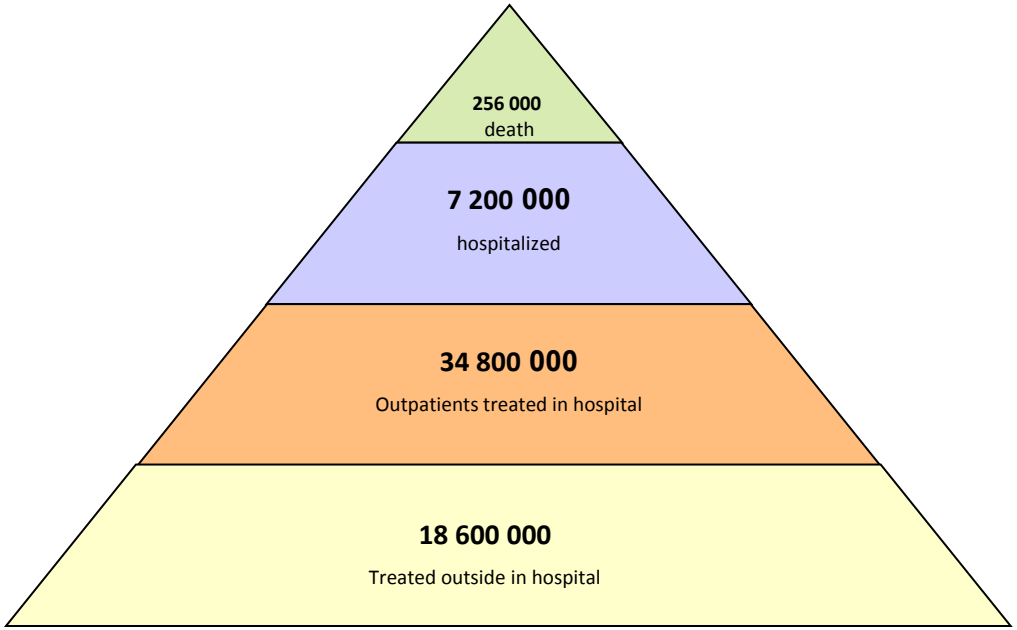
Trauma surgery

Milan Krticka
Trauma surgery department, University Hospital Brno

Epidemiology of injuries

- Injuries are the leading cause of mortality and morbidy in age group ≤ 45 years



Definition of fracture

- Fracture: Break in the structural continuity of the bone
- It can be a crack, splintering of cortex, complete with/without displacement of bone fragments
- Closed/simple facture: overlying ski is intact
- Open/compound fracture: overlying skin or body cavity is ruptured -> increased infection risk

Cause of fractures

1. Trauma: due to sudden and excessive force
   a) direct force: bone breaks at point of impact
   b) indirect force: bone breaks distantly
   esp.: vertebra, tibia, fibula

2. Stress/Fatigue fractures: due to repetitive stress esp.:
   tibia, fibula, metatarsals in
   athletes, dancers etc

3. Pathological fractures: Osteoporosis (skeletal insufficiency)
   Paget's disease (Brittle bone)
   Bone tumors (osteolytic lesion)

Clinical features:

- History
- Clinical examination: (look, feel, move)
  check besides obvious injury also arterial damage, nerve supply, soft tissues
- Imaging:
  - x-ray: rule of two: 2 views, 2 joints, 2 limbs, 2 injuries, 2 occasions
  - CT, MRI, Radioisotope scan
- Secondary injuries: e.g. fracture of rib -> injury on lungs
- Testing for fracture union: absence of pain, tenderness, mobility of fracture site, callus formation in x-ray

Types of fractures:

1. Complete fractures:
   Transverse, spiral, oblique, impacted fracture or comminuted fracture

2. Incomplete fractures:
   Greenstick fracture, Stress fracture or Compression fracture

3. Physeal fractures:

1. Complete fractures:

- Definition: Bone is completely broken into 2 or more parts

A. Transverse fracture: fragments remain in place

B. Oblique or spiral: tend to slip

C: Impacted fracture: fragments are jammed together, indistinct fracture line

D. Comminuted fracture: more than 2 fragments

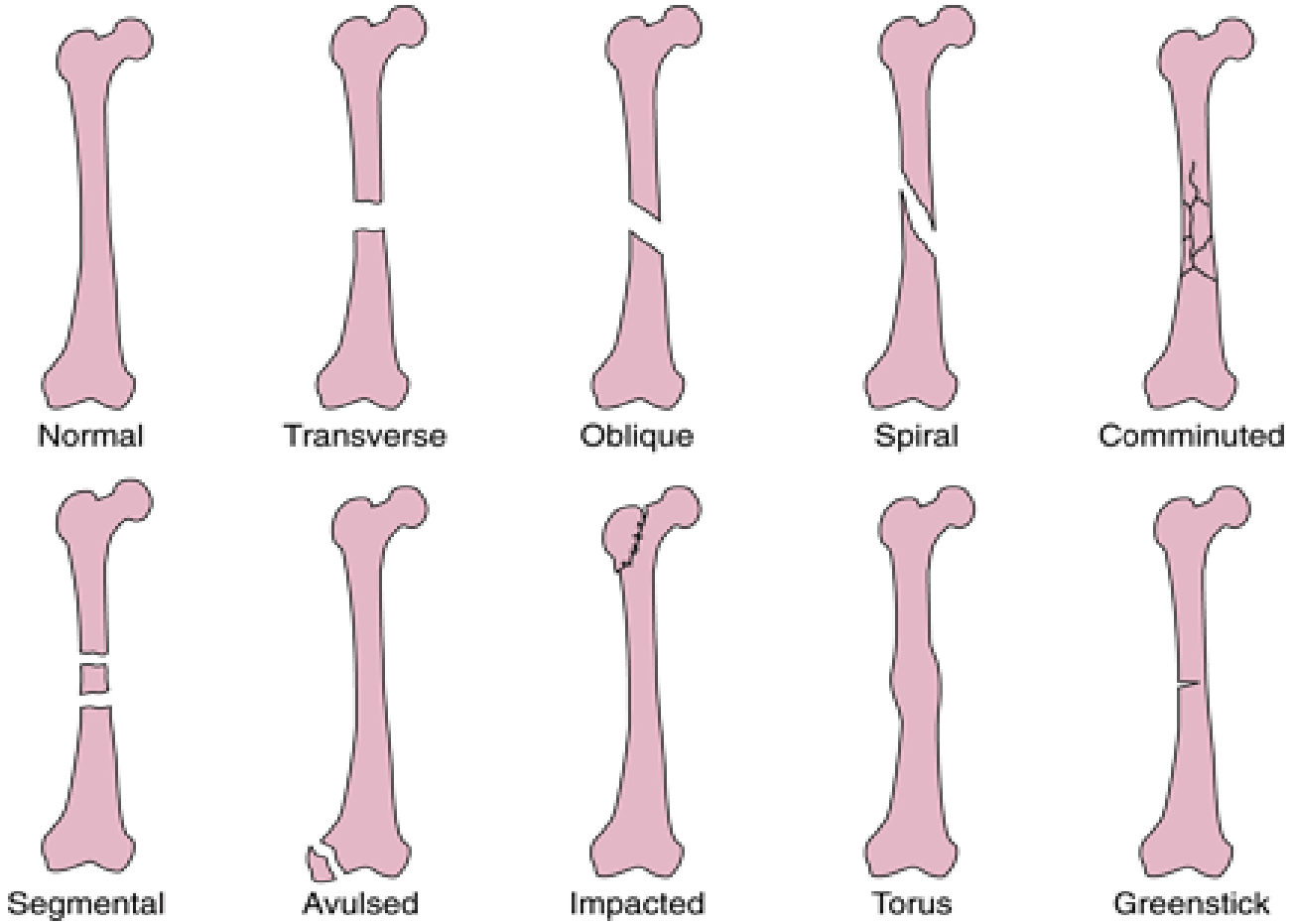
2. Incomplete fractures:

- Def.: bone is incompletely divided -> periosteum remains in continuity

A. Greenstick fracture: In children, bone is buckled or bend, fast healing

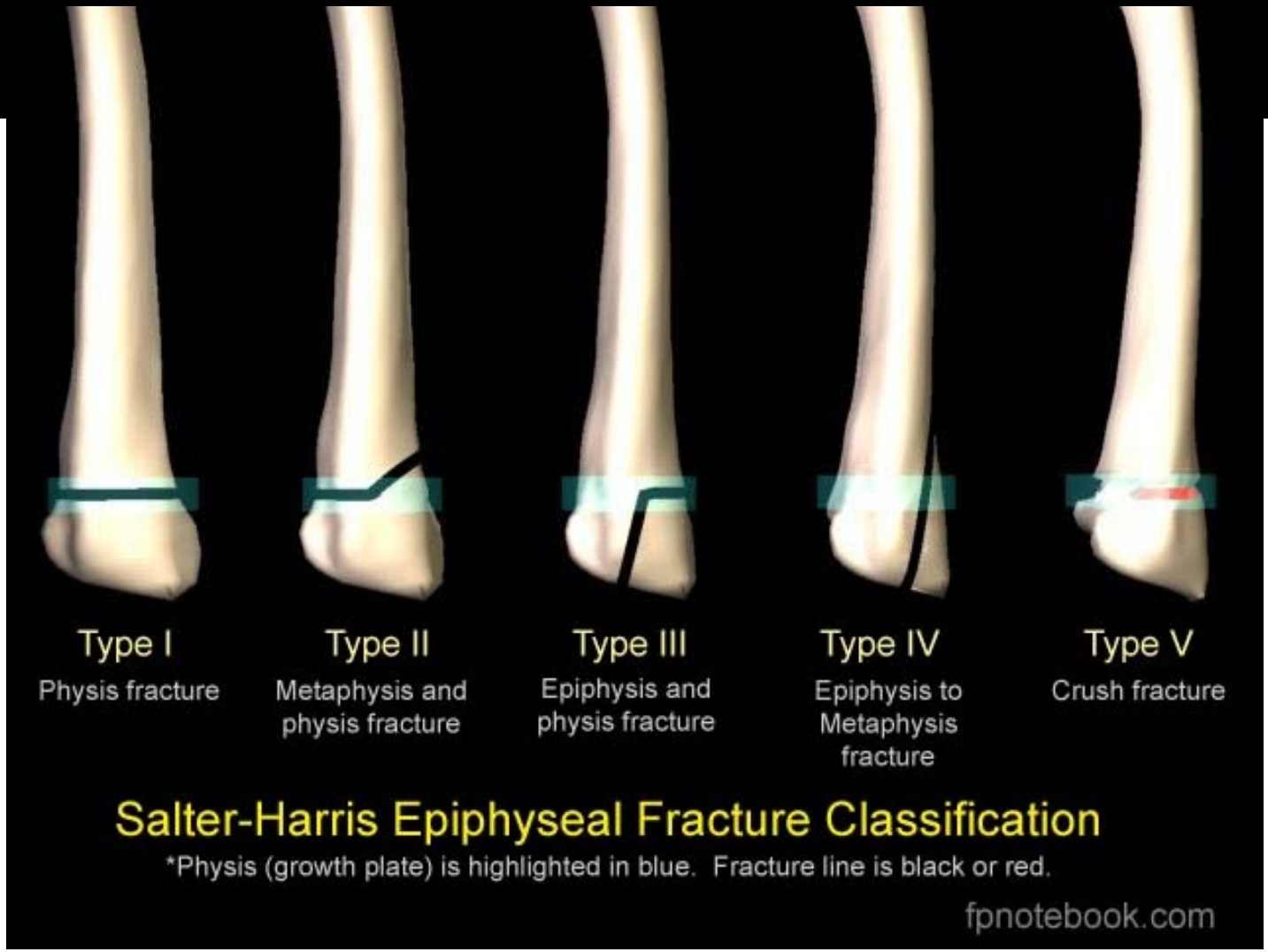
B. Stress factures: Break appears only in 1 part of the cortex, slow healing

C. Compression fractures: spongious bone is crumpled, esp. In vertebral bodies in adults


Normal
Transverse
Oblique
Spiral
Comminuted
Segmental
Avulsed
Impacted
Torus
Greenstick

3. Physeal fractures:

- Def.: Fractures through growing physis, children
- Damaging of carlitagous growth -> deformity
- Classification:
  - Type I: separation of epiphysis
  - Type II: fracture through physis and metaphysis
  - Type III: fracture runs along physis and then veers off into joint, splitting the epiphysis
  - Type IV: vertical fracture through epiphysis and adjacent methaphysis
  - Type V: crushing off the physis without visible fracture


Type I
Physis fracture
Type II
Metaphysis and physis fracture
Type III
Epiphysis and physis fracture
Type IV
Epiphysis to Metaphysis fracture
Type V
Crush fracture
Salter-Harris Epiphyseal Fracture Classification
*Physis (growth plate) is highlighted in blue. Fracture line is black or red.
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Fracture displacement:

1. Translation/Shift: sideward, backwards or forwards shift

2. Alignment/Angulation: Fragment may be tilt or angulated

3. Rotation/Twist: esp.: long bones

4. Length: distracted, separated fragments that can overlap due to muscle spasm -> shortening of bone

Healing of fractures:

A) With callus:

1.) Tissue destruction and hematoma formation: bone deprive blood supply, dies for 1 or 2 mm

2.) Inflammation and cellular proliferation: 8h -> inflammatory reaction with cell proliferation under periosteum -> bridges fracture site, clotted hematoma is absorbed, new fine capillary growth

3.) Callus formation: proliferation cells (chondraogenic and osteogenic) -> forming new bone; Thick cellular mass with islands of immature bone form the callus on periosteal and endosteal sites; Immature bone becomes more dense by mineralization (this process includes fibroblast growth factors, transforming growth factors and bone morphogenic proteins)

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4.) Consolidation: bone is transformed into lamellar bone: osteoclasts take debris at fracture line and osteoblasts fill the gaps between fragments, takes several month

5.) Remodeling: following month/years: resorption and formation of bone -> thicker lamellae are where bone is stressed

B. Without callus:

- Callus is the response to movement at the fracture site (stabilizes fragments as fast as possible) -> in immobilized fractures is no need for a callus -> healing occurs directly between fragments

Time factor in healing:

- Depending on:
  - type of bone: Spongious bone < cortical bone
  - type of fracture: spiral fracture < transverse fracture
  - blood supply: poor circulation means slower healing
  - general condition: healthy bone heals faster
  - Age: children < adults

	Upper limb	Lower limb
Callus visible	2-3 weeks	2-3 weeks
Union	4-6 weeks	8-12 weeks
Consolidation	6-8 weeks	12-16 weeks

Non-union:

- Bone fails to unite, cell proliferation is fibroblastic, fracture gap is filled by fibrous tissue, fragments remain mobile (pseudoarthrosis)
- Can be hypertrophic, non-union or atrophic non-union
- Cause: Separation of fragments, excessive movement at fracture site, poor blood supply, soft tissue damage, infection

Treatment of fractures:

- Manipulation to improve position of fragments -> splintage to hold them together
- Healing is promoted by muscle activity and bone loading -> exercise and early weight-bearing
- REDUCE! HOLD! EXERCISE!
- Fracture quartet:
  - Hold
  - Move
  - Speed
  - Safety

A. Closed Fractures
1. Reduce:

- Swelling in first 12 h makes reduction difficult
- aim: adequate position and normal alignment of bone fragments
  - the greater the contact surface between bone fragments, the greater the healing
- Reduction is not necessary, when there is no or only little replacement, replacement does not matter or when it is unlikely to succeed (compression fractures of vertebrae)

Method of Reduction:

a) **Manipulation**: closed manipulation in minimal displaced fractures, administration of anesthesia and muscle relaxants is needed

b) **Mechanical traction**: when fracture is difficult to manipulate due to powerful muscle pull, e.g. femoral shaft

c) **Open operation**: when closed reduction fails, accurate positioning is needed, bone fragments are hold apart by muscle pull, need for internal fixation or surgery is needed for additional injuries (e.g. arterial damage)

2. Hold

prevention of displacement

Methods of hold:

a) sustained traction: tractition ba gravity

b) Cast splintage

c) Functional bracing

d) internal fixation

e) external fixation

a) Sustained traction:

- is applied to the limb distal to the fracture -> continuous pull in long axis of bone
- useful for spiral fractures of long bone shafts
- slow, avoid in elderly

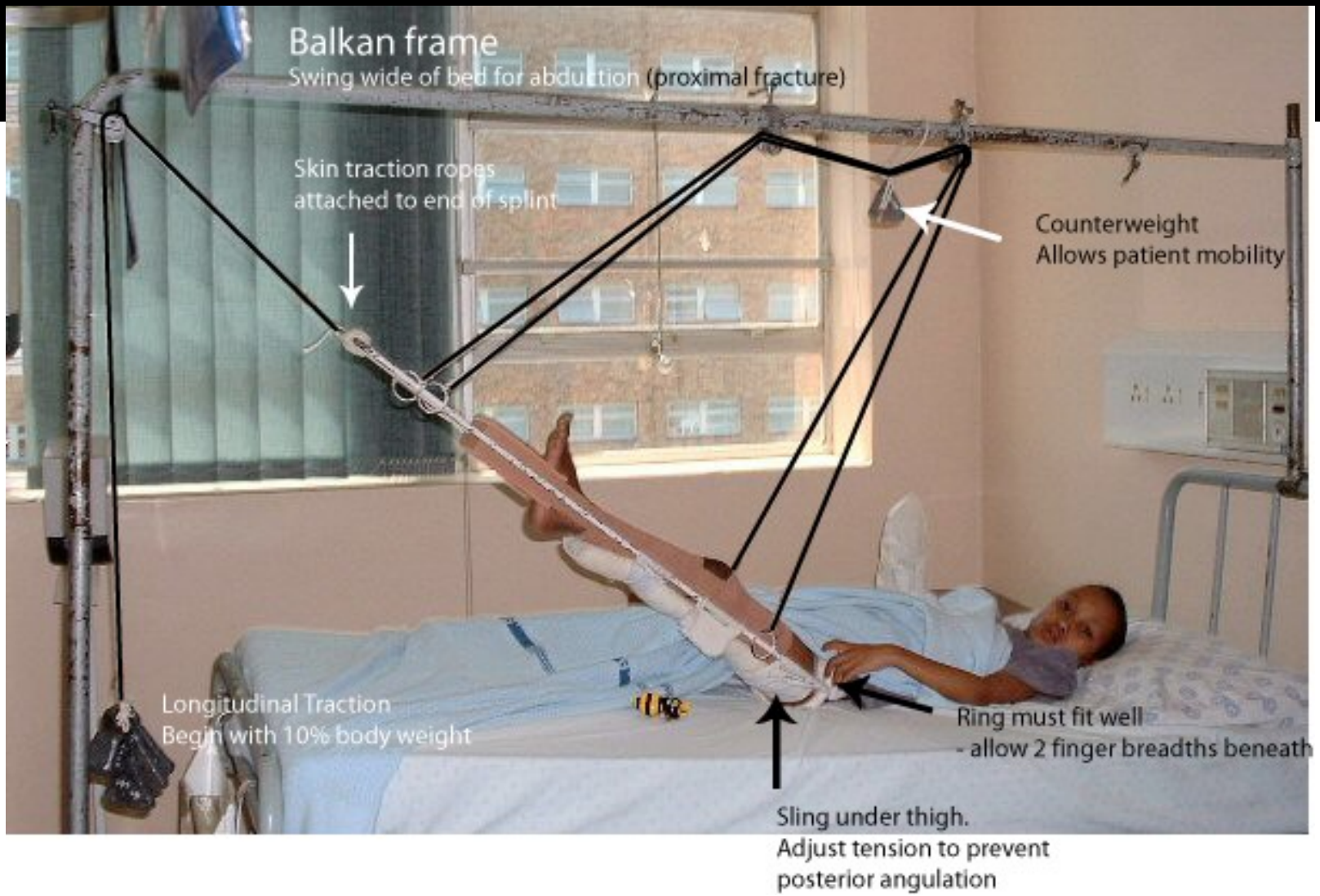
Traction by gravity: fracture of humerus -> weight of arm is sufficient for traction

Balanced traction: applied to the limbs

- Skin traction: strapping is kept in place by bandages (max 5kg pull)

- Skeletal traction: strapping is kept in place by wire or pin inserted to bone

Fixed traction: like balanced traction, but limb is held in Thomas splint and traction tapes are tied to distal end of splint while proximal end is tied firmly to pelvis (transport of patient)


Balkan frame
Swing wide of bed for abduction (proximal fracture)
Skin traction ropes
attached to end of splint
Counterweight
Allows patient mobility
Longitudinal Traction
Begin with 10% body weight
Ring must fit well
- allow 2 finger breadths beneath
Sling under thigh.
Adjust tension to prevent
posterior angulation

b) Cast splintage:

Plaster of Paris is used for distal fractures, e.g. In tibial fracture, weight can be loaded on cast

- due to swelling of fractured limb, perform a delayed splintage or start with a conversional cast that is replaced by a functional brace that permits joint movement

- **complications**: tight cast (diffuse pain), pressure sores (localized pain), skin abrasion or laceration (esp.: in removing of cast), loose cast (when swelling has subsided)

c) Functional bracing:

- use Plaster of Paris, prevent joint stiffness while still permitting fracture splintage and loading

- segments of cast over shafts of bones leaving the joint free, cast segments above and below joint can be connected by metal or plastic hinges -> movement in one plane

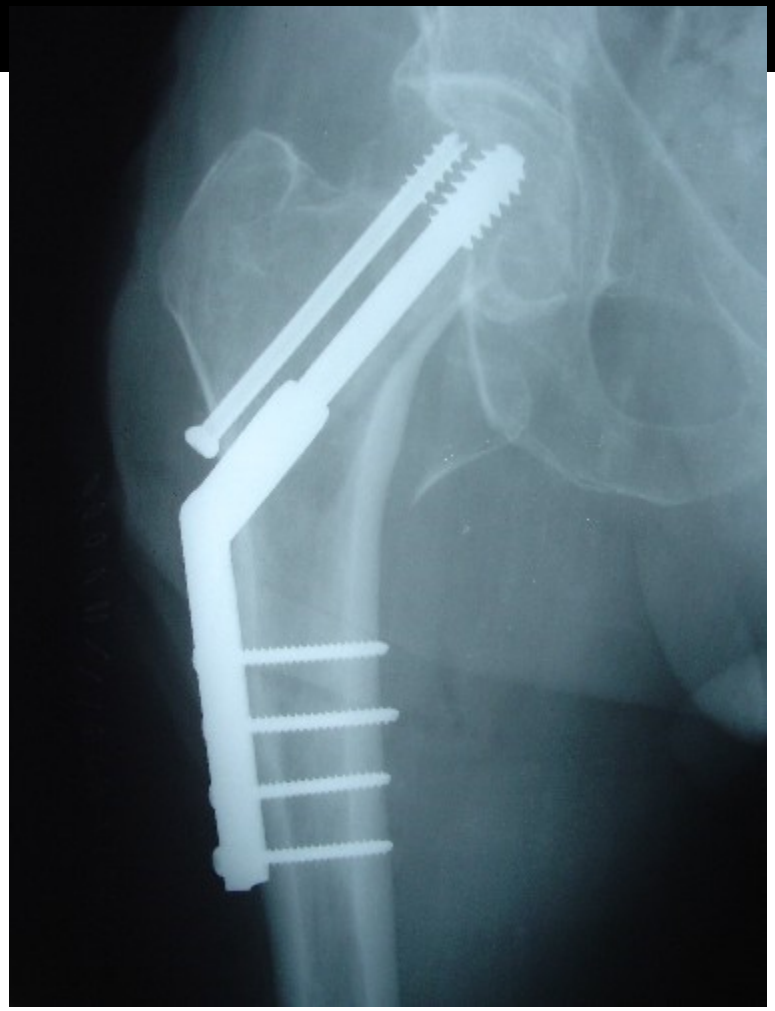
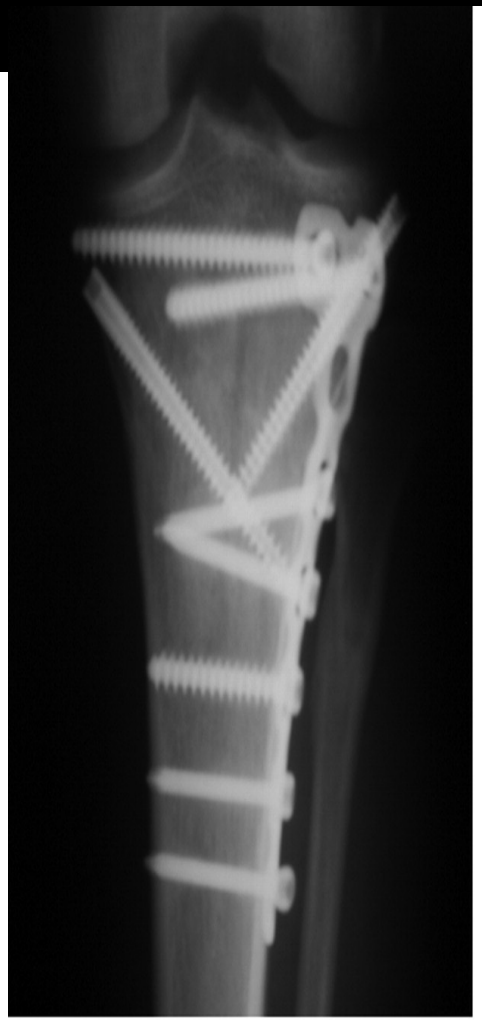
- used for fractures of femur or tibia

d) Internal fixation:

- Bone fragments are fixed with screws, transfixing pins, nails, metal plate, long intramedullary nail or a circumferential band

- Indications: open reduction, re-displacement, poor union of fragments (femur head), pathological fractures, multiple fractures

- Types of fixation:
  a) interfragmentary screws: for small fragments
  b) Kirschner wire: in fast fracture healing
  c) Plates and screws: metaphyseal fractures of long bones
  d) intratamedullary nails: long bones, transfix proximal and distant to fracture needed


Complications of internal fixation

- **Infection**: cause chronic osteomyelitis
- **Non-Union**: due to excessive striping of soft tissue, damage of blood supply or ridged fixation
- **Implant failure**: Pain in fracture site is a danger signal!
- **Re-fracture**: due to early removal of implant, (18-24 month)

e) External fixation

- Bone is transfixed below and above fracture with screws, pins or tensioned wires -> clamped to a frame -> connected to each other by rigid bars
- Allow adjustment of length and reduction in all three planes
- Used for long bones and pelvis
- Indications: fractures with severe soft tissue damage, unstable fractures, with nerve or vessel damage, infected previous internal fixed fractures, ununited fractures

- Complications: increased complication, because it is mostly used for complicated fractures
  - Damage of soft tissue structures: pins or wires can injure vessels, nerves or ligaments and inhibit joint movement
  - Over-distraction: no contact between fragments
  - Pin-track infection: careful pin site care!

AN *ILIZAROV*, CIRCULAR FIXATOR USED TO STABILIZE AND LENGTHEN THE TIBIA.

SMALL WIRES AND PINS FIX THE BONE TO THE FRAME UNTIL HEALING OCCURS.

3. Exercise

- Restore function, reduce edema, preserve joint movement and restore muscle power
- Prevention of edema: “elevate and exercise, never dangle, never force”
- Active exercise
- Assistant movement: esp.: in elbow injuries
- Functional activity

B. Open fractures:

Initial treatment:

- Patients with open fractures have commonly multiple injuries, severe shock
- Treat life-threatening injuries first
- Cover fracture with sterile dressing
- Give tetanus prophylaxis
- The incident of wound infection correlates with the extent of soft tissue injuries

Gustilo's classification:

Type I: low energy fracture with clean wound and little soft tissue damage

Type II: moderate energy fracture with clean wound > 1cm long, but not much soft tissue damage and not more than moderate communication of the fracture

Type III: high energy fracture with extensive damage to skin, soft tissue and neurovascular structures and contamination of wound

A. fractured bone can be covered by soft tissue
B. no covering possible, periosteal stripping, severe communication of fracture
C. arterial injury present

3. Principles of treatment:

- All open fractures must be assumed to be contaminated: ->
  - Prompt wound debridement
  - Antibiotic prophylaxis
  - Stabilization of fracture
  - Realy defined wound cover

1. Sterility and antibiotic cover:

- Mostly combination of benzylpenicillin and fluconazole every 6 hours for 48 hours
- If severe, cover also Gram neg. and anaerobes by gentamicin or metronidazole

2. Debirment and wound excision:

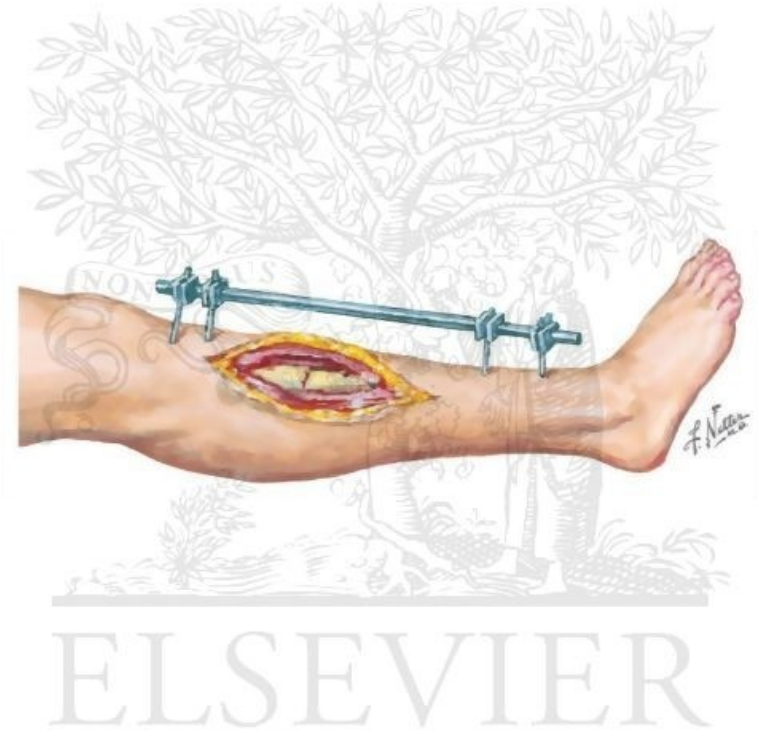
- Surrounding skin is shaved and cleaned, wash wound with saline
- Extend wound, remove debirs, foreign material, dead muscle (purplish color) wash again with saline

3. Wound closure:

- Type I and II can be closed with no tesion
- Type III must be left open, lightly packed with moist, sterile gauze and inspected again after 24-48 hours
  If wound is clean: suture or close with skin graft (delayed primary closure)

4. Stabilization of fracture:

- Type I to IIIA can be treated like closed fracture
- Type IIIB and C: Plastic and orthopedic surgeon -> external fixation with circular frame



Complications:

- local tissue changes like edema, inflammation, but also severe soft tissue damage and vascular impairment
- strained ligaments, subluxation or dislocation of joints, damage of the cartilage

Urgent complications:

- Local visceral injuries
- Vascular injuries
- Nerve injuries
- Compartment syndrome
- Haemarthrosis
- Infection
- Gas gangrene

Less urgent complications:

- Fractures blisters
- Plaster sores
- Pressure sores
- Nerve entrapment
- Tendon lesion
- Joint stiffness

Late complications:

- Delayed union
- Malunion
- Non-union
- Avascular necrosis
- Muscle contracture
- Joint instability
- Osteoarthritis

Thank you for your attention!