Fractures – biomechanics, classification, bone healing, fracture fixation
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Fracture of the bone - fractura ossis
= partial or complete disruption of bone continuity

▪ In general
disruption of continuity of hard tissue
cartilage, tooth, claw

▪ Etiology
1. trauma (hit, fall, car accident, bite)
2. local (bone tumors, osteomyelitis)
3. systemic diseases (“paper bone disease”)
Clinical signs
▪ 1. Local
a) pathological function (functio laesa)
b) swelling (haemathoma, edema)
c) deformity
d) pain
e) crepitus might be unapparent if soft tissue is in fx line

Clinical signs

▪ 2. Systemic
– signs of trauma - shock
Biomechanics
Bone loaded by
▪ Compressive forces fractures
oblique to long bone axis
(inner shearing forces)

▪ Bending forces
transverse fracture
(tension forces on convex bone surface)
+
small fragment can dislocate
(compress side – shearing forces)
Biomechanics
▪ Simultaneous compression and bending
(shearing forces higher on concave surface)
“butterfly” fragment
or comminuted fx on concave surface
Torsion forces
(inner shearing forces oriented parallel to bone column)
Spiral
(fracture line encircling bone circumference in place of highest inner tension)
Biomechanics
Simple fractures
lower energy
Classification of fractures
Presence of a communicating external wound

Open x closed fxs
Classification of fractures
Extent of bone damage

Complete x incomplete fxs
Bone contusion – green-stick fx – fissure fx – avulsion – impacted fx
Classification of fractures
Direction of fracture line

Transverse x oblique x spiral x comminuted x multiple (segmental)
Classification of fractures
Location of fracture line

Diaphyseal x metaphyseal x physeal (Salter-Harris) x intraarticular
Classification of fractures
Dislocation of fragments

Non-dislocated x dislocated
contraction, distraction

Monteggia fx
Classification of fractures
Stability following replacement in anatomical position of fragments

„stable“ x „unstable“
Blood supply to mature bone
Arterial: Centrifugal
Outer 1/3:
Periosteal vessels
Efferent mainly
- Inner 2/3:
- Medullary arteries
- Ascending
- Descending
- Afferent mainly

Circulation after Fracture
- Disruption of medullary supply
- Extraosseous blood supply

Bone healing
- **1. primary (direct)**
  - absolute stability
  - results in a fracture environment conducive to bone formation
  - **no callus formation**

- **2. secondary (indirect)**
  
- **Direct**

  **types**

- **Contact healing**
- **Gap healing**
  - Direct bone healing
  - **Contact healing**
  - gap ≤ 100 – 300 μm

  **Contact Healing**
  - Simultaneous union and reconstruction of the fragment ends by haversian remodeling

  **Gap Healing**
  - Stage I-filling the gap by primary bone formation
  - Woven bone / fracture site

  **Gap Healing**
  - Stage II-longitudinal reconstruction by haversian remodeling

Radiographic Signs of Direct Fracture Healing
- No evidence of endosteal or periosteal callus
- Slow filling of fracture lines with bone density material
- Plate functions as callus during remodeling

Indirect Bone Healing
- Tissue responds to the mechanical environment in an orderly sequence
Inflammatory phase
- Mechanical importance is insignificant
- May be very important biologically
- Viable cells
- Cytokines
- Resorption of fragment ends

Repair Phase
- Elongates 100%,
- Tensile Strength: .1Nm/mm²
- Granulation tissue
- Periosteal and endosteal mesenchymal stem cells
- Fibrocartilage
- Elongates 5-17%
- Tensile Strength: 2-60Nm/mm²
- Callus formation
- Endosteal / periosteal

Repair Phase
- Elongates 2%
- Tensile Strength: 130Nm/mm²
- Endochondral ossification of the cartilaginous callus

Remodeling phase
- Restoration of initial architecture
- No scar

Radiographic Signs of Indirect Fracture Healing
- 0-7 days - fracture gap widens, fracture ends become smoother and rounder

Radiographic Signs of Indirect Fracture Healing
- 7-21 days - variable amounts of callus
- Endosteal callus often first but difficult to see
- Periosteal callus starts some distance from the gap
- Intracortical callus is variable, depending on gap

Radiographic Signs of Indirect Fracture Healing
- 28+ days - smoother, more radio-opaque callus, fracture lines less distinct, filling with trabecular bone
- 2-9 months - fracture remodels, medullary canal restored, cortices reformed, bone remodels according to Wolff's law

**Decision making in fx treatment**
Expressions…
- „Fractures and joint trauma are seldom fatal.“

Expressions….
- „Most of the fractures can heal themselves.“

Expressions….
- „Put a cat into the same room with bone fragments and fracture will heal.“

Expressions….
- „Internal fixation is just for fun.“

Every time!

priority = safe a life

Fx tx „according to cookbook “
- This approach ignores many factors
  - Age and bodysize
  - Behaviour and general condition
  - More legs can be affected
  - Willingnes to co-operate - patient and owner
Inappropriate result of tx!
„Balanced“ fx treatment
▪Fx healing
Stable fixation

„Race“ between bone healing and failure of fx fixation!
„Balanced“ fx treatment
▪Fx healing
Blood supply

„Race“ between bone healing and failure of fx fixation!
FPAS
Scale

considering evaluation of factors

▪mechanical
▪biologic
▪clinical

Score result = average

➢8,9,10 can make some faults
➢1,2,3 no faults

Biomechanics of Bone Healing
▪Biomechanical factors
▪Fx configuration
▪Fixation/Activity

Mechanical factors
▪Load sharing
➢Type and fx localization

▪Patient weight and activity
➢Forces and number of cycles in fx line

➢Number of affected legs
**Biologic factors**
- **Longer fx healing**
  - Open fx
  - Soft tissue injury (shearing)
  - Irradiated bones
  - Old, cachectic, systemically affected patients
  - Long sx procedure, open reposition
  - Extensive manipulation with fragments in comminuted fx

**Clinical factors**
- **Owner co-operation**
  - Activity limitations
  - Post op care (bandages, ESF)

**Conditions for potential complications**
- **Local**
  - Unstable fixation
  - Poor blood supply
  - Malposition
  - Open fx
  - Infection
  - Soft tissue injury

**Systemic**
- Disease
- Steroids
- Age

Young: Faster healing

**Complications**
Methods of fx reduction
Anatomically reducible
Open reduction
Approaches
Anatomically unreducible fx
Anatomically unreducible fx
Anatomically unreducible fx
OBDNT
Minimally Invasive Approach

Goals
▪ Stability until fx heals
  clinical fx healing

▪ Limb function during fx healing

*Choices?*
Type of fixation – implant function
Type of fixation – implant function
Type of fixation – implant function
Faults
Type of fixation – implant function
Type of fixation – implant function
Neutralization osteosynthesis
Type of fixation – implant function
Type of fixation – implant function
Type of fixation – implant function
Type of fixation – implant function
Type of fixation – implant function
Early weightbearing
Type of fixation – implant function
Type of fixation – implant function
Compression osteosynthesis
Type of fixation – implant function
Type of fixation – implant function
Type of fixation – implant function
Type of fixation – implant function
Bridging osteosynthesis
Type of fixation – implant function

Direct and indirect healing
Mechanical factors
Mechanical factors

**Buttress osteosynthesis**
Buttress plate

- DCP with holes

Concentrates strain

➢ Implant failure
Lenghtening plate

-No holes in center
Solution

Diaphysis PR
Indirect reduction
Bi- a monocortical screws
Diaphysis PR - healed

**Buttress osteosynthesis**
Buttress plate
Buttress plate
Buttress plate
Complications
Complications
Solution
Diaphysis
Diaphysis
Diaphysis
Metaphysis
Indications for „plate and rod“
Indications for „plate and rod“
Plate and rod
Plate and rod
Plate and rod

-screws
bi / monocortical

-large fragments
„laso“

➢ OBDNT

Plate and rod - OBDNT
Plate and rod - technika
Plate and rod - miniinvazivní
Dynamization

➢ 4-6 weeks
IM extraction
Podstata PR
**Other PR indications**
Arthrodesis
Arthrodesis
Arthrodesis
Delayed union, osteomyelitis

**LCP**