Principles of fractures

Introduction

How f# occurs?
- injury
- fatigue & stress
- pathological f#

Classification — OA | OTA | Alpha Numeral

Displacement → Translation / shift ; Angulation / tilt ; Rotation / twist ; Length

Healing → by
- direct union → I
- callus formation → II : 5 steps

Union
- Union
- delayed union
- X non union

Clinical features
- History
- GI managment
- Local signs
  - look
  - feel
  - move
- X Rays : rule of 2's
- Special imagings
- Description
  - shape
  - displacement

Secondary injuries

TREATMENT → Later

Cpc → Early
- visceral injury
- Vascular injury → clinical features, treatement
- nerve injury → closed, open, acute compression
- Compartment sd → clinical, trt
- Haemarthrosis
- Infection
- Gas gangrene → clinical, prevention, trt
- F# blisters
- Plaster and pressure sores

Late

CPC
Subt

- Delayed union
  - causes
    - biological
    - biomechanical
    - patient related
  - clinical
  - trt
    - conservative
    - operative
- Non union
  - x Ray
  - causes
  - trt
    - conservative
    - operative
- Malunion
  - Clinical
  - Trt

AVN : Avascular Necrosis

Growth disturbance.

Heterotopic ossification

Tendon lesions

Nerve compression

Muscle contracture

Joint instability

Joint stiffness

Complex Regional Pain Syndrome

Osteoarthritis

Fractures principles

Intro:

F#: break in the structural continuity of bone
- Closed → overlying skin is intact
- Open → overlying skin or body cavity is breached → risk of infection

How F# occurs:

F# caused/
- Injury
- Repetetive stress
- Abn weakening of the bone

- **Injury**: sudden, excessive (overloading) force
  - direct
  - indirect

Direct	Indirect
Bone breaches at the point of impact	Bone breaches at distance from the point of impact
Inevitable soft tissue damage	Not inevitable soft tissue damage at F# site
Direct blow:	Combination of forces with dominant mechanism:
- Transversal splitting	Twisting → spiral
- Butterfly sgt	Compression → short oblique
High energy → comminution, extensive soft tissue damage	Tension → transversal; avulsion
	Bending → butterfly Δ

- **Fatigue or stress fractures**

~~(Normal bone + heavy loading → # remodeling process initiated)~~ (normal)

Normal bone + heavy loading → minute deformations → (+) normal remodeling process

Normal bone + heavy loading → abnormal remodeling: resorption faster than replacement → stress fractures

heavy loading:
- repeated
- prolonged
- ↑↑ from baseline

Athletes
Dancers
Military personnel

Medications: steroids, MTX } chronic inflammatory diseases

- **Pathologic fx:**

Weakened bone + normal stress → Fracture.

Structural change
- osteoporosis
- osteogenesis imperfecta
- paget's disease
- biphosphonate therapy

Lytic change
- bone cyst
- metastasis

How f# occur?

Bone		stress		
Normal	→	Sudden excessive overload	→	injury Trauma
Normal	→	Repeated, Prolonged stress	→	stress f#
Weakened	→	Normal	→	pathologic

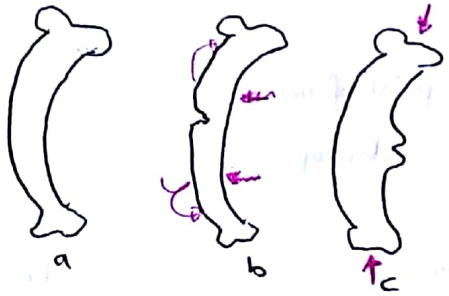
f#

Fractures Types

Complete
Bone splitting
≥ 2 fragments

- Transverse
- Oblique
- Spiral
- Impacted: Jammed frgts
- Comminuted

Incomplete
Bone incompletely devided
Periosteum remains in continuity



a - plastic bowing
b - greenstick
c - Torus
} Children

Compression fx in adults
Cancellous bone.
- vertebral bodies
- calcaneum
- tibial plateau

Classification
Facilitate dialogue
Categorize → Tnt
→ Prognosis
AO/OTA: Alpha numeral

First digit
The bone
1 - Humerus
2 - Radius/ulna
3 - Femur
4 - Tibia/fibula
5 - Spine
6 - pelvis/acetabulum
7 - Hand
8 - Foot
9 - Cranio maxillofacial

Second digit
The segment
1 - Proximal
2 - Diaphyseal
3 - Distal
4 - Malleolar

Letter
F# pattern

diaphysis	metaphysis
A. Simple	A. extra articular
B. wedge	B. Partial articular
C. complex	C. Complete articular

How fractures are displaced?

Complete f# → fragments → displacement by → injury, gravity, muscles attached to them

- Translation = shift
- Angulation = tilt
- Rotation = twist
- Length =

Translation :	Angulation Alignement	Rotation	Length
Frgts shifted : • Sideways • backwards / forward Sufficient Contact → remained / obtained / reduction → union	Frgts tilted / angulated in relation to each other Malalignement → deformity	One frgt twists around its longitudinal axis rRay → aligned bone PE → rotational deformity of the limb	Fragments : - distracted and separated or - overlap

Fracture healing

Fracture healing

New bone formation → fusion of the bone fragments

Primary : direct	secondary : indirect
no callus formation	with callus formation
Absolute stability and compression	Relative stability

Mechanical strain across the fracture gap directs the healing response.

- Absolute stability → Primary healing
- Relative stability → Secondary healing
- Instability → delayed union or non union

Mvts at the Fx site → + callus formation

Stabilize the frgts as soon as possible

↳ Primary bone healing

Absolute stability (= impacted fs in cancellous bone - F# held by metal plate) → no stimulus to callus

Direct formation of osteoblastic new bone

Clinical features

History
General management
Local signs
- look
- feel
- move

X-Rays
Special imagings
Description

History

Injury → inability to use the limb
Patient age
Injury : - mechanism
- reception site (F° can be at the impact point or at distance)
- Trivial trauma → ? pathological lesion

Pain (and other signs of inflammation don't distinguish between bone/soft tissue injuries)
Symptoms of associated injuries : don't be distracted!
- pain somewhere else, swelling
- numbness, loss of movement
- blood in urine
- abdominal pain
- transient loss of consciousness

Previous injuries
Medical history

> Pain, swelling, bruising → can't distinguish bone/soft tissue injury
> Deformity → more suggestive of a fracture.

General management:

General effects of trauma → chap 22
ABC : Airway obstruction
Breathing problems
Circulatory instability
Cervical spine injury / immobilisation

Local signs :

Gentle systematic approach :
1. Examine most obviously damaged part
2. Test for artery and nerve damage
3. Associated injuries - in the region
- at more distant parts

Look	Feel	Move
Swelling, Bruising, Deformity Skin integrity → open ? Distal extremity posture → nerve Skin color → vessel	Localized tenderness Associated injuries in other part Spine pelvis Vascular Peripheral nerve } abnormalities before after TNT	Ability to move joint distal to the ∫ injury.

X-Rays: Rule of 2's

2 views : AP + Lat
2 joints
2 limbs : to compare, in children
2 injuries : ex. femoral f# → xRay pelvis / spine
2 occasions : Some f# are difficult to detect soon after injury but another xRay 1-2 weeks later may show the lesion.
ex : stress f#
Scaphoid
femoral neck
Lateral malleolus

Special imagings

CT : 3D bones -spine, acetabulum, calcaneam
joint complex F#

MRI : Fractured vertebra is it ~~com~~ threatening to compress the spinal cord

Radio isotope scanning : stress f#
undisplaced f#

U/S : in children (fracture line or hematoma)

Secondary injuries

With certain f# → susceptible secondary injuries are assumed to be present until proved otherwise.

Thoracic injuries : rib / sternum f# → lung / heart injury → Cardiorespiratory fct
Spine F# → spinal cord injury → Neurological exam
Pelvic / abdominal injuries → visceral injury → Urinary fct : blood in urine ...
Pectoral girdle injuries : → brachial plexus } injury at the base of the neck.
large vessels }

Fractures complications

F# complications

General
- blood loss
- shock
- fat embolism
- cardioresp failure

Local

Early

urgent
- Visceral / Vascular / Nerve injury
- Compartment sd
- Haemarthrosis
- Infection
- Gas gangrene

Less urgent
- F# blisters
- Plaster and P. sores
- Heterotrophic ossificat°
- Lig. injury
- Tendon lesions
- Nerve compression
- Joint stiffness
- Algodystrophy

Late
- Delayed union
- Non union
- Mal union
- AVN
- Growth disturbances
- Bed sores
- Muscle contracture
- Joint instability
- O.A

Early complications :

Visceral injury :

Rib F# → PNO

Pelvic F# → Rupture of → bladder / urethra

Vascular injury

The artery may be → Cut / Torn / Compressed / Contused

either by → initial injury / swelling / bone fragment / reduction manoeuvres / surgery

normal from outward but → intima detached → vessel blocked / Thrombus
→ arterial spasm

initial injury / swelling / bone fgt / reduction / surgery → Major artery → Cut / Compressed / Contused / Torn / Thrombosed / Spasm

→ Transient ↓ blood flow

→ Profound ischaemia → tissue death → peripheral gangrene

Clinical features :

Toes, fingers → paresthesia, numbness

Limbs → pale, slightly cyanosed / cold

Pulse ~~abs~~ weak or absent

X-Ray
- high risk
- f# pattern

What to do ?

Immediate angiogram or duplex.

If ⊕ → emergency treatment

Common vascular ~~nerve~~ injuries

- 1st rib f# → subclavian
- Shoulder dislocation → axillary
- Humeral supracondyle f# → brachial
- Elbow dislocation → brachial
- Pelvic f# → internal iliac
- Femoral supracondylar fx → femoral
- Knee dislocation → popliteal
- Proximal tibial → popliteal or its branches

TnT

- Remove all bandages and splints
- Re x Ray → if the position of bones is suggestive of vascular injury → reduction ? ? ?
- 30 min later → vascular re assessement
- if no improvement → OR with pre- or per- op angiography.

Cut vessel	sutures
sgt	replaced by vein graft
Thrombosed	endarterectomy

- Stable fixation of the fracture : internal fixation.

Nerve injury

Repeated nerve examination, initially and after reduction

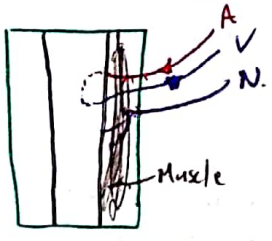
Nerve injuries

Closed
- Spontaneous recovery within 4 months
- EMG at 6 weeks?

Open
- More likely: Complete
- Explore while debridment
- Repair " " or wound closure.

Acute compression
- Fx / dislocation at the wrist
- -numbness, paresthesia
- -medial/ulnar n. distribution
- ↓
- Close monitoring
- 48h → no improvement
- ↓
- explore + decompress

Compartment syndrome



Arm / Leg f#
- Bleeding
- Oedema
- Inflammation (infection)

→ ↑ P in the osteofascial compartment
↓
↓ capillary flow
↓
Ischemia (muscle and nerve)
↓ 6 hours
Necrosis (muscle)

Isthemia
- muscle → necrosis → replaced by fibrosis
- nerve (ending) → regeneration

Compartment syndrome

Osseofascial compartment → arm / leg

Major vessel intact

Bleeding, Oedema, Inflammation (infection) → ↑ P_{comp} → ↓ capillary flow → ischemia —6h→ Necrosis

Clinical features

High risk injuries

Elbow, forearm

Proximal 1/3 of tibia's

Multiple fx of hand and foot

Crush injuries

Circumferential burns

Classic features : 5 P's

PAIN

Pallor

Pulslessness

Paresthesia

Paralysis

Earliest s. : severe pain of or bursting sensation

Ischemia at capillary level : Puls still be felt

Skin not pale

Paresis ++ → weakness in active muscle contraction

Stretch the muscles: hyperextension of fingers / Toes (passively)

→ pain in → forearm / calf

Confirmation

Measure of intracompartmental pressure

$\Delta P = P_{diastolic} - P_{comp.}$ < 30 mmHg → immediate compartment decompression

high risk injuries, unconscious patient → Continuous P monitoring

Treatment

Complete removal of casts bandages and dressings

Limb nursed flat (elevation → ↓ $P_{capillary}$)

ΔP < 30 mmHg → immediate fasciotomy

Clinical Dg Fasciotomy determined even if no P measures are available or don't reach <30

Sft signs

Reexamin at 30 min []

Within 2h ——→ no improvement → fasciotomy

Leg fasciotomy : opening all 4 compartments through medial and lateral incisions

wounds left open —2 days→ re examined : muscle

healthy → Suture (without tension)

necrosis → debridement

Haemarthrosis

F# involving joints → acute haemarthrosis

Joint swollen
tense
tender

Aspirate the blood before dealing with the f#

Infection

Open f# +++

Post-traumatic wound infection → chronic osteitis.

Gas gangrene:

Dirty wound with dead muscle closed without appropriate debridment

Clostridial infection: Clostridium welchii +++
anaerobic: ✗ only in low oxygen tissues

Toxins → ~~soft~~ tissue necrosis → promoting spread of the disease

Clinical features: within 24 h from the initial injury

Pain
Swelling } → around the wound area
discharge: brownish
smell: cadaverous
gas formation: not very marked
pulse ↑
Toxaemia → coma → death

Differential: Anaerobic cellulitis

Gas gangrene	Anaerobic cellulitis
myonecrosis	superficial
low gas formation	abundant gas formation
toxaemia +++	slight toxaemia
Amputation	Unnecessary amputation

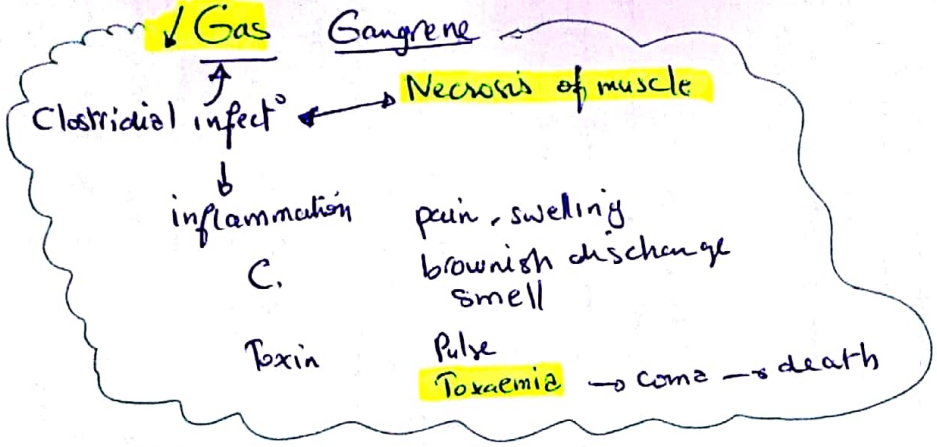
Prevention

Deep wounds penetrating in muscular tissue → explored
Dead tissue → excised
Repetitive debridment

Explore (Excise)$_2$ Debridment repeated

Early Dg

Tt: fluid ATB Hyperbaric oxygen
Wound decompression
Dead tissue removal
Amputation may be necessary



Anaerobic cellulitis : ↑ Gas formation
↓ Toxaemia
no myonecrosis (superficial)

Fracture blisters

2 types — fluid filled
Blood stained

Limb swelling → elevation of epidermis from dermis → blister formation

Puncturing → no advantage.
Surgical incision → may be unsafe, should be ~~←~~ delayed when swelling ↓

Plaster and Pressure sores

Plaster sores : localised° area where skin presses directly onto bone.

Prevention — padding the bony points
moulding the wet plaster → P distributed to the soft tissue around the bony points.

Plastered patient
- localised burning pain
→ immediate window cut in the plaster
↳ otherwise pain ↓ → skin necrosis unnoticed.

Delayed union
Non union
Malunion
} → Table on the next page

Delayed union ⟹ Non union [→ aseptic / → septic] — Malunion

Delayed union

Time before union occurs is prolonged

Causes:

Biological
- Blood supply inadequate
- Periosteal stripping
- Soft tissue severe damage

Biomechanical
- Imperfect splintage
- or Rigid fixation

↖ Infection ↗

Patient Related

Clinical
- Persistent tenderness / swelling
- Acute pain on bone stress
  - rest
  - partial weight bearing } → painful

x-Ray:
- F# line visible
- Callus formation / periosteal rx: little / incomplete
- Bone ends [neither sclerosed nor atrophic]

Conservative
- →eliminate any possible cause
- →promote healing:
  - → sufficient immobilizat°
  - → f# loading: 1) muscular exercise 2) partial weight bearing in the cast or brace

Operative: delayed > 6 months → internal fixation

Non union

F# will never heal without intervention

Causes CASS ask 4 questions
1. Contact → sufficient contact between fgt?
2. Alignment → adequate shearing reduction?
3. Stability → ?
4. Stimulation → ?

What about Biochem? [poor s. tissue, local infection, drug abuse AIV / cytotoxic, non compliance]

x-Ray
- F# visible

Hypertrophy ← Callus → atrophy
(failing to bridge the gap)

Hypertrophy	atrophy
bone ends enlarged	bone ends tapered rounded
osteogenesis ↗ active	osteogenesis ↘ ceased
Biomechanical	Biological

Conservative:
- Hypertrophic: functional bracing, prolonged splintage.
- Magnetic field pulsed
- Ultra sound pulsed, ↘ frequency

Operative

Hypertrophic	Atrophic
Rigid fixation alone	Excision of sclerotic bone ends fibrous tissu in the gap, Bone grafting

Malunion

Frgrs join in unsatisfactory position.

Unacceptable: - angulation, - rotation, - shortening

Causes
- Adequate reduction failure
- Failure to hold the reduction
- Gradual collapse of comminuted or osteoporotic bone

Clinical
- *Limb deformity (compare with the other limb otherwise deformity can be missed)
- Rotational deformity of metacarpal f# → ask him to flatten the fingers onto the palm.

x-Ray follow up ×R: 2-3 first weeks +++

When: before the f# has fully united

What to do: → re manipulation → correction

- Angulation → > 10-15° long bone } → remanipulate → correct
- Rotation → noticible
- Plane [→ of nearby joint motion → better tolerated; → The joint doesn't move in it]
- Shortening → > 2 cm lower limb → equalizing procedure

Cosmetic patient expectations!

	Union	delayed	Non	Mal
F# line	obliterated	visible	Visible	Unsatisfactory
Callus	bridging	partial	hypertrophic or atrophic	Position angulation rotation. shortening
Bone ends	crossed/Trabeculi	not ○ sclerosed ○ atrophic	enlarged or tapered	

Union ≠ Repair

Incomplete repair — complete repair

Calcified callus

How long does it take for a f# to unite? → no precise answer

it depends on
- age
- constitution
- blood supply
- f# type ...

Delayed union → f# healing is not taking place at the expected rate and time

Non union
- Septic → infected osteosynthesis
- Aseptic
  - stiff
  - mobile → impression of a false joint → pseudarthrosis

Avascular necrosis

Early cpc but with late clinical and Radiological presentation

Clinical

No Sx

If f# fails to unite / bone collapse → Pain

Radiology

↑ density
- surrounding disuse osteoporosis → gives the impression of surrounded ↑ density necrotic bone
- new bone formation where normal bone meets the necrotic
- collapse of the trabeculi

Notorius AVN sites

- Head of the femur → femoral neck f#, hip dislocation
- Proximal part of scaphoid → F# on its waist
- Lunate → dislocation
- Body of the talus → neck f#

Trt

when? → when joint fct is threatened

Site

Femoral head (Trt)
- old → arthroplasty
- young → realignment osteotomy or arthrodesis

Scaphoid / Talus → symptomatic trt, arthrodesis of the wrist / ankle may be needed

Bed sores:

Elderly / Paralized

Skin over sacrum
heels

Prevention

Careful nursing
early activity

Trt: difficult

Necrotic tissue excision
skin graft application
Vacuum assisted closure.

General fractures

Crash

Presentations | Types | Alignements

How to classify a f#:

- location: bone + side + part of the bone
- presentation: closed / open
- type
  - non complex → Transverse · Oblique · Spiral · Avulsion
  - complex → multiple lines: Comminuted, Segmental
  - greenstick → in children!
- alignement: complete f# → union / non union / mal union

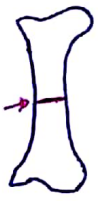
F# classification

Location	Presentation	Type		Alignement
Bone	Closed	non complex	Complex	Union
Part of the bone	Open	1 line	x lines	Non union
Side.		Transverse	Comminuted	Mal union
		Oblique	Segmental	
		Spiral		
		Avulsion		

Fracture types

Non complex

① Transverse f#:



≈ 90° to the long axis
Sharp direct blow
stress f#:
Small transverse f#
newly exercising
"Hair line"
↔ healing

② Oblique

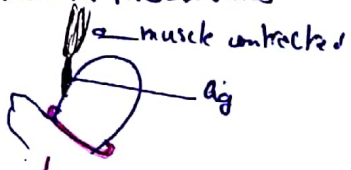
- diagonally oriented
- sharp angulated blow

③ Spiral

30° oblique sc
Twisting force
High specificity for child abuse

④ Avulsed

Portion of bone fractures off the main bone
Athletes near ligaments
Common in tuberosities

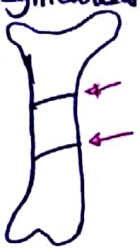


Avulsed: Contracted m. → stressed lig → lig attachment near tuberosity
direct blow on stressed lig → the portion fractures off

Stress f#: Newly exercising and bone can't handle it. x Ray won't show anything that we can see!
Order x Ray a week after symptoms → we see the healing (ossification lines (Hair lines)

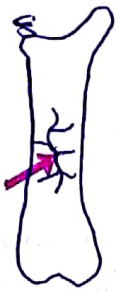
Complex

① Segmented



Multiple
Similar f#
Not meeting on a single point

② Comminuted f#

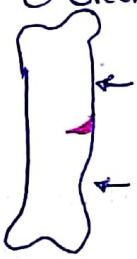


Shattering of bone resulting from severe direct force
Often ouginal from one spot

③ Torus (buckle) f#

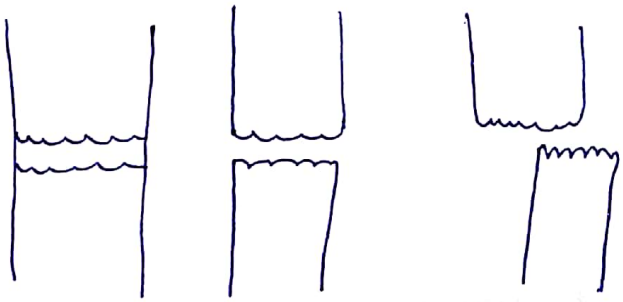
Compression of bone resulting in bulging / bowing
bulging

④ Greenstick



Bending force on bone.
↑ in Peds because bones are softer

F# Alignement



Union Non union Malunion

Union → healing proces
No union ← no " "
Malunion → fracture's parts are out of alignement → after it heals → abnormally shaped bone