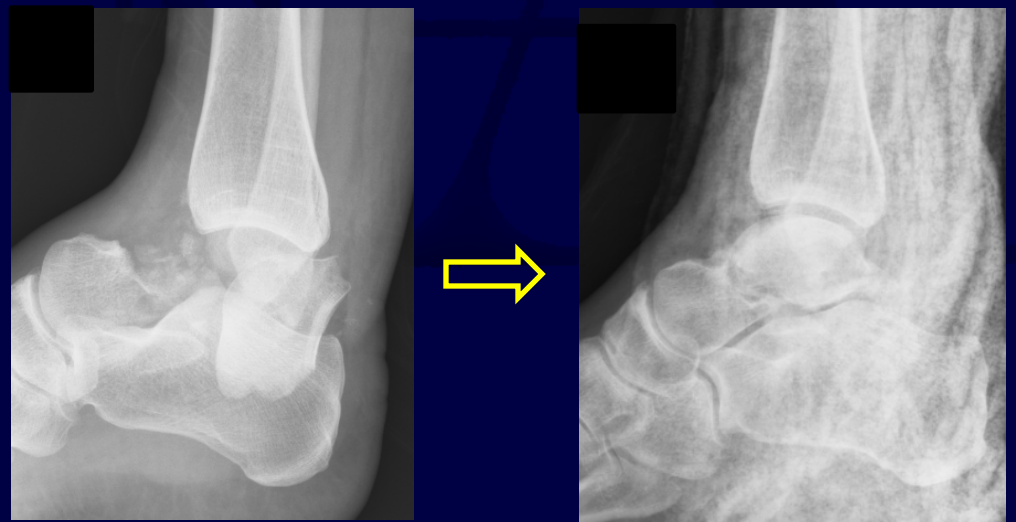
Posterolateral to anteromedial mold for posterolateral ankle fractures

Talus Fracture

- Traction
  - Recreate deformity
  - Flex knee & planter flex foot
- Commonly have skin tenting
  - Important for reduction technique
- Immobilization:
  - Posterior slab splint

    +/- U splint

    +/-Side struts



Calcaneus Fracture

- Traction & planterflexion if posterior significant skin pressure
  - Urgent operative indication
- Significant swelling common
- Immobilization:
  - Bulky Jones Splint
- Splint → Cast if nonop mgnt after swelling decreases

Midfoot Fracture/dislocation

- Traction & medial/lateral with planter pressure
- Commonly need pins to hold reduction
- ORIF frequently definitive mgnt

- Immobilization:
  - Posterior slab splint
    +/- Foot plate
    +/-Side struts

Fracture Bracing

- Allows for early functional ROM and weight bearing
- Relies on intact soft tissues and muscle envelope to maintain reduction
- Most commonly used for humeral shaft & tibial shaft fractures

Humeral Fracture Cuff

- Convert to humeral fracture brace 7-10 days after fracture
  - –Improved pain
  - –Less swelling (nerve compression, compartment syndrome)
- Encourage early active elbow ROM
- Monitor for skin lesions
- Fracture reduction maintained by hydrostatic column principle
- Co-contraction of muscles
  - -Snug brace daily
  - -Gravity traction – no elbow support

Patient must tolerate a snug fit for brace to be functional

Figure from Rockwood and Green, 4th ed.

Casting

- Goal of semi-rigid immobilization while avoiding pressure / skin complications
- Often a poor choice in the treatment of acute fractures due to swelling & other soft tissue pathology
- Good cast technique necessary to achieve predictable results

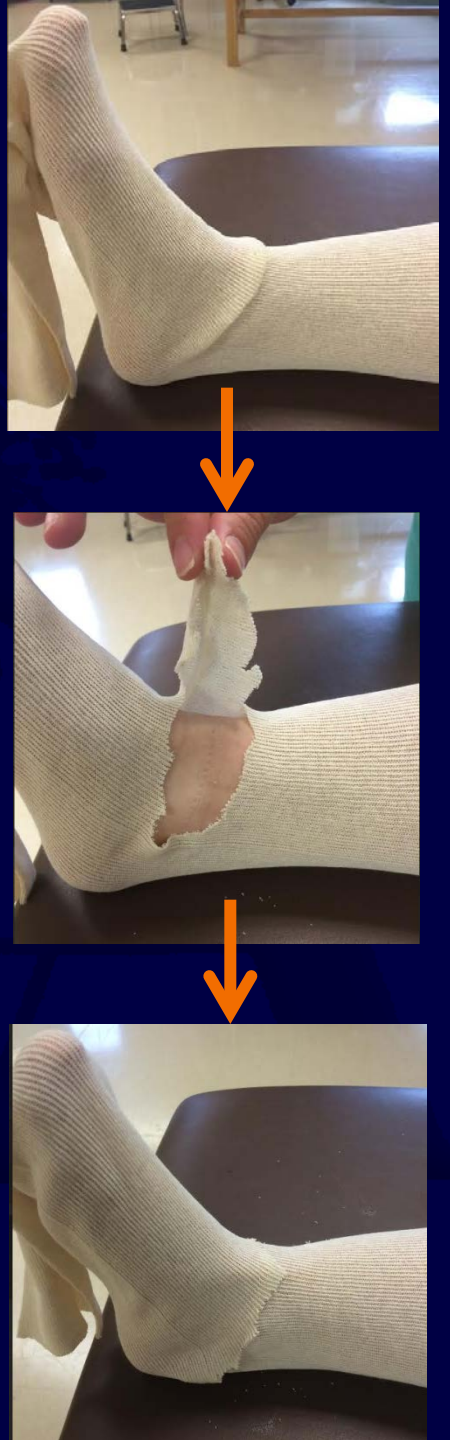
Casting Techniques

- Stockinette
  - May require two different diameters to avoid over tight or loose, redundant material
- Caution not to lift leg by stockinette
  - Stretching the stockinette too tight around the heel may case high skin pressure

Casting Techniques

- To avoid wrinkles in the stockinette
- Cut along the concave surface and overlap to produce a smooth contour
- Applicable to ankle, elbow, posterior knee

Wrinkled stockinette causing skin pressure lesion to antecubital fossa



Casting Techniques

- Cast padding
  - Roll distal to proximal
  - 50 % overlap
  - 2-3 layers minimum
  - Extra padding at boney prominences
    - Fibular head, malleoli, patella, and olecranon

Casting Material

- Plaster
  - Use cold water to maximize molding time & limit exothermic heat reaction (can burn skin)
- Fiberglass
  - More difficult to mold but more durable & resistant to breakdown
  - Generally 2 - 3 times stronger for any given thickness

Width

- Casting materials are available in various widths
  - 4 - 6 inch for thigh
  - 3 - 4 inch for lower leg & upper arm
  - 2 - 3 inch for forearm

Cast Molding

- Avoid molding with anything but the heels of the palm in order to avoid pressure points
- Mold applied to produce three point fixation

Below Knee Cast

- Support metatarsal heads & ensure exposure of toes
- Ankle in neutral position
  - Flex knee to relax gastroc complex
- Thicker cast material at heel/foot for walking casts
  - Fiberglass much preferred for durability

Flexed knee

Padded fibular head

Neutral ankle position

Toes free

Assistant or foot stand required to maintain ankle position

Above Knee Cast

- Apply below knee first (thin layer proximally)
  - Allow to harden prior to proximal casting
- Flex knee 5 - 20 degrees
- Mold supracondylar femur & patella for improved rotational stability
- Apply extra padding anterior to patella

Above Knee Cast

Support lower leg / cast

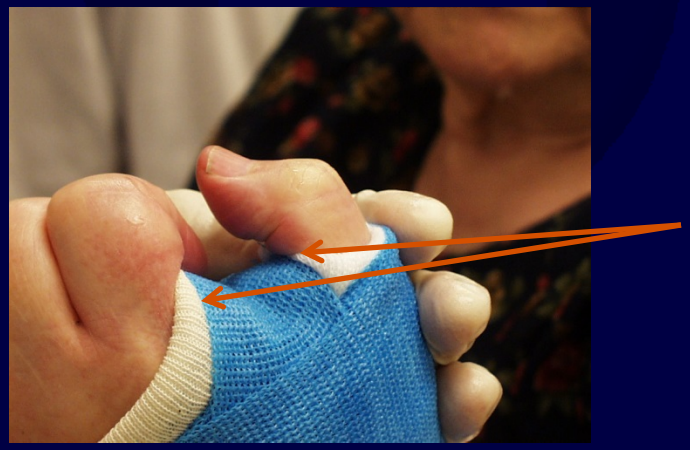
- Assistant or well placed bump

Anterior padding

Extend to gluteal crease

Forearm Casts & Splints

- MCP joints should be free for ROM if not casting hand
  - Do not go past proximal palmar crease
- Thumb should be free to base of MC
  - Unobstructed opposition of thumb to little finger



Avoid digit impingement

Cast proximal to palmar crease permitting thumb opposition

Examples - Position of Function

- Ankle - Neutral dorsiflexion – No Equinus
- Hand - MCPs flexed 70 – 90º, IPs in extension

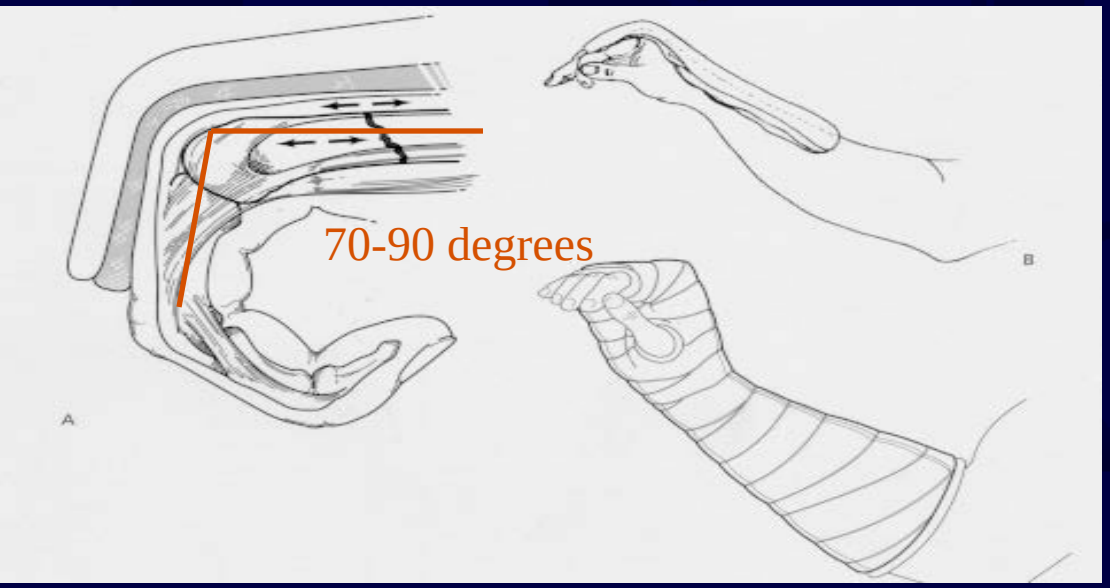


Figure from Rockwood and Green, 5th ed.

Cast Wedging

- Early follow-up x-rays are required to ensure acceptable reduction
- Cast may be “wedged” to correct reduction
- Deformity is drawn out on cast
- Cast is cut circumferentially
- Cast is wedged to correct deformity & the over-wrapped

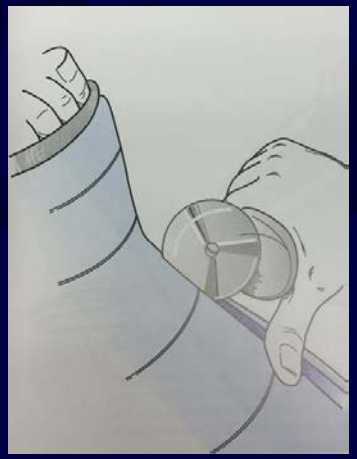
Complications of Casts & Splints

- Loss of reduction
- Pressure necrosis – may occur as early as 2 hours
- Tight cast → compartment syndrome
  - Univalving = 30% pressure drop
  - Bivalving = 60% pressure drop
  - Also need to cut cast padding

Complications of Casts & Splints

- Thermal Injury –
  - avoid plaster > 10 ply
  - water >24° C
  - unusual with fiberglass
- Cuts and burns during removal
  - Appropriate removal technique
  - Appropriate depth of saw
  - Temperature of saw blade

Skin burns from cast removal



Thumb supporting saw during cast removal

Figures from: Rockwood and Green: Fractures in Adults, 6th ed, Lippincott, 2006

Complications of Casts & Splints

- DVT/PE
  - Increased in lower extremity fracture
  - Prior history and family history
  - Birth control → risk factor
  - Indications for prophylaxis controversial in patients without risk factors
- Joint stiffness
  - Leave joints free when possible (ie. finger MCP for below elbow cast)
  - Place joint in position of function
    - Limits long-term morbidity associated with stiffness

Traction

- Allows constant controlled force for initial stabilization of long bone fractures & aids reduction during operative procedure

- Skeletal vs. skin traction is case dependent

Skin (Bucks) Traction

- Limited force can be applied
  - Generally not to exceed 5 lbs
- Commonly used in pediatric patients
- Can cause soft tissue problems especially in elderly or rheumatoid patients
  - Thin extremity skin
- Not as powerful when used during operative procedure for both length or rotational control

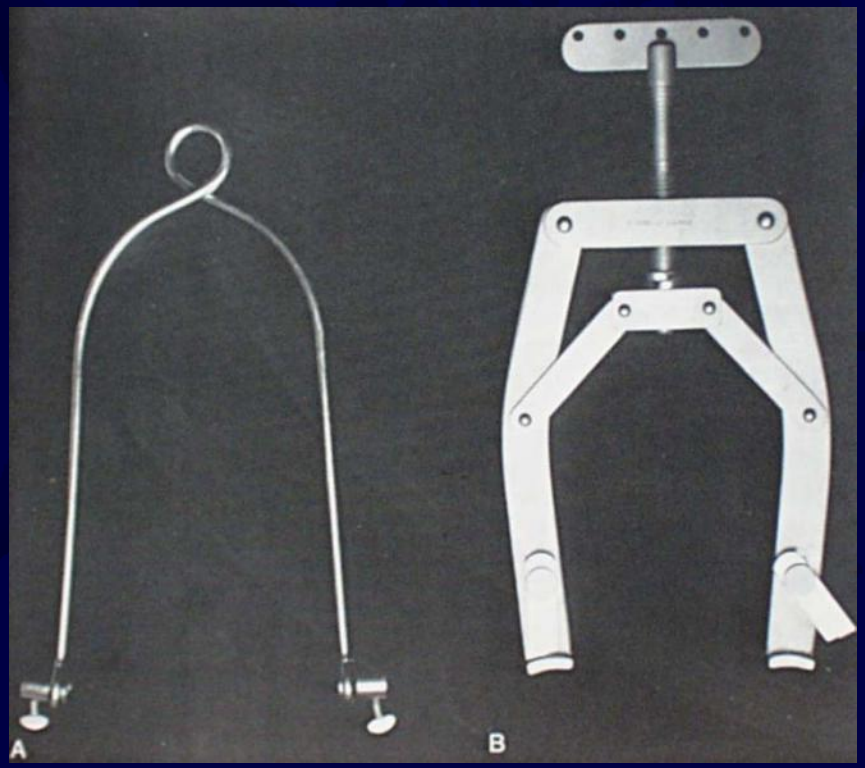
Skeletal Traction

- More powerful than skin traction
- May pull up to 20% of body weight for the lower extremity
- Requires anesthesia (local vs. sedation) for pin insertion
- Preferred method of temporizing:
  - Femur fractures
  - Vertically unstable pelvic ring fractures
  - Acetabulum fractures

Traction Pin Types

- Choice of thin wire vs. thick pin
  - Thin wire requires a tension traction bow

Standard Bow



Tension Bow

Traction Pin Types

- Steinmann pin may be either smooth or threaded
  - Smooth
    - Stronger but can slide if oblique
  - Threaded pin
    - Weaker & can bend with higher weight application
    - Will not slide
- In general a 5 or 6 mm diameter pin is chosen for adults
  - Insertion may induce local bone thermal necrosis

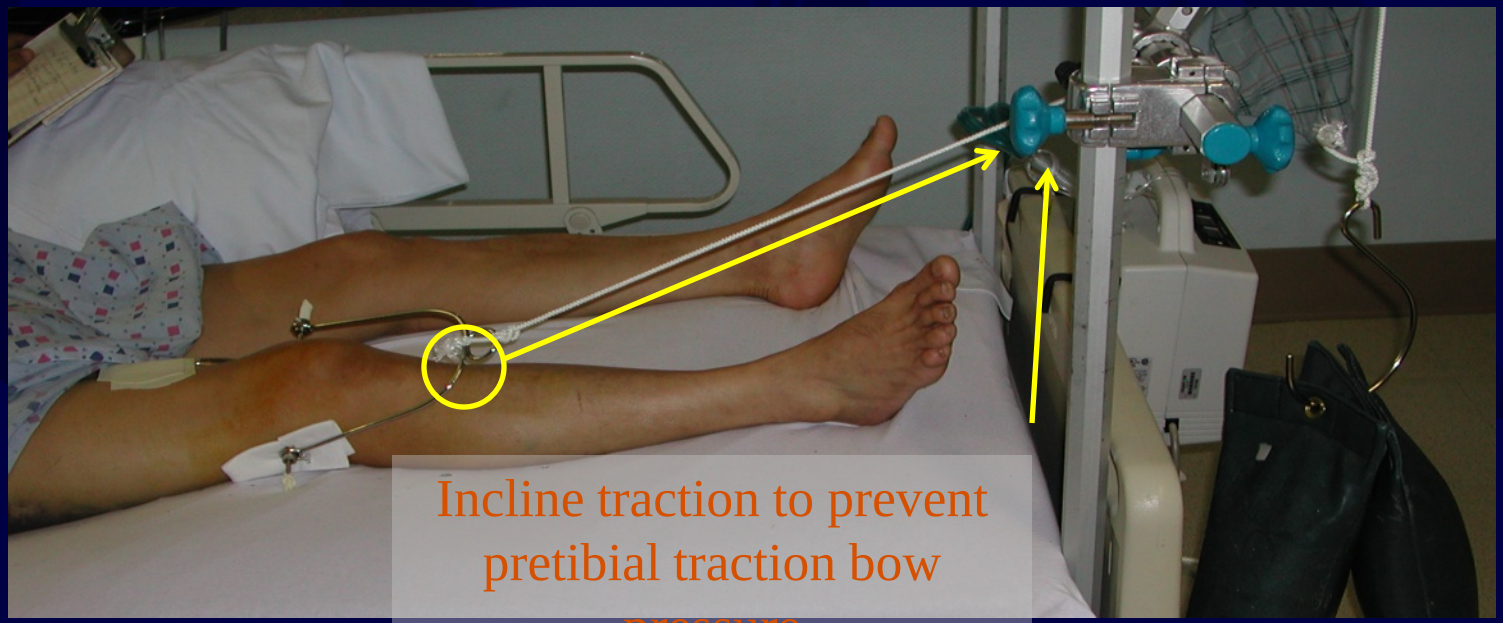
Bent non-tensioned thin wire

Traction Pin Placement

- Sterile field with limb exposed
- Local anesthesia ± sedation
- Insert pin from known area of neurovascular structure
  - Distal femur: Medial → Lateral
  - Proximal Tibial: Lateral → Medial
  - Calcaneus: Medial → Lateral
- Place sterile dressing around pin site
- Place protective caps over sharp pin ends

Distal Femoral Traction

- Method of choice for acetabular/vertically unstable pelvic ring & some femur fractures
- If knee ligament injury suspected → distal femur instead of proximal tibial traction
  - Distraction through knee joint → potential neurvascular injury

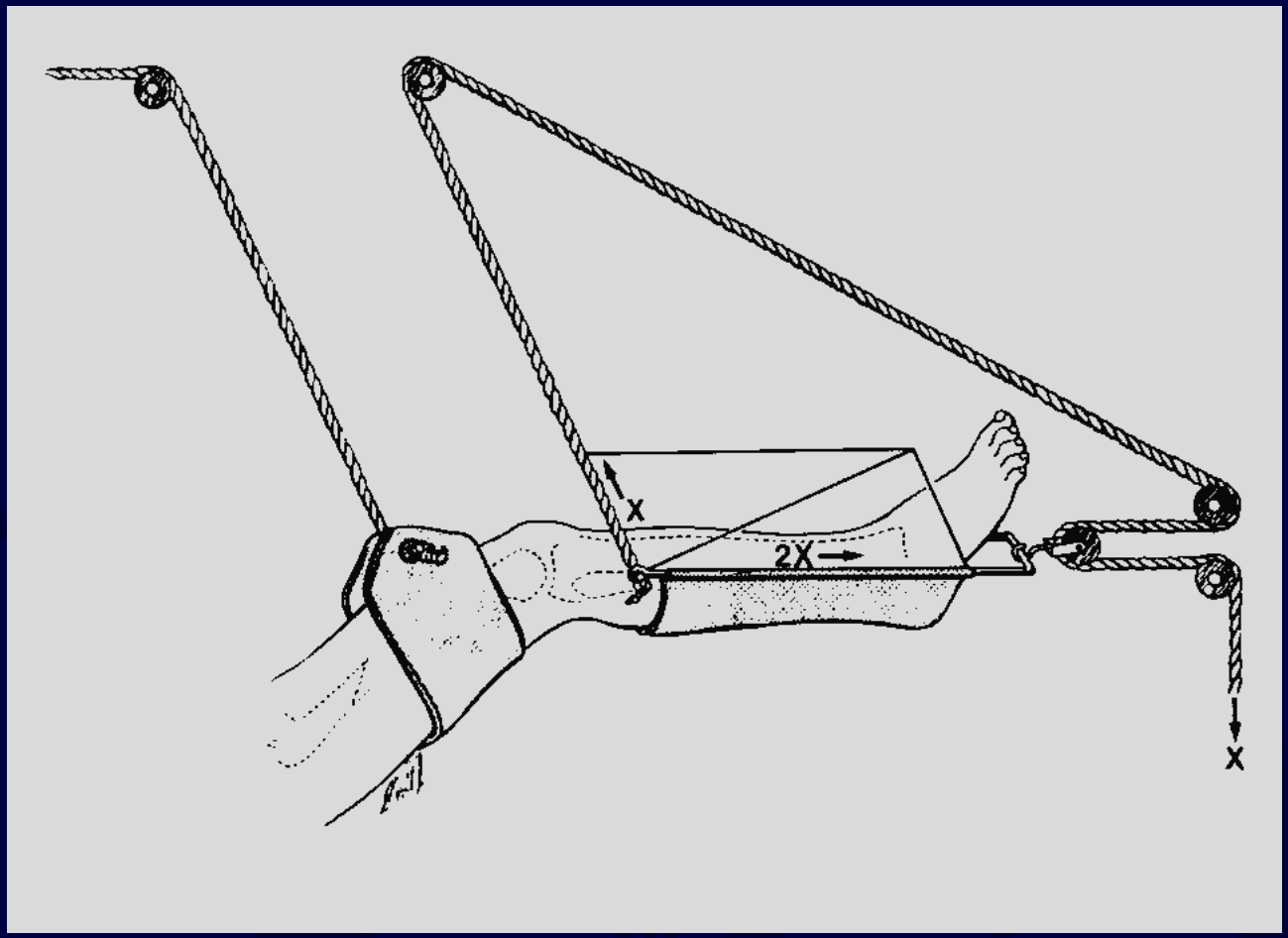


Distal Femoral Traction

- Place pin from medial to lateral at the adductor tubercle - slightly proximal to epicondyle
  - Minimizes risk for vascular injury

Balanced Skeletal Traction

- Suspension of leg with longitudinal traction
- Requires trapeze bar, traction cord, & pulleys
- Allows multiple adjustments for optimal fracture alignment



- One of many options for setting up balanced suspension
- In general the thigh support only requires 5-10 lbs of weight
- Note the use of double pulleys at the foot to decrease the total weight suspended off the bottom of the bed

Figure from: Rockwood and Green: Fractures in Adults, 4th ed, Lippincott, 1996.

Proximal Tibial Traction

- Place pin 2 cm posterior and 1 cm distal to tubercle
- Place pin from lateral to medial
  - Minimizes risk to peroneal nerve

Calcaneal Traction

- Most commonly used with a spanning ex fix for "travelling traction" or may be used with a Bohler-Braun frame
- Place pin medial to lateral 2 - 2.5 cm posterior and inferior to medial malleolus
  - Minimizes risk to posterior medial mal NV structures

Traction Complications

- 5-6mm pin → insertion hole may interfere with distal locking screw site
  - Thermal necrosis → osteomyelitis
- Skin issues
  - Monitor traction set up frequently for problems

Washer causing skin necrosis

Pretibial bow skin lesion

Olecranon Traction

- Rarely used today
- Medium sized pin placed from medial to lateral in proximal olecranon
  - Enter bone 1.5 cm from tip of olecranon & identify midsubstance location
- Support forearm and wrist with skin traction - elbow at 90 degrees

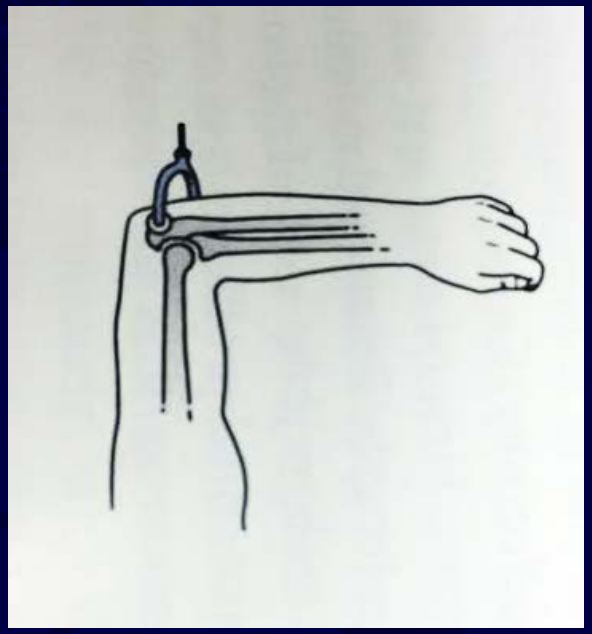


Figure from: Rockwood and Green: Fractures in Adults, 6th ed, Lippincott, 2006

Gardner Wells Tongs

- Used for C-spine reduction / traction
- Pins are placed one finger breadth above pinna & slightly posterior to external auditory meatus
- Apply traction beginning at 5 lbs. and increasing in 5 lb. increments with serial radiographs and clinical exam

Halo

- Indicated for certain cervical fractures as definitive treatment or supplementary protection to internal fixation
- Disadvantages
  - Pin problems
  - Respiratory compromise

“Safe zone” for halo pins. Place anterior pins ~ 1 cm cranial to lateral two thirds of the orbit & below skull equator

“Safe zone” avoids temporalis muscle & fossa laterally, supraorbital & supatrochlear nerves & frontal sinus medially

Posterior pin placement less critical because of lack of neuromuscular structures & uniform thickness of the posterior skull.

Figure from: Rockwood and Green: Fractures in Adults, 4th ed, Lippincott, 1996.

Halo Application

- Position patient maintaining spine precautions
- Fit Halo ring
- Prep pin sites
  - See previous slide for placement sites
  - Have patient gently close eyes for pin placement to prevent eyelid dysfunction
- Tighten pins to 6-8 ft-lbs.
- Retighten if loose
  - Pins only once at 24 hours

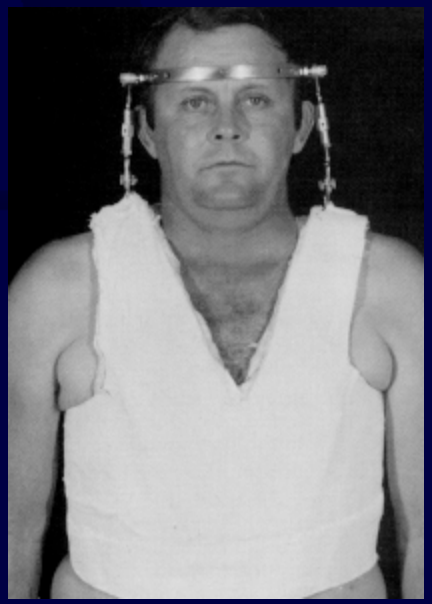


Figure from: Rockwood and Green: Fractures in Adults, 4th ed, Lippincott, 1996.

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Return to General/Principles Index

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