BASICS: HISTOLOGY AND PHYSIOLOGY OF BONES

Basics

- Bone / Osteon
  - Organic /matrix /Osteoid (30-35%)
  - Water
    → more in Children
  - Inorganic / mineral (60-65%)
  - matrix /protein /Osteoid (95%)
  - Cells(5%)
    - • Collagen Type I
    - • Osteocalcin /GCA Protein
    - • Osteonectin

Histology of bone

Functions:

- Osteoblasts
  - Build the Bone
  - Osteoid matrix
    ↓ mineral
    → Osteon
  - Alkaline Phosphatase enzyme rich
  - Bone formation markers:
    - ALP ↑
    - Osteocalcin
    - Osteonectin
    - Pro Collagen I

- Osteocytes
  - Resting Or Spent Osteoblasts
  - most abundant
  - Longest Life Span

- Osteoclasts
  - Resorb or Remodel
  - Least in number
  - monocytes aggregates & forms giant cells
  - Enzyme - Tartarate Resistance Acid Phosphatase (TRAP)
  - Carbonic anhydrase
  - Hoxship's Lacuna helps in bone resorption
Bone Resorption markers
- Hydroxy Proline
- Hydroxy Lysine
- N/C Telopeptide
- TRAP

Parts of bone

Osteoprogenitor Osteoblasts: Found under periosteum and endosteum
- Help The Bone in Growth: Appositional Growth of The Bone
- Growth in Length Of Bone: Interstitial Growth
- Periosteum is absent in articular Surface, Sesamoid Bone

Nutrition of bone

Sources:
- Periosteum
- Endosteum
Types of bone

- Immature Bone
  - Woven Bones
  - Weak
  - Callus

- Mature Bone
  - Lamellar Bone
  - Compact / Cortical (diaphysis)
  - Spongy / Cancellous (epiphysis & metaphysis)

Growth Plate:

- Epiphysis
- Metaphysis

Layer of Growth Plate From Epiphysis to Metaphysis:
- Germinal / Resting: most Important Layer (injury- arrest growth)
- Proliferative
- Hypertrophic Layer → Weakest Layer
- Calcification
- Ossification

Physiology of bone

Calcium Homoeostasis:
- Calcitonin → Normalises Calcium if High
- Parathyroid Hormone → Bring Serum Calcium Back to Normal when its low
Para Thyroid Hormone:
\[ \downarrow \text{Calcium} \Rightarrow \text{Parathyroid hormone} \uparrow \uparrow \]
(Secondary)

- Activates 1α Hydroxylase in Kidney
  - Activate Vitamin D₃
  - GIT Tract
  - Reabsorption of Calcium
    - Normal Calcium
      - Suppress PTH

→ Bone Break Down
  - Immediate Bone Formation
    - Osteoblastic Activity ↑
      - ALP ↑

→ PTH does not directly act on Osteoclasts
→ PTH acts on Osteoblasts → Activates Osteoclasts → Resorb the bone
→ Activates with the help of RANK
  - Denosumab inhibit RANK Ligand:
→ In primary hyperparathyroidism (adenoma):
  - hypercalcemia, destruction of bone
**BASICS: FRACTURE AND HEALING**

- **Fracture:**
  - A break or breach in the continuity of cortex
  - Clinically: pathognomonic sign - Abnormal mobility, crepitus
    - most consistent sign - Tenderness

**Types of fractures**

- **Fractures**
  - Trauma → Open #
  - Closed #
  - Insignificant trauma
    - Pathological # (Abnormal bone)
    - Stress # (normal bone)

- **Direct Trauma**
  - Transverse #

- **Indirect Trauma**
  - Oblique #

- **Comminuted #**

- **Spiral #**

- **Butterfly #**
- **Avulsion #**
  - eg: patella #
  - olecranon #
Pathological fractures

Causes

Localized
- infection
- ischaemia
- Radiation
- Cyst
- lesion
- tumor

Generalized
- Rickets
- Osteomalacia
- Paget's
- Osteoporosis (most common)
- Osteopetrosis
- Scurvy
- Osteogenesis imperfecta
- metastasis

Clinical features
- Pain in the bone prior to #
- most common pathological fracture (due to osteoporosis):
  vertebral fracture  \( \rightarrow \) kyphosis

Management:
- X ray and apply Mirel's criteria

<table>
<thead>
<tr>
<th>Mirel's criteria</th>
<th>score &gt; 8 suggests prophylactic fixation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Score</strong></td>
<td>1</td>
</tr>
<tr>
<td>Site</td>
<td>upper limb</td>
</tr>
<tr>
<td>Pain</td>
<td>mild</td>
</tr>
<tr>
<td>Lesion</td>
<td>blastic</td>
</tr>
<tr>
<td>Size</td>
<td>&lt; 1/3</td>
</tr>
</tbody>
</table>

if score > 8, prophylactic internal fixation
- Treat underlying cause

Active Score
Stress fractures

- Fracture seen in normal bone due to repeated abnormal loading of bone.
- Commonly seen in: dancers, athletes, military recruits
- Site: commonly seen in lower limb (foot)
  - Most common ➔ # metatarsal, 2nd ➔ 3rd
    - Neck ➔ shaft
  - March fracture ➔ # 2nd metatarsal neck

- History of sudden increase in intensity/frequency of activity.
- Point tenderness at fracture site.
- Investigation of choice for stress #: MRI
  - Multiple stress #: Bone scan
- Shin splits ➔ Stress # Tibia ➔ seen in marathon runners
  - Pain in anteromedial aspect of leg
- Treatment: Rest + Immobilization.

Open fractures

- Fractures that communicate with external environment
  - Hematoma communicates with the outside
  - Introduction of bacterial infections
    - Most common: Staphylococcus aureus
  - Delayed fracture healing
Classification of open fractures

- Gustilo - Anderson classification

Type I: Wound < 1 cm long
- Treated as closed

Type II: Wound 1 to 10 cm long but without significant soft tissue stripping, gross contamination, or high-energy fracture patterns
- Treated as open or closed based on clinical scenario
  - IIIa
  - IIIb
  - IIIc

Type III: Wound > 10 cm long or lesser skin lesions with gross contamination and or high-energy fracture patterns
- Bone coverage adequate

Management of open fractures

- It is an emergency
- Antibiotic coverage
- Wound management:
  - Debridement: with sterile NS, povidone iodine or H₂O₂
  - If wound is clean and vascular after debridement:
    - Wound can be closed → primary closure
  - If wound is contaminated,
    - >6 hrs (6 hrs - golden period of wound)
    - or associated nerve injury +
      - → Serial debrideements
      - Delayed primary closure (48 - 72 hrs)
      - Heals by tertiary intention
Basics: Fracture and Healing

- Fracture management
  - External fixators:
    - Rail fixator / LRS (Limb Reconstruction System)
    - Ilizarov ring fixator
      - Principle: distraction osteogenesis
      - Physiological limit for distraction: 1 mm/day

- Amputation
  - Cutting of the limb through the bone
  - Cutting of the limb through the joint - disarticulation
  - mSS: mangled Extremity Severity Score
  - Limit salvage index
  - Ganga score
  - mSS depends on following parameters
    - velocity of injury
    - Ischemia of limbs
    - Shock
    - Age
    - mSS > 7 → Amputate

- To assess if the limb is salvageable
Healing of fractures

Fracture healing

Primary
- Direct
- no callus
- Absolute stability

Secondary
- Indirect
- Callus is formed
- Relative stability

micro movements

► bridging

callus

• Stage of fracture healing

Hematoma → collection of blood within # site

Inflammation / Granulation

Callus → earliest sign on x-ray at 3 weeks

Consolidation → disorganized bone formation

Remodelling
Factors affecting fracture healing

- Patient factors
  - Age
  - Nutritional status
  - Smoking, alcohol
  - Steroid use
  - Systemic disease

- Type of fracture
  - Open
  - Contamination
  - Soft tissue interposition
  - Inadequate soft tissue coverage

- Tissue
  - Hypoxia
  - Ischemia

- Treatment
  - Inadequate reduction
  - Improper immobilization (most common cause of non-union)

Non-union

- Arrest in healing process of fracture > 9 months

Types
- Hypertrrophic
- Oligotrophic
- Atrophic
- Pseudarthrosis

Hypertrophic non-union
Biology - Normal
mechanics - abnormal
Rx: stabilization / immobilization

Atrophic non-union
Biology - Abnormal
Rx: Bone graft (from iliac crest) stabilization / immobilization
Pseudarthrosis (False joint)
- Too much movement at non-union site
  ↓
  Central portion of callus undergoes
  Cystic degeneration
  ↓
  appearance of a bony ends with fluid in between them
  ↓
  False joint / Pseudarthrosis

- Cause of pseudarthrosis
  - Idiopathic, neglected non-unions
  - Neurofibromatosis
  - Congenital pseudarthrosis (commonly Tibia)

- Rx: corrective surgery

Malunion

- Fracture unites in anatomically abnormal position
- Rx: osteotomy
  Indications: functional deformity
  cosmetical reasons
  eg: cubitus varus deformity: modified French osteotomy
POLYTRAUMA MANAGEMENT AND AMPUTATIONS

Advanced Trauma Life Support (ATLS)

• A B C D E

Primary Survey

A → Airway following cervical Spine Stabilisation
B → Breathing (treat conditions like pneumothorax)
C → Circulation
- Bleeding: apply pressure
- Central line (IV)
- Peripheral lines
- 2x18G used
D → Disability
- Glasgow coma scale
  • mild → 13-15
  • moderate → 9-12
  • Severe → < 8
E → Exposure
  • Logroll method → minimum 4 people required

Damage control orthopaedics

• Limited surgical intervention
  To control hemorrhage and contamination caused by fracture
• Early temporary fixation of fracture
  Stabilize the patient
  Definitive care

Crush syndrome

• Due to crushing injuries
  Eg: Heavy object falls on the patient
  motor vehicle accident
  Earthquake
  Industrial accident
Pathophysiology:

- Ischemia → tissue death
  - Cell wall disrupted
  - Contents of cell escapes out
    - K^+ 
    - Myoglobin
  - Limb is freed from pressure
  - Reperfusion
    - Returns to normal tissue
      - Oxygen free radicals
      - Further aggravation of injury
      - Carries toxic substances
        - K^+
        - Myoglobin
        - Lactic acid
      - Further release of K^+ and myoglobin
  - Systemic circulation
    - Hyperkalemia
    - Myoglobinemia
    - Lactic acidosis
  - Hypocalcemia

Myoglobin → damage tubules

Acute tubular necrosis → Renal Failure → crush syndrome

Electrolyte imbalance:
- Hyperkalemia
- Hypocalcemia
- Myoglobinemia
- Myoglobinuria
- Acidosis
management
• Maintaining good urine output by good hydration.
• Forced alkaline diuresis
• Renal dialysis

Amputation

Requirement scores:
• mESS (mangled Extremity Severity Score)
• Limb Salvage index (score > 7 → amputation)
• Ganga score

Indications:
• Trauma leading to ischemia of limb
• Peripheral vascular disease, Buerger’s disease (thromboangiitis obliterans)
• Infection of the limb → gangrene → Gas gangrene, Diabetic gangrene
• Congenital abnormal limb
• Tumor

Methodology

↓ single stage  Two stage (in case of infections)

→ Tourniquet  → Reduce bleeding
   Contraindication: Ischaemia.
→ all the structures are cut
→ bone should be cut 5 cm shorter.
→ suture the muscle to the bone → myodesis
   Contraindication: Ischaemic amputation
   ↓ myoplasty
   (suture muscle to muscle)

Amputation Neuroma pain:
   Neuroma formed from cut nerve endings after amputation, if
   stuck to scar tissue → Pain
   Complication of improper amputations
Treatment: traction to the nerve → ligate the nerve → cut the nerve with fresh sharp blade (retracts back to the soft tissue)

Step 1: change the prosthesis
Step 2: Transcutaneous electrical nerve stimulation / interferential therapy
Best method: Surgical excision / Revision
Suture line: anterior to mid coronal plane (posterior flap longer than anterior)

Advantage: prosthesis does not compress the suture line.

Complication of amputation

- Infections
- Amputation neuroma
- Phantom Limb / pain
  Treatment: massages, ice packs, heat therapy, sympathetic blockades, mirror therapy.

Amputation in children
- Disarticulation is preferred over amputation as it will allow growth
- Multiple revisions of stumps
- Adapts well to prosthesis

Named amputations

Hind foot amputations:
- Syme's
- Sarmiento's
- Boyd's
- Pirogoffs

Mid foot amputations:
- Lisfranc → tarsometatarsal region
- Chopart → inter-tarsal / mid tarsal

Krukenberg's amputations:
- Performed in below elbow amputations.
- Radius & ulna used as pincers
Warning: Not all points are covered in the notes, especially conceptual explanations. Please use the notes in conjunction with marrow Edition 4 videos.

Prosthesis:

Below Knee prosthesis:

- SACH Foot
  - Solid ankle cushioned heel
  - Restricts mobility
  - No dorsiflexion
  - No inversion & eversion
  - Not aligned for walking barefoot
  - Costly

- Jaipur Foot
  - Invented by Dr. AK Sethi in Jaipur
  - Movement at ankle allowed
  - Dorsiflexion present
  - Permits inversion & eversion
  - Walk without footwear
  - Cheaper

SAFE Foot: Stationary Attachment Flexible Endoskeleton
- Similar to Jaipur Foot
BONE INFECTION: PYOGENIC

- *Staphylococcus aureus* most common organism.
- **Route**: Hematogenous
- Infection in the medullary cavity: osteomyelitis
- Infections in the joints: osteoarthritis
- Pyogenic organism: *staphylococcus aureus*
- Tubercular organism: *mycobacterium tuberculosis*

**Osteomyelitis**

Pathogenesis:

- **Route** - Hematogenous
- Femur is more affected than tibia (Distal femur more than tibia)
- Metaphysis - most common site in children
  - In metaphysis blood vessels are in hairpin loop fashion
    - Sluggish flow
    - Relative ischaemia, hypoxia
    - Venous stasis
    - Organisms thrive
  - The area is more vascular
  - Deficient in macrophages
- Most common site in adult: vertebrae

Most common cause of osteomyelitis:
- Overall
- Acute
- Chronic
- Developed countries
- HIV
- AIDS
- Immunocompromised
- Open fracture
- After surgery

Staphylococcus aureus
Exceptions:
- Sickle cell disease → Salmonella → in diaphysis
- Prolonged parenteral therapy → fungal infections
- I.V. Drug Abusers → Pseudomonas
- Animal bites → Pasteurella
- Human bites → Eikenella

Pathophysiology:

- **<24 hour**

  Abscess

- **>24 hour**

  **periosteal reaction (7-10 days)**

  Sequestrum (dead bone)

  Involucrum

  Cloaca

  Sinus

  Periosteal reaction: Periosteum reacting to an insult (infection, tumor)
  → 7-10 days

  Involucrum: to prevent the spread of lesion

  Cloaca: formed when abscess perforates involucrum

  Sinus: formed when abscess perforates skin

Acute osteomyelitis
- Pathological hallmark: Abscess
- Clinically: fever, pain

Chronic osteomyelitis
- Pathological hallmark: Sequestrum
- Clinically: active discharging sinus

Sequestrum → On X-ray → Calcification within a lucent lesion
Acute osteomyelitis → less than 2 weeks
Sub acute osteomyelitis → 2 - 4 weeks
Chronic osteomyelitis → > 4 weeks

Clinical features of osteomyelitis

• Child: Toxic → high grade fever, ↓ appetite, failure to thrive, pain and tenderness around the knee joint.

Pseudoparalysis

Management:
• Collect blood sample - CBC, ESR, CRP↑, TLC, Neutrophils↑
• Culture and sensitivity sent - only in 50% cases culture will be +ve
• Broad spectrum antibiotics
• Serum procalcitonin - most sensitive and specific marker for acute osteomyelitis
• Analgesic
• Antipyretic
• Rest
• Splint
• Ice packs and elevation

Radiology:

<table>
<thead>
<tr>
<th>MRI</th>
<th>Bone scan</th>
<th>X-ray</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 24 hours</td>
<td>Tc 99 MDP</td>
<td>within 48 hours</td>
</tr>
<tr>
<td>Marrow edema</td>
<td>Gallium 67</td>
<td>- Soft tissue swelling</td>
</tr>
<tr>
<td></td>
<td>Indium 111 labelled with WBC - Best bone scan</td>
<td>- Soft tissue lucency</td>
</tr>
<tr>
<td></td>
<td>bone scan</td>
<td>- Periosteal reaction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - 10 days → 3 weeks</td>
</tr>
</tbody>
</table>

Gold standard investigation: Tissue Biopsy

Treatment:
• Less than 24 hours → Antibiotics ↓
  
a weeks - followed by - 4 weeks
  i.v.
  CRP → 6 hours → 2 days → 1 week
  oral antibiotics
• After 24 hours → Drainage under antibiotic coverage
Complications of acute osteomyelitis
- Chronic osteomyelitis → most common
- Septicemia
- Altered growth
- Septic arthritis

Chronic Osteomyelitis

Types of Sequestrum
- Tubular - Pyogenic osteomyelitis
- Annular - Amputation stump
- Feathery / coarse sandy - TB
- Fine sandy - Viral
- Bombay - H₂S inhalation
- Black / coke - Fungal, actinomycosis
- Ivory - Syphilis

Radiology
- X-Ray

MRI:

Penumbra sign

management:
- Collect blood sample
- Broad spectrum Antibiotics
- Sinogram
- Gold standard investigation: Tissue biopsy.
Treatment:
- Antibiotics cover
- Sinus tract excision
- Sequestrectomy
- Debridement
- Curettage - till fresh bleed (paprika sign)
- Saucerization
- Close the dead space with bone graft or cement
- Cover with skin or muscle → myoplasty
- VAC / NPWT (-75 to -120mm) → negative pressure wound therapy
  Contraindicated in → Eschar or Tumor

Complications:
- Pathological fracture
- Acute exacerbation of osteomyelitis
- Amyloidosis
- Squamous cell carcinoma

Brodies abscess

- Sub acute osteomyelitis
- Tibia → Proximal part → metaphyseal - diaphyseal junction
- Central lucency → Pus present
- Dense sclerotic rim

Treatment: curettage and antibiotics

Garres sclerosing osteomyelitis
• Chronic osteomyelitis
• Mandible
• Excessive bone formation
• Treatment: Antibiotics

**Septic arthritis**

- Infection of the joint.
- Most common in children.
- Most common site is Knee, infants → Hip
- Route: hematogenous
- Causative organism: overall - Staphylococcus aureus
  - In sexually active individuals - Gonococcus
  - I.V. drug abusers - Pseudomonas

**Clinical features**
• Fever
• Toxic child with inflammatory signs
• No joint movement
• Patellar tap sign +
• Position of ease
  - Hip → flexion, abduction, external rotation
  - Knee → flexion

**management:**
• Blood investigations
• X-ray → increased joint space
• MRI
• USG - Arthrocentesis (Aspiration)

**Treatment:**
• Arthrotomy - irrigation
  • Debridement of joint.

**Pathogenesis if treatment delayed:**
- Due to enzyme damage - bony ankylosis
- Enzymes released:
  • Collagenases
  • Elastases
- Destroys articular cartilages within 4–6 hours.
- Bony Ankylosis

![Image of joint structures showing healthy joint, joint inflammation, and bony ankylosis]

- Bony immobile
  - Stable
  - Painless
- Fibrous mobile
  - Unstable
  - Painful

- Septic arthritis (pyogenic)
- TB Spine
- Ankylosing spondylitis
- Rheumatoid arthritis

**Tom Smith arthritis**

- Septic arthritis of hip in infancy
- Capital femoral epiphysis is cartilaginous
- Hypermobile hip
- Telescopy positive

**Transient synovitis**

- Most common cause of limp in a child
- Second common → Septic arthritis
- Third common → Perthe's disease
  - 6–12 years (Septic arthritis < 5)
  - Kocher's criteria.
  - Also known as Observation hip.
Infection of the hand

Paronychia:

- Most common organism → Staphylococcus aureus.
- Treatment → Remove soft tissue and nail.

Felon:

- Whitlow
- Thumb more affected than index finger
- Staphylococcus aureus
- Most common complications → Osteomyelitis of distal phalanx, tenosynovitis of flexor tendon.
- Treatment: vertical incision and antibiotics.

Palmar spaces:

- Tenosynovitis
  → Inflammation of tendon sheath
  → Staphylococcus aureus
  → Fusiform swelling
  → Pain on passive extension
  → Pain on percussion - most specific sign - Kanavel sign
BONE INFECTIONS: TUBERCULOSIS

MC site of TB: Lungs
MC site of TB in skeletal system: Axial system > Appendages
   (Spine)   (Hip > Knee)
   ↓
TB - spondylitis TB - Arthritis

MC spine affected:
   ↓
Thoraco - Lumbar vertebrae → Dorsolumbar → Dorsal → lumbar
   > Dorsolumbar junction

MC spine affected in children: Cervical spine
Rarest involved joint in TB: TMJ
Rarest musculo-skeletal structure involved in TB: Bursa
If Bursa is involved → Trochanteric Bursa.

**TB spondylitis**

- Spina ventosa: TB of the fingers / small bones of hand & feet.
- Caries Sicca: Non exudative TB of shoulder
- Types of TB Spine:

- Paradiscal
- Anterior / wet / Exudative → MC in children
- Central
- Posterior → Rarest [least involved - Facet joint]

**Paradiscal**: MC type because,
   embryologically - lower 1/3 of upper vertebra & upper 1/3 of lower vertebra have common origin along with the intervening disc.
Infections of Bones & Joints

- Sclerotome (has its own blood supply)
  - Disease affects the anterior aspect of the neural element

Clinical features:
- Constitutional symptoms:
  - Low grade fever
  - Night pain
  - Appetite
  - Weight loss

- Local findings:
  - Pain (earliest symptom)
  - Paraspinal muscle spasm/Tenderness
  - Cautious gait
  - Military attitude
  - Cold abscess

- Deformity:
  - Knuckle → 1 bony prominence
  - Gibbus → 2-3 bony prominence
  - Angular Kyphosis → > 3 bony prominence

- MCC of Kyphosis in males in India:: TB
- MCC of Kyphosis: Osteoporosis

- Diagnosis:
  - MRI → IOC
  - CT guided biopsy → gold standard
  - X-ray: Triad
    - Disc space narrowing (earliest x-ray finding)
    - Paravertebral abscess → Birds nest abscess
    - Vertebral Lysis
End sequelae of TB spine:

- TB → Ankylosis
  - Bony
  - Spine
  - Fibrous
  - Hip, Knee

Pott's paraplegia

- Compression of spinal cord because of disease process resulting in neurological symptoms
- MC: Upper thoracic TB
- Cause:
  - Early: due to compression of spinal cord by granulation tissue / onset: abscess, vascular thrombosis, ischemia
  - Late: mechanical Compression (knuckle, gibbus, Angular Kyphosis)

- Earliest neurological sign:
  - Ankle clonus / DTR++
  - Extensor Plantar

- Late manifestation:
  - Flaccid paralysis, Bowel & Bladder involvement

Terminal stage

Prognostic Factor of Pott's Spine

<table>
<thead>
<tr>
<th>Feature</th>
<th>Better Prognosis</th>
<th>Poor prognosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of cord involvement</td>
<td>Partial (eg only sensory or motor)</td>
<td>Complete (grade IV)</td>
</tr>
<tr>
<td>Duration of cord involvement</td>
<td>Shorter</td>
<td>Longer (&gt;12 months)</td>
</tr>
<tr>
<td>Speed of onset</td>
<td>Slow</td>
<td>Rapid</td>
</tr>
<tr>
<td>Type</td>
<td>Early onset</td>
<td>Late onset</td>
</tr>
<tr>
<td>Age</td>
<td>Younger</td>
<td>Older</td>
</tr>
<tr>
<td>General condition</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Vertebral disease</td>
<td>Active</td>
<td>Healed</td>
</tr>
<tr>
<td>Kyphotic deformity</td>
<td>&lt;60°</td>
<td>&gt;60°</td>
</tr>
<tr>
<td>Cord on MRI</td>
<td>Normal</td>
<td>Myelomalacia/ syrinx (Cord changes)</td>
</tr>
<tr>
<td>Intra-operative</td>
<td>Wet lesion</td>
<td>Dry lesion</td>
</tr>
</tbody>
</table>

Treatment:

- Middle path Regime
  - By Dr. S.M Tuli
  - Start with ATT + Brace & Resting → Surgical treatment
    (18-24) (Taylors Brace) (if no improvements in 3-6 weeks of treatment initiation)
  - Symptoms worsen
  - Bowel & Bladder involvement.
- **Surgery**: Decompress spine \& Remove the debris.

  In TB: Anterior or Lateral approach (Left is preferred)

  - Antero-lateral decompression (Best)
  - Remove: Rib, Transverse process, pedicle, vertebral body
  - Costo-Transversectomy (for temporary decompression)

- TB → Disc is involved
- If Disc not involved → Think of other causes like tumor/metastasis

  In case of metastasis
  - Winking owl sign → 1 pedicle is not visible
  - Blind bat sign → 2 pedicles not visible

**TB-arthritis: Hip**

- **Route**: Hematogenous spread
- In Hip → mc site: Acetabulum > Femur
  - mc site involved in Acetabulum: Babcocks Triangle

  Has least amount of macrophages \& monocytes

- **Stages**:
  1. Synovitis: • Capsular distention
     - Pain
     - Hip at position of ease: Flexion, Abduction, External rotation
     - Apparent lengthening
  2. Early Arthritis: • Attitude of limb
     (cartilage-destroyed)
     - Flexion, Adduction, Internal rotation
     - Apparent Shortening (< 1cm)
III - Late Arthritis: Shortening $> 1$ cm $\rightarrow$ True Shortening
$\rightarrow$ Limb attitude: Flexion, Adduction, internal rotation

IV - Wandering Acetabulum - Pestle & Mortar deformity
$\rightarrow$ large cavity of acetabulum but small head of femur

V - Fibrous Ankylosis

- Clinical features:
  - Constitutional Symptoms
  - Painful limb / Antalgic Gait
  - Shortening
  - Deformities

- Radiological finding:
  - X-ray - Earliest sign
    Juxta articular osteopenia
    Osteoporosis

Phemister Triad in TB arthropathy:
  - Juxta articular osteopenia
  - Peripheral osseous erosions
  - Gradual narrowing of joint space

- Treatment:
  - ATT + Rest + Traction in Early stage
  - Late stage of disease $\rightarrow$ Deformity $\odot$

- Gridlestone Excisional Arthroplasty -
  Head & Neck of femur removed & interposed with muscle

- Arthrodesis - surgical fusion of the joint corrective osteotomy done prior to arthrodesis if required

- Arthroplasty - Best done only after disease disappears.
TB Knee

- Clinical features:
  - Constitutional symptoms
    - Generalized weakness
    - Weight loss
    - Evening ↑ temperature
    - Cachexia
    - Low grade fever
  - Localised symptoms

- IOC = MRI
- Gold standard investigation → Biopsy
- Early stage:
  - Synovitis
    - Position of knee: flexion
- Late stage: Triple deformity →
  - Posterior subluxation
  - External Rotation
  - Flexion

Other conditions of triple deformity:
- Rheumatoid arthritis
- Iliotibial band contracture (IBC)
- Polio
- Hemophilia

Test for IBC - Ober's test or abduction contracture
- X-ray: Phemister triad +
AVASCULAR NECROSIS AND OSTEOCHONDRODITIS

Avascular Necrosis (AVN)

- Also known as Osteonecrosis or Aseptic Necrosis
  
  Avascular + Necrosis

  no blood supply → cell death

- Bones with AVN tendency:
  - Head of femur: most common
  - Proximal pole of scaphoid
  - Body of talus
  - Proximal pole of Lunate
  - Distal femoral condyle
  - Head of humerus
  - Capitulum

- On x-ray,

  - X-ray: a necrotic bone or AVN: ↑ density
  - Changes seen at 6-8 weeks
  - IOC for AVN: MRI

![Normal](image1)

![Avascular necrosis](image2)

![AVN: Body of Talus](image3)

![AVN: Proximal pole of scaphoid](image4)
**Snow cap sign**: AVN of Proximal Humerus

AVN of proximal humerus: snow cap sign

- Subchondral lucency / Hawkin's sign: suggestive of increased vascularity / viability

AVN: # neck of talus

Fracture following trauma

\[ \downarrow \]

Blood supply of bone is disturbed

\[ \downarrow \]

Avascular Necrosis

- Examples:
  - Head of femur necrosis following # neck of femur
  - AVN of body of talus following # neck of talus
Blood supply of head of femur

Femoral artery (FA)

Profunda femoris artery (PFA)

medial femoral circumflex artery (MFCA) (predominant)

Lateral femoral circumflex artery (LFCA)

Extracapsular arterial ring (ECAR)

Retinacular vessels

medial Epiphyseal vessels - mEv → Head of Femur

Lateral Epiphyseal vessels - LEV (predominant)

Foveolar artery

- AVN of proximal pole of scaphoid following waist of scaphoid.
Causes of avascular necrosis

- Traumatic causes:
  - # Neck of femur
  - Hip dislocation > 12 hours
- Non-traumatic causes:
  - Idiopathic: Chandler's disease (AVN of head of femur)
  - Infections: Osteomyelitis, septic arthritis
  - Haemoglobinopathy: Sickle cell disease
  - Storage disorder: Gaucher's disease
  - Dysbaric osteonecrosis: caisson disease
  - Coagulation disorders:
    - Familial Thrombophilia, Hypofibrinolysis
    - Hypoproteinemia, Thrombocytopenic purpura
  - Others: Perthe's disease
    - Cortisone administration (and most common)
    - Alcohol abuse
    - SLE (↑ in antiphospholipid antibodies)
    - Pregnancy
    - Anaphylactic shock
    - Ionizing radiation

Warning: Not all points are covered in the notes, especially conceptual explanations. Please use the notes in conjunction with marrow Edition 4 videos.

Clinical features of AVN

- Males > females
- Age - 20 - 40 years
- Unilateral - in traumatic causes
  - Bilateral - non traumatic causes usually
    - if idiopathic: 50% chance to be bilateral
    - if due to steroids: 80% chance to be bilateral
- Clinical features:
  - Walks with a limp - Antalgic gait
  - Painful restriction of movements at hip joint:
    - Internal rotation >> Abduction (first sign)
      Also seen in: Congenital coxa vara
      Perthe's disease
      Slipped capital femoral epiphysis
• **Sectoral sign**: pain in a particular sector of hip movement
  Anterolateral part of head of femur
  (weight bearing part)

  AVN comes in contact with acetabulum while applying pressure

  Pain elicited

• **x ray in head of femur AVN**: increased density
  First x ray sign: crescent sign (3 - 6 months)

  AVN head of femur

• **MRI**: investigation of choice

• **management**
  
  Early: Sphericity of head of femur is maintained.
  Protection from weight bearing
  Traction or rest

  Late:
  - core decompression
    decreasing pressure within head of femur by drilling holes
  
  - muscle pedicle grafts
    insertion of muscle + its blood supply is grafted to head of femur

  - meyer’s surgery
Osteochondritis

- disruption of blood supply to the osteochondral part of bone
  ↓
  ischaemia
  ↓
  compression, fragmentation & separation

- Age: adolescence or growing age
- Cause: trauma,
  physical activity that stresses the bone
  ↓
  decreased vascularity
  ↓
  Osteonecrosis

- Bakshi's surgery
- Vascular fibular graft:

- Total hip replacement is the final option
Crushing (push)
- Freiberg's disease - and metatarsal heads
- Ischene disease - 5th metatarsal base
- Kohler's disease - Navicular
- Keinbock's disease - Lunate
- Panner's disease - Capitulum
- Scheuermann's disease - Ring epiphysis of vertebrae
- Calve's disease - Central bony nucleus of vertebrae

Traction (pull)
- Osgood-Schlatter - Tibial tuberosity
- Sever's disease - Calcaneal epiphysis
- Johansson-Larsen syndrome - Inferior pole of patella

X-rays:
- Osgood-Schlatter: Osteochondritis of tibial tuberosity
- Scheuermann's disease: Ring epiphysis of vertebrae
- Sever's disease: Calcaneum
- Kohler's disease: Navicular
• Heinbock's disease: AVN of proximal pole of lunate
  Another cause: negative ulnar variance
  (ulna much shorter than radius)
  ↓
  Load of radius transmitted
directly to lunate
  ↓
  Compression forces on proximal
pole of lunate
  ↓
  Osteochondritis / avascular
necrosis of lunate

- Presentation: (usually manual labourers)
  pain at wrist - 3rd metacarpal
  pain aggravates during dorsiflexion - decreased
grip strength

Osteochondritis dissecans

• Terminal stage of osteonecrosis / osteochondritis
• Softening and separation of the osteochondral fragment
  (due to ischaemia and necrosis)
• Most common site: knee joint
  (lateral part of medial femoral condyle)
  Elbow joint

• Investigation of choice: MRI
• View on x-ray: Tunnel view
• Clinical features:
  pain, restriction of movements
- Wilson's Test:
  - Damaged parts of femoral condyle are brought in between the articular surface of tibia and the knee joint is moved
  - Internal rotation + extension → pain
  - External rotation → pain is relieved

- Management:
  - Early: conservative
  - Later: microfractures - around the broken bone heal with cartilage formation
    - OATS - Osteochondral Autologous Transplantation system

- Loose bodies in knee joint:
  - Most common cause: osteochondritis dessicans
  - Most common cause in elderly: osteophytes in osteoarthritis
  - Most common cause for multiple loose bodies:
    - Synovial chondromatosis
Frozen shoulder
- A/V/ A adhesive capsulitis
- Pain & restriction of all movements of the shoulder (global stiffness)
- External rotation - first to be affected
- Usually self-limiting
- 10% A/L

- Associated conditions - DM
  Hyperlipidemia
  Cardiac disorders
  Hypo & Hyperthyroidism
  Hemiplegia
  Following injury or surgery to shoulder

- Stages
  1. Freezing stage - ↑ pain in night
  2. Frozen stage - ↑ stiffness, ↓ ROM, ↓ pain
  3. Thawing stage - ↓ stiffness, ↑ ROM

- Diagnosis
  - mainly clinical
  - X-ray - Normal
  - MRI - capsulitis

Rx:
- Resolves even if it is not treated
- Physiotherapy
- Pain and anti-inflammatory medications
- Steroid injections
- Manipulation under anesthesia (Adhesiolysis)
- Arthroscopic capsular release
Impingement syndrome

- A/K/A painful arc syndrome
- mid - abduction pain (60° - 120°)

- Causes:
  1. Subacute tendonitis of supraspinatus
  2. Calcification
  3. Sub acromial bursitis
  4. Abnormally shaped acromion

- Neer’s impingement test
  Passive elevation of the internally rotated arm in the sagittal plane (Shoulder forward flexion)

- Hawkins test - with the elbow flexed to 90° the shoulder passively flexed to 90°, and internally rotated

- on injecting anaesthetic agents into subacromian space, pain reduces if ROM ↑

- Rx:
  1. Avoid painful and overhead activities
  2. Physiotherapy - stretching & range of motion exercises
     Strengthening exercises
  3. NSAIDS
  4. Steroid injection into subacromian space
  5. Arthroscopic subacromial decompression
Rotator cuff tear - arthropathy

- In young - due to Trauma
- In elderly - due to Degeneration
- Most tendon to rupture - Supraspinatus

Tests
1. Subscapularis - lift off test
   - belly press test
   - bear hug / Gerber test
2. Supraspinatus - beer can / empty can test
3. Infraspinatus - ER lag test
4. Teres minor - Horn blowers test
- Forgotten tendon of rotator cuff - Subscapularis
- On injecting anaesthetic agent into subacromian space, no effect on ROM

Rx: 1. Avoid painful & overhead activities
   2. Physiotherapy
   3. NSAIDS
   4. Steroid injection
   5. Arthroscopic repair if repairable
   6. If irreparable

Young pt
  Tendon transfer (Latissimus dorsi)

Elderly
  Reverse shoulder Arthroplasty

Tennis elbow and golfer’s elbow

- Wrist extensors originate from lateral epicondyle
- Wrist flexors originate from medial epicondyle

- Inflammation of lateral epicondyle - lateral epicondylitis (tennis elbow)

  Tennis elbow
  - lateral epicondylitis
  - muscle affected - extensor carpi radialis brevis

  Golfers elbow
  - medial epicondylitis
  - muscle affected - flexor carpi radialis

- Inflammation of medial epicondyle - medial epicondylitis
- Test : extension of wrist resistance 
  Cozen's test

- Flexion of the wrist against resistance
  Reverse Cozen's test

Rx :
- Conservative - Rest
  Splint
  NSAIDS
  Physiotherapy
  a. Surgically release the culprit muscle
  b. Platelet rich plasma

De Quervain's disease

- Stenosing tenosynovitis of 1st extensor compartment
- Tendons affected - 1. Extensor pollicis brevis
  2. Abductor pollicis longus
- Females > males

- Test : Finkelstein test
  Grasp the thumb & perform ulnar deviation → pain

- Rx :
  Immobilisation with splints
  NSAID
  Local injection of steroids
  Surgical release of extensor sheath

Dupuytren's contracture

- Abnormal fibrosis of palmar aponeurosis
- Cause : Idiopathic ( m. c )
- M. C affected fingers - Ring finger
- M. C affected joint - MCP
- Fibrosis → cord / nodule formation
- o > Q
Ectopic Dupuytren contracture

1. Plantar fascia - ladder hose disease
2. Penis - Peyronies disease

Rx: 1. Conservation by stretching, inject collagenase
2. Fasciectomy if MCP contracture > 30°
   PIP contracture > 15°

Zones and pulleys of hand

- AI pulley: located over the MCP joint involved in Trigger finger
- Zone II: No man's land of Bunnell

Trigger finger

- Females > males
- MC cause - Trauma
- MC tendon involved - Flexor digitorum profundus
- AI pulley gets stenosed / tendon sheath is swollen
- MC involved finger - Ring finger

Rx: 1] Rest, physiotherapy, splinting
2] Surgical release of AI pulley
Gamekeepers thumb / skier’s thumb

- Hyperabduction of thumb → torn ulnar collateral ligament

Stener lesion

Entrapment of Adductor pollicis muscle between the torn ligament

Rx: 1. Thumb spica cast - for 4-6 weeks
   a. Surgical repair - if complete tear

Ganglion

- m.c.c. of mass / swelling in hand/ wrist
- Unilocular cystic swelling arising from synovium or tendon sheath
- Dorsal side > ventral side

- Rx: 1. Aspirate the contents & injection of sclerosants
   a. Surgical removal

Compound palmar ganglion

- Chronic inflammation of common flexor sheath seen in TB, RA
- Hour glass appearance
Regional condition of knee

Chondro malacia patellae
- Anterior knee pain / patello - femoral syndrome
- Young females
- Idiopathic
- loc : mri
  movie sign
Snapping knee, snapping hip
- Iliopsoas tendon snapping over femoral head
  → Snapping hip
- Semitendinosus and gracilis tendon snapping over medial tibial condyle
  → Snapping knee

Bakers cyst

- aka popliteal / morrant baker cyst
- Pressure, pulsion diverticulum

- Swelling becomes prominent on knee extension
- causes :
  1. Osteoarthritis
  2. RA
  3. PVNS - pigmented villo nodular synovitis

- Diagnosis : USG
- Rx : Excision
Bursitis - inflammation of bursa
1. Prepatellar bursitis - House maid's knee
2. Infrapatellar bursitis - clergyman's knee
3. pes anserinus bursitis
4. Ischial bursitis - weaver's bottom
5. Student Elbow - olecranon bursitis
6. Trochanteric bursitis - TB
7. Retrocalcaneal bursitis - Haglund / pump bump deformity

**Hallux valgus**

- lateral deviation of great toe
  - overcrowding of fingers
    - Overriding of and fingers
      - Prominance of 1st MTP head

**CF** = pain > Deformity

**RX**:
1. Conservative - Fillers between fingers
   a. Surgery - [Chevron osteotomy
      Keller osteotomy]
Synovial fluid

Cells in synovium:
A - cells: phagocytic
B - cells: secrete hyaluronic acid (lubrication)

Non-newtonian thixotropic fluid
i.e viscosity of fluid ↓ on applying force

↓ viscosity

- Gout
- Septic arthritis
- TB arthritis
- RA

Viscosity unchanged

- Trauma
- Degenerative joint disorders / Osteoarthritis

Synovial fluid analysis:
Normal: clear, < 200 PMN/μL
Infection:
Pyogenic - > 50000 cell/μL, ~90% PMN
TB - 10000 to 20000 cell/μL
lymphocytes predominate

Articular cartilage

Zones of articular cartilage

Collagen Arrangement of the Articular Cartilage
Zone 1: Superficial tangential zone
  Highest water content
  Highest density of chondrocytes

Zone 2: Middle transitional zone
  Lowest density of chondrocytes

Zone 3: Deep zone
  Most active chondrocytes
  Lowest water content

Zone 4: Calcification of chondrocytes

Changes in cartilage

<table>
<thead>
<tr>
<th>Aging</th>
<th>Osteoarthritis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>↓</td>
</tr>
<tr>
<td>Proteoglycans</td>
<td>↓</td>
</tr>
<tr>
<td>Proteolytic enzymes</td>
<td>↑</td>
</tr>
</tbody>
</table>

Joints involved

Osteoarthritis
- DIP (m.c.)
- PIP
- 1st Carpometacarpal

Rheumatoid arthritis
- MCP (m.c.)
- Wrist
- PIP

Joints spared: wrist MCP

Osteoarthritis

M.C. joint disease
degenerative disease of the cartilage
types

1° Osteoarthritis
- MC
- Idiopathic
types:
  - Localised
  - Knee (MC)
  - Hand
  - Hip, Spine

2° Osteoarthritis
- Causes:
  - Trauma
  - Overweight
  - AVN
  - Developmental anomalies: perthe's
  - SCFE
  - DDH

00:10:06
Deformities in Osteoarthritis

Hand: inflammation around the joints

- **Bouchard's node** - PIP
- **Heberden's node** - DIP

Knee:

- **Genu varus** (Tibia medialised)
  - medial side of knee bears more weight
  - destroyed first

Clinical features

- Pain - during active and passive movements
  - extra-articular disease: pain only during active movement
- ↓ movements: ↓ wasting of muscles
  - m.c muscle involved → quadriceps (vastus medialis)

Radiological features

1. ↓ joint space - earliest finding
   (articular cartilage destruction)

2. Bone density ↑ - sclerosis
   - Subchondral sclerosis
3. Subchondral necrotic cysts
4. **osteoophytes** - regeneration of bone around necrotic cysts
   ↓
   - break off and form loose bodies
   - m.c cause of loose bodies in elderly → osteophytes

**Warning**: Not all points are covered in the notes, especially conceptual explanations. Please use the notes in conjunction with marrow Edition 4 videos.
Treatment of Osteoarthritis

Conservative management
- Physiotherapy
  - Heat
  - Strengthening (vastus medialis strengthening)
- Walking with support
  - Crutches (on normal side)
- Braces
- NSAIDS: Acetaminophen (safest)
- COX inhibitors
- Cartilage protectors: Glucosamine, Chondroitin sulphate - in early stages only
- Lubrication: Visco - supplements
  - Inj hyaluronidase

Surgical methods:

1. Arthroscopic joint washout
2. High Tibial Osteotomy (HTO)
3. Unicondylar/Total Knee replacement (UKR/TKR)
4. Total Hip replacement (THR)

High Tibial Osteotomy (HTO)

- To correct genu varum
- Metaphysis of proximal tibia cut and separated
  - Gap filled with bone block and protected with plate

Contraindications of HTO
- >20 degrees correction required
- Bicompartmental disease / lateral condyle involved / RA
- Flexion contracture > 15°
- Knee flexion < 90°

Unicondylar / unicompartmental knee replacement (UKR)
- For Osteoarthritis involving only medial condyle
Total knee replacement (TKR)
- 3 components
  - femoral component
  - tibial component
  - liner

Patellar clunk syndrome
complication of TKR
Femoral prosthesis / component of TKR
  ↓ mechanical irritation
  ↓ Fibrous nodule (scar tissue) formation
  at superior pole of patella.
  ↓ mechanical catching on extension of knee

Total hip replacement (THR)

Types:
- Cemented
- Uncemented - preferred in young patients.
  - prosthesis coated with hydroxyapatite

Materials used:
1. Metal on poly → polyethylene acetabular cup
2. Ceramic on ceramic
3. Metal on metal

Contraindications of metal on metal prosthesis
- Hypersensitivity
- Renal impairment
- Females (metal ions → teratogenic and carcinogenic to fetus)

Complications:
- Infection
- Dislocation
- Aseptic loosening
- Pulmonary thromboembolism
- Sciatic nerve injury
Bone cement
Help in attaching implant to the bone

Components:
- **Power**
  - PMMA
  - Initiator - Benzoyl peroxide
  - Radio opacifier
    - Zirconium dioxide / BaSO4
  - Antibiotics
    - Aminoglycosides
- **Liquid**
  - Monomer - MAA
  - Accelerator
    - Dimethyl para Toluidine
  - Stabilizer
    - Hydroquinone

Cementing process
- Mixing time: 5 to 6 min
- Setting time: 3 - 4 min
- Total bone cementing time → 8 - 10 min

Bone cement → cause peripheral vasodilation
lead to ml

**Rheumatoid arthritis (RA)**

- MC type of inflammatory arthritis
- Disease of the synovium
- Auto - immune multisystem disorder
- Erosive type → destroys joint
  - [SLE → inflammatory condition that cause non - erosive arthritis]
- Females > males

Joint involvement:
- Symmetrical, peripheral joint involvement
  - Axial (rare) → Cervical spine
  - MCP (MC), wrist, PIP
  - Less common: knee, hip, cervical spine
  - C1 - C2 subluxation
  - Cord compression
  - Quadriplegia
Pathogenesis

Inflammation of synovium
  ↓
Microvascular proliferation
  ↓
Pannus formation (peripheral to central - vessel formation)
  ↓
Immune complex deposition in vessels
  ↓
Synovial destruction
  ↓
Cartilage destruction
  ↓
Joint subluxation

Deformities in RA

↓ Life expectancy
MC cause of death: coronary artery disease
Most sensitive marker: Rheumatoid factor (RF)
Most specific: Anti-CCP

Poor prognostic factors
High RF, ESR, CRP
Subcutaneous nodules
Erosions on X-ray
History of disease > 1 year

Deformities:
1. Swan neck deformity
   Flexion at DIP
   Extension at PIP

2. Boutonniere deformity
   Flexion at PIP
   Extension at DIP
mallet finger: isolated deformity
RA: affects multiple fingers

3. Z - deformity
   - Radial deviation of wrist and ulnar deviation of fingers
   - Rheumatoid nodules

4. Hammer toe

5. Hallux valgus

6. B/L genu valgum

7. Wind swept deformity
   affects foot and knee
   - one knee in varus,
   - other in valgus

mc cause of wind swept deformity (overall and knee): Rickets > RA
mc cause of deformity in foot: RA

Radiological features

1. Juxtaarticular osteopenia / osteoporosis
   a. ↓ joint space
   3. marginal erosions (pannus)
      No sclerosis, osteophytes

management
Physiotherapy
DMARDS - methotrexate (DOC)
   stopped 1-3 months prior to pregnancy
Immunosuppresant - Leflunomide
Infliximab / Adalimumab - TNF α inhibitors
Anakinra - IL - 1 receptor antagonist
Rituximab - Anti CD - 20 antibody
Surgical management:
- Synovectomy
- Partial / subtotal joint replacement
- Deformity corrections

**Spondyloarthropathies**

- RF - ve (sero - negative arthropathies)
- Young population affected
- Males > Females
- HLA - B27 + (90%)
- Extra-articular manifestation: Uveitis
  - (In RA → Scleritis)

Includes:
- Ankylosing spondylitis (m.c.)
- Enteropathic arthritis - associated with Inflammatory Bowel Disease
- Psoriatic arthritis
- Reiter's syndrome
- Reactive arthritis

**Reiter's syndrome**
- Conjunctivitis
- Urethritis
- Polyarthritis

**Reactive arthritis**
- Reaction to infections
  - Chlamydia
  - Shigella

**Ankylosing spondylitis - Pathogenesis**

- Marie - Strumpell disease / Bechterew's disease
- Axial > Peripheral
  - Spine, sacroiliac joint (m.c.), hip
- Enthesopathy

**Clinical features**
- Males > Females
- Young
- Low back ache / gluteal pain (indicative of sacroiliitis)
- Uveitis
- Early morning stiffness
Degenerative Bone Disorders

Diagnostic criteria:
Sacroilitis - essential criteria
- lumbar spine movement
- chest expansion
- Inflammatory back pain

Sacroilitis: iliac area affected first, identified first on MRI > x-ray

Supportive criteria

Pathogenesis:
- Enthesitis - inflammation of enthesis (site of attachment of ligament / tendon)

Erosion & destruction
Calcification and bone formation

Radiological features of ankylosing spondylitis

1. Blurring / haziness of sacroiliac joint
2. Juxta-articular sclerosis

In spine,
- vertical / bridging syndesmophytes

Squaring of vertebrae
- Bamboo spine

- Trolley track sign
- Dagger sign
- Shiny corner sign / Romanus lesion
  - inflammatory lesions at edges of vertebrae

**Clinical tests**

- chest movement
- lumbar spine movement

**For sacroiliitis:**
- Gaenslen's test
- Patrick test / Faber test
- Figure of 4 test
- Pump handle test

**For lumbar spine:**
- Schober / modified schober test

**Management:**
- Exercise
- NSAIDS ↓ pain
- surgeries → correct deformities

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**Psoriatic arthritis and acroosteolysis**

- **Diagnostic criteria:**
  - Caspar criteria
    - History of psoriasis
    - RF -ve
    - X-ray findings
    - Dactylitis
    - Nail changes

- **Males = females**
- **Middle age affected**
- **Joints involved**
  - asymmetrical: oligoarticular involvement (m. c)
  - m. c joint involved: DIP
Clinical Features:
- Dactylitis - Sausage digits
- Shortening of digits
- Arthritis mutilans
- Telescoping of fingers

Arthritis mutilans:
- Erosive arthritis of ends of hand and feet

X-ray findings:
- Pencil in cup deformity

Treatment:
- Methotrexate

Acro Osteolysis:
- Destruction of terminal ends of phalanges.

Causes:
- Psoriatic Arthritis
- Scleroderma
- Raynaud's phenomenon
- Hyperparathyroidism

Hemophilic arthropathy:
- Recurrent spontaneous bleeding into joints
  - Synovitis
  - Articular cartilage destruction
- MC > Knee > Elbow
- Knee in flexed position (position of ease)
• arthroscopy / aspiration: relative contraindication
  (↑ risk of infection)
• bleeding into muscles → m.C: iliopsoas > Quadriceps
• Subperiosteal bleeding
• Pseudotumours
  iliopsoas pseudotumour → Femoral nerve compression
• triple deformity: posterior subluxation
  external rotation
  flexion of knee

Radiological finding
juxtaarticular osteopenia.
↓ joint space
widening of inter condylar notch
squaring of patella

Treatment
Ice pack, analgesics, rest
Aspiration → only in severe cases
  treat hemophilia.

Crystal deposition diseases - Gout

• Crystal deposition in synovium → local inflammation
  ↓
  joint destruction

Gout:
purine metabolism defect
↑ S. uric acid levels [N: 3.5 - 6.5 μg/dl]
m.C. joint: 1st metatarsophalangeal joint

Radiological findings
  Joint destruction
  Punched-out lesions
  Overhanging / martel / G sign
Degenerative Bone Disorders

IOC: aspiration of synovial fluid
- monosodium urate crystals +
  - Needle shaped
  - Negatively birefringent

Treatment

Acute phase:
- Swelling / tophi \(\rightarrow\) pain:
  - NSAID - Indomethacin (DOC)
  - Colchicine
- S/E: Diarrhea

Chronic phase:
- Xanthine oxidase inhibitors
  - Allopurinol
  - Febuxostat

Uricosuric drugs
- probenecid

Pseudogout and Milwaukee shoulder

- females > males
  - elderly
  - larger joints involved
  - MC \(\rightarrow\) Knee
Calcium pyrophosphate dihydrate (CPPD) deposition
- Polygonal shape
- Positively birefringent

Chondrocalcinosis

- Also seen in: Ochronosis / Alkaptonuria
  - Hemochromatosis
  - Hyperparathyroidism
  - Hypothyroidism

Ochronosis - pigment deposition
- Black discolouration of cartilage
- Black discolouration of urine

Milwaukee shoulder:
- Calcium hydroxyapatite crystal deposition

Synovial chondromatosis

- Foci of metaplastic changes in synovium
  - Hyaline cartilage formation
  - m.C → Knee > Elbow

X-ray: Snowstorm appearance

Treatment:
- Open / Arthroscopic synovectomy

m.C cause of multiple loose bodies in Knee joint

Neuropathic joint
- Destruction of joint due to ↓ peripheral sensation / proprioception

Causes:
- Diabetes (m.C) → Tarsal joints
- Leprosy → Interphalangeal joints
- Syphilis (Tabes Dorsalis) → Knee joint
Features: Signs disproportionate to symptoms

X-ray: total destruction of joint (bag of bones)

Treatment: Arthrodesis
Bone Tumors - 1

Orthopedic oncology - General

- Father of orthopedic oncology - Enneking
- Enneking divided bone tumors.

Bone Tumors

- Benign
  - Latent
  - Active
    - Aggressive

- Malignant
  - Low grade
  - High grade

- Metastasis
  (Any grade)

Location of Bone Tumors:

- Epiphyseal tumors:
  - Chondroblastoma.
  - Osteoclastoma / Giant cell tumor

- Metaphyseal tumors:
  - Osteosarcoma.
  - Osteochondroma.
  - Simple bone cyst / unicameral bone cyst
  - Aneurysmal bone cyst
  - Non-ossifying fibroma / Fibrous cortical defect - can also occur in the diaphysis.

- Diaphyseal tumors:
  - Ewing sarcoma.
  - Osteoid osteoma.
  - Adamantinoma.
  - Fibrous dysplasia - can also occur in metaphysis.
Nature of tumours

**Benign**
- Osteoid osteoma
- Osteochondroma
- Fibrous dysplasia
- Simple bone cyst
- Aneurysmal bone cyst

**Benign aggressive**
- Osteoclastoma / GCT
- Chondroblastoma

**Malignant**
- Chondrosarcoma
- Osteosarcoma
- Ewing sarcoma
- Adamantinoma
- Chordoma

**Periosteal reactions:**

Insult to the bone ⇒ periosteal reaction.
1. Onion peel / Onion Skin: Ewing's sarcoma
2. Sunburst / Sun ray: Osteosarcoma
3. Codman's triangle: Osteosarcoma

**Pulsatile bone tumors:**
- Osteosarcoma: most pulsatile
- Aneurysmal bone cyst
- Osteoclastoma / Giant cell tumor (GCT)
- Metastasis - Kidney, Thyroid

**Polyostotic lesions:**
Lesions that involve multiple bones.
- Fibrous dysplasia
- GCT / Osteoclastoma
- Enchondroma / Osteochondroma

---

**Fibrous dysplasia**

Developmental anomaly

\[ \text{Bone tissue replaced by fibrous tissue} \]

- Two types: monoostotic
  Polyostotic

- X-ray: Ground glass / Hazy appearance with
  Dense sclerotic rim - Rind Sign

- Shepherd crook deformity
- Treatment: Bisphosphonates
• MC Cune Albright Syndrome:
  - Precocious puberty
  - Polyostotic fibrous dysplasia
  - Cafe-au-lait spots.

Fibrous cortical defect

- Also known as Mon-ossifying fibroma
- Eccentric lesion
- Most common lesion of the bone
- Usually occurs in the first decade
- Occurs in metaphysis.
- Self-resolving.

Bone cysts

<table>
<thead>
<tr>
<th>Simple</th>
<th>Aneurysmal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benign</td>
<td>benign</td>
</tr>
<tr>
<td>Metaphyseal</td>
<td>metaphyseal</td>
</tr>
<tr>
<td>Age: 10-30 y</td>
<td>Age: 10-30 y</td>
</tr>
<tr>
<td>Unilocular</td>
<td>Multilocular</td>
</tr>
<tr>
<td>Site: Proximal Humerus</td>
<td>Site: Proximal tibia.</td>
</tr>
<tr>
<td>Content: Serous (Straw coloured / Clear fluid)</td>
<td>Content: Blood</td>
</tr>
<tr>
<td>Treatment: Aspiration followed by injection of sclerosants or Steroids (or) Excision and Curettage</td>
<td>Treatment: Extended Curettage</td>
</tr>
<tr>
<td>In Extended curettage - Fill the cavity with liquid Nitrogen (Best) or phenol</td>
<td>In pelvis: Embolisation.</td>
</tr>
</tbody>
</table>

- Bone graft is made up of PMMA.

Simple bone cyst: 
- Fallen leaf sign
- Trap door sign

Aneurysmal bone cyst:
Fluid fluid level on m.R.L:
1. Aneurysmal Bone cyst
2. Giant cell tumor / Osteoclastoma
3. Telangiectatic osteosarcoma

Cyst like lesions in bone

<table>
<thead>
<tr>
<th>Centric lesions</th>
<th>Eccentric lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>• simple bone cyst</td>
<td>• Aneurysmal bone cyst</td>
</tr>
<tr>
<td>• Enchondroma</td>
<td>• GCT / Osteoclastoma</td>
</tr>
<tr>
<td>• Brodie’s Abscess</td>
<td>• Non-Ossifying Fibroma – mc</td>
</tr>
</tbody>
</table>

Osteoid osteoma

- Children & young Adolescents
- Presents with Night pains relieved by salicylates (Aspirin)
- Femoral Diaphysis – mc location
- Eccentric and cortical
- Treatment: NSAIDS
- Radio Frequency Ablation, Excision

X-ray findings:
- Central nidus
  - Dilated blood vessels
  - Osteoblasts
  - Osteoclasts & woven bone.
- Dense sclerosis around central nidus.
- Central nidus > 2 cm is Osteoblastoma.
- Central nidus releases Prostaglandins - Causes Pain.
- mc true benign bone tumor.

Osteochondroma / Exostosis

- Developmental anomaly
- Growth plate grows abnormally outwards
- sessile or pedunculated
- Pedunculated – contains stalk - Grows away from the joint.
- It has cartilagenous cap - usually < 2 Cm.
- Stops growing after skeletal maturity.
- mc Benign Bone tumor.
• MC cause of pain in this lesion - Bursitis due to compression by lesion
  - Nerve compression
  - Fracture
  - Malignant transformation - chondrosarcoma
    (cartilaginous cap > 2 cm)

• Treatment: Extra periosteal excision.

Chondroblastoma

• Benign tumor
• Also known as Codmans tumor.
• Epiphyseal lesion
• Occurs before skeletal maturity.
• MC location: Upper end of Humerus and Tibia.
• On x-ray: Punctate calcification.
• Best IOC for any bone tumor: Biopsy.
• On biopsy: Chicken wire calcification.
• Treatment: Extended curettage.

Chondroma, enchondroma

• Chondromas - tumors of Hyaline Cartilage
• If they occur in the medullary cavity of bone: Enchondroma.
• If they arise from synovium: synovial chondromatosis.
  On x-ray: Popcorn calcification, also known as Ring or Arc Calcification or O'Ring Sign.

Lesion with O’ Ring Sign:
• Chondrosarcoma
• Chondroma
• Pulmonary Hamartomas
• Fibroadenoma of breast.
Enchondroma:
- MC bone tumor of Hand / Feet
  (MC tumor of hand: Squamous cell carcinoma.)
- Metaphyseal
- Treatment: Extended curettage.

Syndromes associated with Enchondroma:
1. Maffucci Syndrome:
   - Multiple enchondromas
   - Hemangioma
   - Phleboliths.
   - 100% premalignant.

II. Ollier’s Syndrome:
   - Multiple enchondromatosis
   - 30% premalignant

Both are Sporadic

Hemangioma

- Benign, Asymptomatic vascular tumor
- Spine > Skull > Pelvis
- On X-ray: Jail house / Jail Bar Sign
- On CT: Polka dot sign.
- Treatment: Conservative, curettage +/- radiotherapy.
Giant cell tumor (GCT) / osteoclastoma

- Locally aggressive
- Location: Epiphyseometaphyseal.
- Grow up to 1-1.5 cm above joint line.
- Occurs after skeletal maturity.
- MC location: lower end of femur
  upper end of tibia
  Distal end of radius.
- MC tumor in distal end of radius: GCT
- On examination: Egg shell crackling
- On X-ray: Soap bubble appearance.
- On biopsy: Nuclei of Giant cell = mononuclear cells
- Malignant: <5%
- Treatment: Extended curettage.

GCT variants:
- Chondromyxoid fibroma
- Chondroblastosma
- Fibrous dysplasia - MC variant
- Aneurysmal bone cyst - Closest resemblance.
- Simple bone cyst / unicameral bone cyst
- Brown tumor
- Non-ossifying fibroma
- Telangiectatic osteosarcoma.
- GCT is more common in females.

Osteosarcoma

- MC bone tumor in children occurring in 2nd decade
- Known as primary osteosarcoma.
- 2° osteosarcoma - Older population.
- Patients with Paget's disease, fibrous dysplasia, exposed to radiation develop 2° osteosarcoma.
- 1° Osteosarcoma > 2° Osteosarcoma.
- Metaphysial tumor - Distal end of femur.
- Most radio resistant tumor.
- MC radiation induced tumor.
- It is a bone forming tumor forming abnormal osteoid and matrix.
- 50% will have micro metastasis to lungs during presentation
  - can present as pneumothorax.
- on x-ray: Sun - ray / sunburst appearance

- Elevated periosteum: Codman's triangle.
- Types of osteosarcoma:
  1. Classical / Intramedullary - mc
  2. periosteal
  3. parosteal - favourable prognosis
     - mc in females
     - Occurs in posterior aspect of femur.
  4. Telangiectatic type
- Treatment: Neoadjuvant Chemotherapy
  Surgery
  Adjuvant chemotherapy.
- Chemotherapy: Protocol: Actinomycin, Bleomycin, Cyclophosphamide
  Doxorubicin, High Dose methotrexate, vincristine.
- 5 year survival rate: 70%

Ewing sarcoma

- more common in males > females
- Diaphyseal
- mc tumor of 1st Decade; but it most commonly occurs in 2nd decade.
- mc- Occurs in femur.
- Both Ewings and Osteosarcoma presents as infection in children.
Poor prognostic factors:
- Fever
- Age > 13 y
- Males
- ESR
- Anemia
- Metastasis
- Relapse
- Chemoresistant.

X-ray finding:
- Onion peel appearance

IOC: Biopsy
- Variable consistency
- Small round blue cells with Pseudorosettes
- Diastase digestible, PAS +ve.
- MIC 2 / CD 99 IHC +ve

Bone marrow biopsy: To know extent of the lesion.
- Arises from endothelial lining of medullary cavity.
- Translocation (11:22) - MC
  - t(11:22)
  - t(7:22)
- Associated with trisomy 8 and 21.
- Treatment: Chemotherapy and surgery
- RT is not used, but it is radiosensitive.

Chondrosarcoma

- Most favourable prognosis
- Metaphyseal
- 40-50 y
- Pelvic calcifications with haziness in background
- Radiotherapy and chemotherapy resistant.
- Associated with hyperglycemia.
- Treatment: Surgery.

Chordoma

- MC: Sacrum
  - Base of skull vertebra.
Active space

- A primary malignant tumor of spine.
  (MC primary malignant tumor of spine - multiple myeloma)
- MC malignant tumor of bone - metastasis
- Chordoma arises from physaliferous cells of primitive notochord
- Treatment: Surgery or Radiotherapy.

Adamantinoma

- Very rare malignant tumor, occurring in < 1%.
- Arises from epithelial cells.
- MC site: Tibia.
  (Ameloblastoma arises most commonly from mandible.)
- Diaphyseal.
- Honeycomb appearance / soap bubble appearance in diaphysis.
- Treatment: Wide resection / Amputation
- Radiotherapy and chemotherapy resistant.
- MC presentation: Pain
- MC Tumor of mandible: Squamous Cell Carcinoma.

Synovial sarcoma

- Misnomer - does not arise from synovium.
- Arises from joint capsule, bursae, tendon.
- MC arise from knee or elbow.
- MC associated with t(X:18) → SYT:SSX fusion gene
- Biphasic tumor - Epithelial + mesenchymal.
- Treatment: Surgery.

Secondaries to bone

- Most common site of metastasis in musculoskeletal system: thoracic vertebrae.
- MC source: Breast > Prostate > Lungs
- MC source of secondaries to the bone in children: Neuroblastoma.

Bone to bone metastasis:
- Ewing's sarcoma.
- Osteosarcoma.
most commons in ortho oncology
- mc 1º malignant: multiple myeloma> Osteosarcoma.
- mc 1º malignant, Non hematogenous: Osteosarcoma.
- mc benign lesion in bone: Non ossifying fibroma or fibrous cortical defect.
- mc benign bone tumor: Osteochondroma / Exostosis.
- mc true benign bone tumor: Osteoid osteoma.
METABOLIC BONE DISEASES - 1

Basics of bone physiology

- Principle mineral of bone - Calcium hydroxyapatite (Ca<sup>2+</sup>)
- Calcium is regulated by
  - Normal range - 9 - 11 mg/dL
  - Calcitonin triggered in hypercalcemia normalises Calcium level
  - Parathyroid hormone (PTH) triggered in hypocalcemia normalises calcium level

Hypocalcemia - Secondary hyperparathyroidism

- In Parathyroid adenoma - ↑ PTH - Primary hyperparathyroidism
- In Hypocalcemia or vitamin D ↓ ↓ PTH - Secondary hyperparathyroidism
- Normalises Ca<sup>2+</sup> level
  - ↑ Ca<sup>2+</sup> absorption activates 1α-hydroxylase
  - Vitamin D<sub>3</sub> in GIT activates
  - Reabsorbs Ca<sup>2+</sup> with exchange of PO<sub>4</sub><sup>3-</sup>
  - PTH receptors present on osteoblast
  - PTH activates osteoclasts
  - During bone formation ↑ Alkaline phosphatase (ALP)
  - Osteoblast - Release osteoprotegerins - suppress osteoclasts
Secondary hyperparathyroidism in renal failure

- In renal failure - Activation of vitamin D₃ ↓
  \[ \downarrow \text{Ca}^{++} \text{ (hypocalcemia)} \]
  \[ \downarrow \text{triggers PTH - } \uparrow \]
  \[ \downarrow \text{Act on} \]

  \[ \text{Kidney} \]
  \[ \downarrow \text{but vitamin D₃ not activated} \]
  \[ \downarrow \text{Ca}^{++} \text{ not absorbed from GIT} \]
  \[ \downarrow \text{Ca}^{++} \text{ cannot be reabsorbed with exchange of PO₄} \]
  \[ \downarrow \text{So } \uparrow \text{PO₄} \]
  \[ \uparrow \text{Ca}^{++} \text{ excretion (Hypercalciuria)} \]

- Serum Calcium is always low
  PO₄ is raised
  ALP is high
  PTH is high

- Parathyroid adenoma - Primary hyperparathyroidism
  \[ \uparrow \text{PTH - without any trigger} \]
  \[ \downarrow \text{Act on} \]

  \[ \text{Kidney} \]
  \[ \uparrow \text{Ca}^{++} \]
  \[ \uparrow \text{Ca}^{++} \text{ absorption with PO₄ exchange} \]
  \[ \downarrow \text{PO₄} \]

  \[ \text{Bone} \]
  \[ \uparrow \text{Ca}^{++} \text{ release} \]
  \[ \uparrow \text{ALP} \]

- \[ \uparrow \text{Ca}^{++} \text{ in serum} \]

  - bony pain, abdominal groans,
  - Psychiatric overtones, Renal stones
Metabolic bone problems

Osteoid

- Tetracycline labelling test
- ↑ dose of tetracycline is given - 2 times few weeks apart
- Tetracycline gets deposited in two layers - in normal bone.

- Osteoid has two components

Cellular

- Osteoblastic Problem
- Bone formation markers
  - ↑ ALP
  - Procollagen - I
  - Osteocalcin / gla protein
  - Osteonectin

Proteins

- Osteoclastic Problem
- Bone resorption markers
  - Tartrate resistant acid phosphatase (TRAP)
  - N/C - Telopeptides
  - Hydroxyproline and hydroxylysine

Normal Ca\(^{2+}\) - 9 - 11 mg/dL
Normal PO\(_4\) - 3 - 4.5 mg/dL

Disturbed in mineral problem

Warning: Not all points are covered in the notes, especially conceptual explanations. Please use the notes in conjunction with Marrow Edition 4 videos.
Defects in osteoid and mineral

- Osteoid:
  - Cells
  - Osteoclastic activity
    - Paget's disease
    - Osteopetrosis
  - Osteoclastic activity

- Mineral:
  - Protein
    - conversion of Procollagen to Collagen
  - Vitamin - C
    - Scurvy
    - Vitamin D
      - Rickets (N: 20 to 40 ng)
      - Osteomalacia
    - 1α or 25 α PTH

- Osteoporosis - none of the lab parameters are disturbed

Rickets / Osteomalacia

- Cause - m. C - ↓ Vitamin D - m. CC: nutritional deficiency
  - malabsorption
  - Liver / Renal failure
  - Lack of Sunlight exposure
  - Drugs

- Osteoid maturation time
  - Time taken for osteoid to become osteon
  - here - Hypocalcemia
    - osteoid maturation time - ↑

- mineral apposition rate
  - Speed at which the mineral gets deposited on osteoid
    - Here - rate - ↓
Rickets Laboratory and clinical findings

Laboratory findings
1) Hypocalcemia
2) ↑PTH - secondary hyperparathyroidism
3) ↑Alkaline phosphatase (ALP)
4) ↓PO₄

Clinical findings - in Skull / Chest
1) Craniotabes / Softening of the skull / Ping pong skull - earliest change
   a) Frontal bossing
   b) delayed closure of fontanelle

In chest
1) Rachitic rosary - Costochondral junction swellings, blunt, non tender
2) Pigeon chest / pectus carinatum → Prominent sternum
3) Harrison sulcus - under the ribs where the diaphragm inserts

Rickets - Long bone findings

- Coxa - hip, Genu - Knee, Cubitus - elbow

In hips
- Coxa vara - at proximal femur
   Bending of shafts of bones - legs, thigh.

In knee
- Bilateral - Genu valgum - leg distal to knee goes laterally
  Genu varum - leg distal to knee goes medially
- Wind swept deformity - One knee - genu valgum
  Other knee - genu varum
• Wind swept deformity - m. c. c overall → Rickets
  In children → Rickets
  In adults → Rheumatoid arthritis

Rickets - Joint findings

Interstitial growth of bone at growth plate

Germinal layer - Cells are born
Proliferative layer - Cells multiply
Hypertrophic layer - Cells grow in size to accommodate Ca\(^{2+}\)
Layer of calcification - Cells calcify after accommodating Ca\(^{2+}\)
Layer of ossification - Cells become part of normal bone at metaphyseal end.

• In Rickets - disease of hypertrophic layer of growth plate
  ↓
  Lack of mineralisation
  ↓
  So hypertrophied cell do not calcify
  ↓
  Continuous hypertrophy pushes the metaphysis
  ↓
  Causing widening - Splaying / Cupping of metaphysis
Healing Rickets

- After administration of Ca\(^{2+}\) + vitamin - D
  
  Bone begins to mineralise
  
  Calcium deposition seen on X-rays over growth plate
  
  Evidence of rickets healing
  
  After calcification
  
  Osteoclasts - helps in remodelling
  
  reverses abnormal swelling

- The residual deformity after treatment
  
  corrects itself with the growth of child
  
  if not corrected - requires surgical intervention
Osteomalacia

- Vitamin D deficiency - in adults (after the fusion of growth plate)
- Seen in young females >> males
- C/F - non-specific, presents as proximal myopathies and arthralgias
- Lab findings - Same as rickets
- Radiological findings - Pseudo-fracture or milkman's fracture or
  looser zone

Transverse band of rarefaction perpendicular to long axis of the bone.

m. c Site - Neck of femur
other sites - clavicle, ribs, scapula and pubic rami

i) Trefoil pelvis or triradiate pelvis

Pelvis assumes shape of trefoil

Head of femur protrudes into soft acetabulum - protrusio acetabuli

ii) Codfish vertebrae

Intervertebral disc exerts pressure on weaker vertebrae - gives codfish appearance

Seen in osteoporosis > osteomalacia

Pseudo fracture or milkman's fracture
Tumors associated with osteomalacia.

i) Fibrosarcoma.
ii) Osteoblastoma.
iii) Osteosarcoma.
iv) Non-ossifying fibroma.

Treatment of Rickets and osteomalacia.
- Vitamin D and calcium supplements

Stoss regimen
- 3 lakh - 6 lakh IU deep IM or oral (Stat or over 1-5 days)
  (or)
- Daily: 2000 - 5000 IU for 4-6 weeks
  (or)
- Weekly: 5000 - 6000 IU for 8-12 weeks

- Over treating / poor compliance - Causes vitamin D toxicity

Scurvy
- Vitamin C deficiency - Improper maturation of Collagen
  ↓
  Defective collagen
  ↓
  Osteoid part of bone is weakened
  ↓
  but normal mineralisation
- **C/F - Bleeding in**

  - Bone
    - Subperiosteal bleeding
    - Pain in limb
    - Pseudoparalysis

  - Gums

  - Costochondral junction
    - Scorbutic rosary
    - Sharp pain and tenderness present

- **Bony manifestations**

  - Diaphyseal
    - Subperiosteal hemorrhages
    - Ground glass / hazy appearance with fine pencil thin cortex

  - Metaphyseal
    - White line of Frenkel
    - Scorbutic lucent zone
    - Pelican spur

  - Epiphyseal
    - Wimberger's ring sign
    - Differentiates healing rickets and scurvy
Primary hyperparathyroidism
- m. c. cause - Parathyroid adenoma - ↑ Parathyroid hormone (PTH)
  - ↑ bone destruction
    - ↑ Ca²⁺
  - In Kidney
    - ↑ Ca²⁺ absorption
    - ↑ vitamin D activation
    - ↑ Ca²⁺ absorption

Clinical findings
- In bone → due to destruction
  - Hemorrhage in bone
  - Hemoglobin disintegrates into Hemosiderin
  - Appears brown
  - Brown tumor (Tumor - misnomer) or Von Recklinghausen's disease or osteitis fibrosa cystica
- In Skull - Pepper pot skull / Salt & pepper skull
- In teeth - Lamina dura resorption
  - Leads to loosening of teeth
In phalanges - m. c in middle phalanx

Subperiosteal resorption on radial side.

Warning: Not all points are covered in the notes, especially conceptual explanations. Please use the notes in conjunction with Marrow Edition 4 videos.

Laboratory findings in Primary hyperparathyroidism and Renal failure

In primary hyperparathyroidism

i) ↑ Ca²⁺
ii) ↑ PTH
iii) ↓ P0₄
iv) ↑ Alkaline phosphatase (ALP)

In Renal failure - Secondary hyperparathyroidism

- A/K/A Renal Osteodystrophy
  i) Hypocalcemia.
  ii) ↑ PTH
  iii) Hyperphosphatemia.
  iv) ↑ ALP

- C/F - in vertebrae
  Rugger jersey Spine (Sclerosis under the endplate)
  also seen in osteopetrosis
Osteoporosis

- Porous bone disease
- Quantitative defect
  - Osteoid + mineral are equally deficient - ↓ Quantity
  - Age ↑ - Peak bone mass ↑ - depends on genetics, exercise, diet
    - After sometime gradually ↓ - estrogen prevents ↓ in bone mass

- ↓ estrogen or sudden arrest in production
  - Causes ↓ in bone mass / density
    - m.c in females - Post menopausal

Osteoporosis - Causes, Clinical findings

Primary
  - Post menopausal
  - Senile

Secondary
  - Drugs like - Steroids
  - Hormones
  - Prolonged immobilisation

Clinical findings -
  1) Pathological fracture
     - Earliest symptom - backache
     - m.c - vertebral fracture
     - Hip fracture - Neck of femur
     - Colle's fracture - distal end of radius

Lab findings - Normal
ii) Kyphosis - Forward bending  
   m. c. cause osteoporosis

iii) Codfish vertebrae / Fish mouth vertebrae

Osteoporosis - Diagnosis, Screening

1OC - Bone mineral density  
   ↓  
   DEXA - Scan (Dual energy x-ray absorptiometry)  
   ↓  
   Assess spine (preferred), hip, Calcaneum
   • The results are compared  
   ↓  
   between two population
Diseases -

**DEXA - Scan results**

Compared between

- **Z - Score**
  - Population of same age, sex, Race

- **T - Score**
  - Young reference male / female

  used for diagnosis of osteoporosis
  - Standard deviation
    - 0 - (1) - normal
    - (1) - (-2.5) - osteopenia
    - > (-2.5) - osteoporosis

**Osteoporosis Screening**

National osteoporosis Foundation (NOF)

NOF recommends bone density test for:
- Females > 65 years of age
- Males > 70 years of age
- Fracture after the age of 50
- Female of menopausal age with risk factors
- Postmenopausal females under the age of 65 with risk factors
- Males aged 50-69 with risk factors

**Osteoporosis - Treatment**

- **Bone resorption (BR)**
- **Bone formation (BF)**
- BR & BF

  - Bisphosphonates
    - **1) Risedronate**
      - Once weekly
    - **2)ibandronate**
      - Once monthly
    - **3) Zolendronate**
      - Once yearly

  - **Teriparatide**
    - Synthetic PTH
    - Pulsatile release

- **Strontium ranelate**
- **Nephrotoxic**
  - Not preferred

- **Monoclonal antibody**
  - Denosumab
    - (Rank-L inhibitor)

- **Selective estrogen receptor modulators (SERM)**
  - Raloxifene
Metabolic Bone Diseases

- For destruction of vertebra
  vertebroplasty - using PMMA (Polymethyl methacrylate)
  bone cement

- Kyphoplasty - restoring kyphosis
  needle with balloon injected into vertebrae
  balloon inflated
  vertebral height restored
  injected with bone cement
  balloon kyphoplasty

Pagets disease / Osteitis deformans

- Occurs in 5th decade of life
  - Common in males > Females
  - M.C. - Pelvis > Tibia
    ↑ Osteoclastic activity
    ↑ Bone resorption
    ↑ Compensatory bone formation by osteoblasts
    ↑ turnover of bone

- Cause - Idiopathic
- Associated conditions - SQSTM1 - gene mutation
  Paramyxovirus - ↑ Osteoclastic activity
• 3 Stages of disease

  - Lytic
    - bone destruction
  - Mixed
    - Bone destruction
    - Bone formation
  - Elastic

• Lab findings - Serum Ca\(^{2+}\), Po\(_4\) - Normal
  \[ \text{↑ ALP (3-4 times the normal range)} \]

Osteoporosis - Treatment

• ↑ vascularity in bones - warm to touch
  - Irregular bones

• All the foramens of skull - Stenosis - due to ↑ Bone formation
  - Compresses cranial nerves
    - \(2, 5, 7, 8\)
  - Visual and hearing disturbances

• M. C C/F - Pain, M. C site - Pelvis.

I0C - Biopsy - Shows mosaic pattern of bone
Bone Diseases

Radiological Finding -
• in lytic phase - Osteoporosis circumscripta
  Blade of grass / Candle flame appearance

Osteoporosis Circumscripta Blade of grass appearance

• in mixed phase - Picture frame vertebra
  Ivory vertebra
  Cotton wool skull

Picture frame vertebra. Ivory vertebra

In blastic phase - Tam O’Shanter skull
Pagets Diseases - Complications, Treatment

- Banana fracture
- Cranial nerve compression - a, s, 7, 8
- Can transform to osteosarcoma
- High output Cardiac failure
  - m. c. c of death

Treatment
- Doc - Bisphosphonate (long acting - preferred)
- Calcitonin - for pain
  - Can be acquired from
    - Salmon / Porcine
      - has better results

Osteopetrosis / Albers Schonberg Disease / Marble bone disease

- Due to ↓ Osteoclastic activity
  - Carbonic anhydrase II proton pump defect
    - ↓ acidic environment → ↓ Osteoclastic activity
      - leads to ↑ osteoblastic activity

manifests as

- Autosomal dominant
  - Benign
  - Better prognosis
  - Usually incidental finding
  - C/F - Pain
    - Pathological fracture
      - Normal Healing
- Autosomal recessive
  - Poor prognosis
  - Severe from
  - Excessive bone growth
    - Invades > bone marrow
      - myelophthisic disease
Bone Diseases

C/F - Anemia
  Thrombocytopenia - bleeding
  Leukopenia - infection
e.g. - Osteomyelitis of mandible

- Hepatosplenomegaly
  (Extra osseous medullary sites - Flare up)

- Excessive bone growth
  also involve Neural foramen
  
  - Compress cranial nerves,
  - Obstruct flow of Cerebrospinal fluid (CSF)

  Hydrocephalus

Osteopetrosis - Radiological findings

- Erlenmeyer Flask deformity - flaring of metaphysis

- Endo bone appearance

Treatment - Bone marrow transplant
Marble bone disease

- Due to defect in collagen A-I gene
  
  abnormal collagen

  Two types

  - Autosomal dominant
    - Better prognosis
    - Classical type
    - C/F - multiple fractures
      
      m. C in diaphyseal
      
      with Normal healing
      
      Causes deformity (bent bones)

  - Autosomal recessive
    - Severe disease
    - Still birth

- Diagnosis - Prenatal chorionic villus sampling
- Prevention of fractures - Splints
- Treatment - Surgical - Realignment - Osteotomy /
  Schofield miller operation

Still born baby - Osteogenesis imperfecta with bruising

Re-alignment osteotomy
### Lab findings in metabolic diseases

<table>
<thead>
<tr>
<th></th>
<th>Calcium</th>
<th>PTH</th>
<th>PO4</th>
<th>ALP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rickets</td>
<td>OI</td>
<td>OM</td>
<td>Sec Hyper PTH</td>
<td>↑↓</td>
</tr>
<tr>
<td>Renal Osteodystrophy</td>
<td>↓</td>
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<tr>
<td>Osteoporosis</td>
<td>N</td>
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<tr>
<td>Primary Hyper PTH</td>
<td>↑↑</td>
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<tr>
<td>Paget’s Disease</td>
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</tr>
</tbody>
</table>
FUNDAMENTALS OF NERVE INJURY

Anatomy of nerve

Nerve injury
1. Incomplete injury - Axon injured
   One of the three nerve sheath: intact
   Distal segment of axon undergoes Wallerian degeneration
   proximal limb regenerates
   Bundle of naked fibres formed: Neuroma in continuity
   Growth rate: 1 mm/day

2. Complete resection
   - All layers lost,
     proximal limb forms neuroma without sheath
   End neuroma
   Doesn't regenerate
Peripheral Nerve Injuries

Signs of nerve injury

Tinel's sign:

- Percussion of a nerve from distal to proximal
- Tap the neuroma
- Law of projection
- Tingling / burning sensation (positive Tinel sign)

Progressive Tinel

- Progressive positive Tinel:
  - By virtue of recovery of nerve by Wallerian degeneration
  - The Tinel's test is elicited more distally at the rate of 1mm/day

- Non progressive positive Tinel: End neuroma

High v/s low nerve injury

- Lower the nerve injury, lesser the disability
- Motor march phenomenon:
  - In incomplete nerve injury
  - All muscles lose function at once
  - Recovery occurs from proximal to distal
    (due to neuroma in continuity)

Classification of nerve injury

<table>
<thead>
<tr>
<th>Seddon's Neuropraxia</th>
<th>Sunderland's Type I (similar to neuropraxia)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary physiological reversible conduction block</td>
<td>Splints: prevent contracture</td>
</tr>
<tr>
<td>Slow conduction</td>
<td></td>
</tr>
<tr>
<td>Eg: Sitting for too long, tourniquet palsy, Saturday night palsy, crutch palsy</td>
<td></td>
</tr>
<tr>
<td>Recovery: spontaneous, 100% (3-6 wks)</td>
<td></td>
</tr>
</tbody>
</table>
Axonotmesis

Seddon's
- Only axons injured
- Nerve continuity intact
- Neuroma in continuity
- Positive progressive Tinel
- < 100% recovery
- Motor march +
- Neurotmesis
  - Axon + all sheaths injured
  - End neuroma
  - Tinel +ve non progressive
  - No recovery
  - Repair + graft
  - Eg. Lacerations

Sunderland's
- Type II: Axon injured
- Type III: Axon + endoneurium injured
- Type IV: Axon + endoneurium + perineurium injured
- Type V: (similar to neurotmesis)

Evaluation of nerve injuries

Best investigation: Nerve conduction Studies

2nd best investigation: Clinical diagnosis.

Nerve conduction studies

- Nerve conduction velocity
  - Best
- Electromyogram
  - Earliest

- Tinel's test
  - Helps us in assessing recovery.

Treatment

1. Conservative (neuropaxia / axonotmesis)
   - Closed → Splint (Prevent contractures)

2. Exploration
   a) Open #
   b) Obvious nerve injury
   c) Nerve injury while manipulation
Type of nerve repair:
1. Primary < 6 hrs
2. Delayed primary 7 - 18 days
3. Secondary >18 days

Best method: End to End repair
m/c nerve graft - Sural nerve > Saphenous nerve.

Tendon transfer

- If the nerve injury > 1 yr
- Transfer insertion of a functioning/normal tendon to injured tendon

Free tendon grafts (to augment length of the tendon transferred)
1) Palmaris longus
2) Plantaris tendon

Prognosis of nerve injuries:
1. Neuropraxia - Best
2. Early repair
3. Radial nerve (most resilient, almost purely motor)
   \[ \text{No axonal confusion} \]
4. Vascularity
5. End to End repair
6. Growing age - Children
NERVE INJURIES - 1

Axillary Nerve and musculocutaneous nerve

Root Value: C₆ & C₇

- Motor
- Sensory

Deltoid - 15-90 degrees Abduction
Teres minor - External Rotation Of Shoulder

Axillary nerve injury
- Presenting Deformity
- Adduction
- Internal rotation

MC cause - Shoulder Dislocation > Proximal Humerus Fracture
Splint - Shoulder Abduction Splint

Musculocutaneous Nerve

- Coraco brachialis - Lateral Cutaneous nerve
- Biceps Brachii - Elbow flexion Forearm Supination
- Brachialis - Elbow flexion

MC Cause - Shoulder dislocation
Presenting Deformity
- Extension
- Pronation

Median Nerve

- Supplies forearm flexor compartment - A/K/a Labourer's Nerve

Sensory supply - Lateral 3 and half fingers in the palmar aspect & tips of lateral 3 and half fingers in dorsal aspect

Autonomous zone - Independent zone supplied by a single nerve
- Median nerve - tip of index finger
motor supply - 1) Anterior compartment of forearm except Flexor carpi ulnaris and medial half of Flexor digitorum

a) Thenar muscles except adductor pollicis
   - Abductor Pollicis brevis
   - Flexor Pollicis brevis
   - Opponens Pollicis.

3) Lumbricals 1 & 2

- Anterior interosseus nerve - supplies Flexor Pollicis longus and lateral half of Flexor digitorum profundus
- Median nerve supplies Flexor digitorum superficialis

**Median nerve injuries**

*Wrist*
1) Loss of thenar muscle tone \( \rightarrow \) wasting
   - Abduction
   - Flexion
   - Opposition \( \rightarrow \)
   \[ \text{Ape Hand Deformity} \]

2) Abductor pollicis brevis action lost
   - Pen test: Palm facing upwards and touch a pen held above it with the thumb
   - Sensation is also lost at the areas supplied by the nerve in the hand

*Elbow*

- Wrist lesion \( \circledast \)
- Flexor Pollicis longus, Flexor digitorum profundus \( \rightarrow \) lost
- Flexor digitorum superficialis

- Index Finger Doesn't Flex On Making a Fist
- Pointing Index / Benediction Sign

- Clasp hand - Oschner clasp hand.
Isolated Anterior interosseous nerve injury
- Pure motor Nerve
- Seen in supracondylar fracture humerus
  - Flexor pollicis longus
  - Flexor digitorum profundus

- Able to flex metacarpophalangeal joint & proximal interphalangeal joint, not able to flex distal interphalangeal joint in index and middle finger & interphalangeal joint

  AsKed To make 'OK' sign

  Weak OK Sign or Kiloh - Nevin Sign.

Ulnar Nerve

- Aka musician's Nerve
  - Predominantly Supply Intrinsic Muscles Of Hand

Muscles supplied:

- Forearm: Flexor Carpi Ulnaris
- Medial 1/3 Flexor Digitorum Profundus.

- Hand:
  - Adductor Pollicis
  - Lumbricals 3, 4 - Flexion of metacarpophalangeal joint & extension of interphalangeals
  - Interossi
    - Palmar - Adduction
    - Dorsal - Abduction
  - Hypotenar muscles

Sensory - medial 1/4 fingers

Injury Behind medial Epicondyle / Cubital tunnel

- Lumbricals 3 & 4 - action lost - Partial claw hand
- Wasting of Hypotenar eminence
- Paresthesia

- Ulnar + median nerve injury - Complete claw hand
Interossei Function:
1) Palmar Interossei - action - adduction
   Card test +ve if action is lost

2) Dorsal Interossei - action - abduction
   Fan the fingers - Egawa test

Adductor Pollicis Function: Adduct thumb

Book Test
   Hold Book b/w Thumb and Index Finger
   ↓ Flexion Of Thumb (due To lack adduction)
   ↓ Froment Sign

Splint Used - Knuckle Bender Splint

Ulnar Paradox: High ulnar nerve palsy - Less clawing / less deformity

Ulnar nerve injury at wrist - Flexor Digitorum Profundus Spared
   (Significant Clawing)
   v/s

Ulnar nerve injury at elbow - Flexor Digitorum Profundus Paralysed
   (Less Clawing)

Radial Nerve

- MC Injured nerve, but best prognosis
- Extensors Of elbow, wrist & Fingers.
Radial nerve supplies
1) Long head of triceps
2) Lateral, medial head of triceps, anconeus at spiral groove
3) Extensor carpi radialis longus (ECRL)
4) Extensor carpi ulnaris
5) Extensor digitorum communis
6) Extensor carpi radialis brevis (ECRB)

- Posterior interosseous nerve - extends thumb and fingers
  Supplies - Superficial extensors
  1) Extensor digiti minimum
  2) Extensor carpi ulnaris
  3) Extensor digitorum communis
  4) Extensor carpi radialis brevis (ECRB)
- Deep extensors
  1) Extensor indicis
  2) Extensor pollicis brevis
  3) Extensor pollicis longus
  4) Abductor pollicis longus
  5) Supinator

Palsy: Finger drop and thumb drop

- Low radial nerve palsy
  Finger drop, thumb drop, and sensory loss
- High radial nerve palsy
  Thumb drop, finger drop, sensory loss and wrist drop
- Very high radial nerve palsy
  - Loss of function of triceps → elbow goes to flexion

- Injury is proximal to ECRL → wrist drop
- Injury distal to ECRL → No wrist drop

- MC cause of radial nerve injury → Holstein Lewis fracture (lower 1/3 humerus fracture)

- Nerve gets tethered before ECRL
  Wrist drop, sensory loss, thumb drop, finger drop
**Peripheral Nerve Injuries**

- Wrist drop (radial nerve injury)

* Splint: Cock up splint

  - Static cock up splint
  - Dynamic cock up splint

- Late presentation - splint cannot be used

  - Tendon transfer
    1) Modified Jones tendon transfer
      - Wrist drop (paralysed ECRL / ECRB) - pronator teres tendon used
      - Finger drop (paralysed extensor digitorum communis)
      - Thumb drop (paralysed extensor pollicis longus)
    2) Boye's tendon transfer
    3) Brandt's tendon transfer
NERVE INJURIES - 2

Brachial plexus injuries

- C5 - Preset brachial plexus.
- T1 - Postset brachial plexus.
- Mechanism of injury - Traction

Injury

- Supraclavicular
  - Good Prognosis
  - Eg: Erb's palsy

- Combined
  - Worst Prognosis

- Infraclavicular
  - Eg: Klumpke's palsy

Winging of Scapula - Long thoracic nerve injury (C5, C6, C7)
(Supplies serratus anterior)

Brachial plexus injury

- Preganglionic
  - Injury proximal to dorsal root ganglion
  - Poor prognosis
  - Not amenable to repair

- Postganglionic
  - Injury distal to dorsal root ganglion
  - Better prognosis
  - Repairable
Histamine test:
- Inject histamine & scratch the skin
- Preganglionic
- Positive histamine test
- Postganglionic
- Negative histamine test

Erb's palsy
- Suprascapular nerve
- Erb's point - point of confluence of C₅, C₆, & suprascapular nerve
- Nerves injured:
  1. Suprascapular nerve → Supraspinatus
  2. Axillary nerves → Deltoid + teres minor
  3. Musculocutaneous nerve → Biceps brachii + brachialis

Deformity:
- Shoulder adducted & internally rotated
- Elbow & wrist - extended and pronated

Splint: Aeroplane splint
Klumpke’s palsy

- Injury at C₈ T₁
  - Due to hyperabduction injury
  - Less common
  - Clinical manifestation
    - (median + ulnar) > Radial
    - Complete claw hand
      - if presented along with
    - Loss of sympathetic supply of eye due to T₁ injury
      - (Horner’s Syndrome)
  - Ptosis, miosis, Hidrosis & loss of ciliospinal reflex

R₅ - Plexus reconstruction

Aeroplane Splint

Shoulder abducted
Elbow flexed
Wrist extended

Sciatic nerve injury

- MC Cause - Iatrogenic
  - MC nerve injured in hip surgery - Sciatic nerve
  - Other Causes - Hip dislocation, forearm injury etc
  - Sciatic nerve - cross section

Common peroneal (commonly affected)

Tibial

Common Peroneal nerve (CPN)
Superficial branch
- Evertors of foot

Deep branch
- Ankle dorsiflexors
- Toe extensors

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Peripheral Nerve Injuries

Injury to common peroneal nerve:
- causes Head of fibula fracture
- Lateral knee injury

Foot drop (Equinovarus deformity)

↓

Dragging of toes
↓ to prevent that

High stepping gait / foot drop gait / Steppage gait

Splint: Foot drop Splint (Toe raising Splint)
AFO (ankle foot orthosis)

any device that augments a body part

Entrainment neuropathies

-Conditions where a nerve gets entrapped under a structure resulting in compression.
MC affected nerve - median nerve

<table>
<thead>
<tr>
<th>SYNDROME / PATHOLOGY</th>
<th>NERVE</th>
<th>SITE OF COMPRESSION / INJURY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpal tunnel syndrome (MC)</td>
<td>Median</td>
<td>At Wrist</td>
</tr>
<tr>
<td>Cubital tunnel</td>
<td>Ulnar</td>
<td>Behind the medial condyle humerus</td>
</tr>
<tr>
<td>Guyon’s canal</td>
<td>Ulnar</td>
<td>Under the Pisio-hamate ligament</td>
</tr>
<tr>
<td>Pronator syndrome</td>
<td>Median Nerve</td>
<td>heads of PT</td>
</tr>
<tr>
<td>Klusch – Nevin Syndrome</td>
<td>AIN</td>
<td>Supracondylar humerus #</td>
</tr>
<tr>
<td>Choralgia parasthetica</td>
<td>Superficial Radial Nerve</td>
<td>Radial Styloid, insertion of Brachial Radialis (wrist watch, cuffs, bangles)</td>
</tr>
<tr>
<td>Meralgia parasthetica</td>
<td>Lateral Cutaneous Nerve of thigh</td>
<td>Under Inguinal ligament (tight Belt)</td>
</tr>
<tr>
<td>Pyriformis syndrome</td>
<td>Sciatic Nerve</td>
<td>Pyriformis &amp; Obturator Internus Muscle</td>
</tr>
<tr>
<td>Tarsal tunnel syndrome</td>
<td>Posterior Tibial Nerve</td>
<td>Behind Medial Malleolus Below the Flexor Retinaculum of foot (RA)</td>
</tr>
<tr>
<td>Morton metatarsalgia</td>
<td>Interdigital nerve of foot</td>
<td>Between 3rd &amp; 4th toe</td>
</tr>
</tbody>
</table>

Carpal tunnel Syndrome
- Nerve affected - median nerve
- Site - In the carpal tunnel under the transverse carpal ligament and flexor retinaculum

Etiology:
- Idiopathic (MC)
- Hypothyroidism
- Rheumatoid arthritis
- Pregnancy
- Acromegaly
- Gout
- Amyloidosis
- Colles’ Fracture
- Diabetes
- Lunate dislocation
- F > m
- 30-60 yrs

Clinical features:
- Pain
- Tingling
- Burning along median nerve distribution of hand (mc - during night)

Occupation: Typist / Computer Operator (compress median nerve)

Progression of disease
- Sensory symptoms → Motor symptoms → Wasting → Atrophy → Poor prognosis

Diagnosis:
1. Provocative tests
   - Phalen's test
   - Reverse Phalen's test
   - Durkan's test
   - Best clinical test
2. Torniquet test

IOC - Nerve Conduction Studies
- Nerve Conduction velocity
  - under carpal tunnel
  - velocity of impulse (due to compression)

Rx - Early: Conservative (Rest, steroids, splints)
- Late: Surgical
  - Decompress the carpal tunnel
    - Most importantly: Transverse carpal ligament release
      - Flexor retinaculum release
    - Flexor and palmar aponeurosis release

Popliteal artery entrapment syndrome

Congenital anomaly
- Medial head of gastrocnemius wraps around the popliteal artery
- Gastrocnemius hypertrophy (mc in athletes)
- Popliteal arterial blockade
- Ischemia
Peripheral Nerve injuries

A/WA - Exercise induced claudication

MC injured artery - Popliteal artery
MC cause:
1) Dislocation of Knee
   2) Distal femur fracture
MC injured artery in upper limb - Brachial artery
   - MC injury associated is Supracondylar humerus fracture

Thoracic outlet syndrome

- Entrapment of structures as they pass out through the thoracic outlet
- Boundaries: Anterior scalene, posterior

- Structures involved:
  1. Brachial Plexus > Artery > Vein
     $C_8 - T_1$
- Causes of obstruction
  1. Abnormal positioning of neck/upper limb
  2. Lung tumor causing compression
     Nerves $\rightarrow$ Brachial Plexus $\rightarrow$ $C_8T_1$ $\rightarrow$ Klumpke’s palsy
     Artery $\rightarrow$ symptoms of claudication
- Diagnosis: Clinically

1. Adson’s test - Abduct + Externally rotate shoulder & extend elbow
   ↓
   Turn head towards affected side and extend neck
   ↓
   Decreased pulse / claudication / pain

2. Roo’s test - (Elevated arm stress test)
   Abduct + Flex the elbow
   ↓
   Open and close hands (for 3 mins)
   ↓
   Symptoms of claudication seen

3. Wright’s hyperabduction test
   Hyperabduction of elbow & shoulder
   ↓
   Extend the neck
   Absent/Diminished pulsation $\rightarrow$ Positive Wright’s test
R - Conservative management (rest, splint, physiotherapy)
<table>
<thead>
<tr>
<th>Root</th>
<th>Myotome</th>
</tr>
</thead>
<tbody>
<tr>
<td>C5</td>
<td>Elbow Flexion</td>
</tr>
<tr>
<td>C6</td>
<td>Wrist Extension</td>
</tr>
<tr>
<td>C7</td>
<td>Elbow extension / Wrist Flexion</td>
</tr>
<tr>
<td>C8</td>
<td>Finger Flexion</td>
</tr>
<tr>
<td>T1</td>
<td>Finger Abduction</td>
</tr>
<tr>
<td>L2</td>
<td>Hip Flexion</td>
</tr>
<tr>
<td>L3</td>
<td>Knee extension / Quads</td>
</tr>
<tr>
<td>L4</td>
<td>Ankle dorsiflexion</td>
</tr>
<tr>
<td>L5</td>
<td>EHL / Hip Abductors</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Root</th>
<th>Reflex</th>
</tr>
</thead>
<tbody>
<tr>
<td>C5</td>
<td>Biceps</td>
</tr>
<tr>
<td>C6</td>
<td>Supinator (Brachioradialis)</td>
</tr>
<tr>
<td>C7</td>
<td>Triceps</td>
</tr>
<tr>
<td>L1, L4</td>
<td>Knee (Quadriceps)</td>
</tr>
<tr>
<td>S1</td>
<td>Ankle (Gastrosoleus)</td>
</tr>
</tbody>
</table>

### Denis 3 Column Of Stability

A spinal injury is considered stable, unless there is involvement of a column or the middle column.

### Spine Trauma

- MC mode of injury overall: RTA
- Developing country: Fall From Height
- Developed: RTA
- MC mechanism of injury: Flexion and distraction force
- MC site of: Lower Thoracic
  - Dislocation - Cervical (Dislocation without #)

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m/c site of spinal cord injury - Cervical (max. movement)

Hinge # /motorcyclist #

middle Cranial Fossa #

Into Anterior & Posterior halves

Jefferson's #

• mC # of C vertebrae
• Compression / Axial Forces

• xRays - Open mouth / Odontoid View

Treatment: Rigid brace ➔ Fusion Surgery

Hangman's fracture

• # & Dislocation of C vertebrae Over C
• spondylyosis of C
• spondylyolisthesis of C Over C

spondylyosis - fracture in pars interarticularis

mC C # - Odontoid #

whiplash #

- Anterior Longitudinal Ligament Sprain
- Classical Neck Pain - Chronic
Undertaker’s fracture

### Clay Shoveler’s #
- **Avulsion # of Spinous Process Usually Of C7 > T1**

### Chance #
- Aka seatbelt #, Jack Knife #
- Only Lumbar Belts, No Thoracic support
  - Flexion + Distraction Force
  - Bony Chance #
  - Soft Chance

### Sciwora
- **Sciwora - Spinal cord injury without radiographic Abnormality**
  - Children < 8yrs
  - Spinal column can move beyond physiological range but spinal cord injury
  - Spinal Shock - Physiological Disruption Of Spinal cord
  - All reflexes lost immediately
  - 24 - 48 hrs
  - 1st Reflex to reappear - Bulbocavernous Reflex

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Neurogenic shock

Sympathetic Supply to peripheral blood vessels & heart lost

Peripheral vasodilation

↓ BP (compensatory tachycardia)

Neurogenic Shock (Peripheries → warm)

Types of spinal cord injury

Partial

- Sacral Sparing
- Perianal sensations
- Rectal tone

Complete

- Sacral Sparing
- Perineal Sensations
- Rectal Tone
- Deep tendon reflexes

Above the level of lesion → Normal
At the level of lesion → Absent
Below the level of lesion → Exaggerated

Management of spinal cord injury

- NASCIS III (National Acute Spinal Cord Injury Study Protocol)
  - Steroids can be used (within 6 hrs of injury)
    - methyl prednisolone can be given as:
      - Bolus dose: 30mg / Kg / Body wt → later
      - 5.4mg / Kg / Body wt → IV infusion (maintenance dose)
  - After 8 hours of injury → no role of steroids
  - Use of steroids → ↑ Risk of pneumonia
    - MC cause of death in Spinal cord injury patients.
Conus Vs Cauda injury

In Conus medullaris lesion:
- Bowel & Bladder involvement
- No lower limb weakness.

PIVD

- Prolapsed Intervertebral Disc
  Function:
  - Acts as a cushion / shock absorber
  - ↑ loading of spine (abnormal posture)

  Degeneration:
  - disc bulges out posteriorly
  - Prolapse
  - Proximal disc associated with prolapse!

- L₄ - L₅ > L₅ - S₁

Types of disc prolapse:
1. Disc Degeneration
   a. Prolapse
   b. Extrusion
   c. Sequestration

Locations for disc prolapse:
- Vertebral body
- Spinal canal
- Spinous process

Types:
1. Central
2. Paracentral
3. Lateral
Clinical Features

1. Pain - Lower backache
   - Radiating to lower limb

2. Test: Straight leg raising test - Patient is unable to do it
   - Dermatomes
   - Myotomes
   - Reflexes
   - Helps to differentiate the type and site of disc prolapse

3. Level

LOC - MRI Spine
- In Cervical Spine - MC disc prolapse - C₄ - C₇

Treatment Of PIVD

- Rest
- Physiotherapy
- No Recovery / Bowel & bladder involvement
  - Surgery
  - Discectomy
  - Laminectomy
  - Laminotomy
  - Hemilaminectomy

Warning: Not all points are covered in the notes, especially conceptual explanations. Please use the notes in conjunction with Marrow Edition 4 videos.
Cauda Equina Syndrome

- Massive prolapse of the intervertebral disc causing compression of all the nerve roots
- Surgical management

Lysthesis

- Slipping of one vertebrae over another

Break of the Pars Interarticularis—Spondylolysis

Causes
a) Congenial
b) Traumatic (mc)
c) Degenerative / Dysplastic

Scottish Terrier Sign (Scotty Dog) (Normal view)

Pars Interarticularis—

Dog with collar sign (oblique view) — Spondylolisthesis — beheaded scotty dog sign

Spondylolisthesis - L₅ - S₁
Spondylolysis - L₅

Scoliosis

Lateral deviation with or without rotational component

- Lumbar Scoliosis
- Dorsal Scoliosis
MEASURING THE COBB ANGLE

**Causes**

- Non-structural
  - Postural / positional (reversible)
    - Detected by Adam's test

- Structural
  - Idiopathic (mc)
    - $\varphi > \sigma$

**Congenital Scoliosis**

- Semi segmentation
- Fully segmented
  - Block
  - Unsegmented bar

**Treatment Of Scoliosis**

1. Milwaukee Brace
2. Boston Brace
1. Surgical Scoliosis Correction
   - Harrington Rod - Usually used in correction surgeries

Lateral Points
Tear Drop #

Teardrop Fracture

- Fexion + Axial Compression force
- Vertebral Body - Shape of teardrop
UPPER LIMB TRAUMA: CLAVICLE & SHOULDER

mechanism of injury: Fall on an outstretched hand

To protect face

Clavicle

mc site of clavicle #: Junction of medial 2/3 & lateral 1/3
or
middle 1/3rd
or
medial 3/5th and lateral 2/5th

- Only horizontally arranged long bone
- A primary centres of ossification & one secondary ossification
- First bone to start ossification 5th week of IUl
- Last bone to complete ossification
- Only long bone ossify in membrane.

mc # at birth - clavicle #
( mechanism: birth extraction )
mc # overall clavicle newborn

Displacements of clavicle fracture

Sterno cleidomastoid

- weight of the limb
- pectoralis muscle.

mc complication of clavicle # - malunion

Other complications
1. Neurovascular injury
   - brachial subclavian plexus vessels
a. Non-union: very rare.

Rx of clavicle #

1. Conservative
   - Arm sling / arm of pouch
   - Figure of 8 bandage

2. Indications of surgery:
   a) Open clavicle #
   b) Massive displacement
   c) Clavicle # → Lateral (involving acromioclavicular joint)
   d) # with neurovascular injury
   e) Floating Shoulder

   - # Clavicle
   - # Glenoid

Shoulder injuries

- Ball & socket joint

  Head of Glenoid
  Glenohumeral ligaments
  Glenohumeral ligaments
  Glenohumeral ligaments

  Movements
  - Flexion
  - Extension
  - Adduction
  - Abduction
  - Internal rotation
  - External rotation
  - Circumduction

Most mobile joint in the body: Shoulder joint

Most commonly dislocated joint

Stabilisers of shoulder joint

- Static
  1. Capsule
  2. Labrum
  3. Glenohumeral ligaments
      - superior
      - middle
      - inferior

- Dynamic
  1. Rotator cuff muscles
      - Supraspinatus
      - Infraspinatus
      - Teres minor
      - Subscapularis

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a) Deltoid
3) Biceps tendon

Shoulder joint is weak inferiorly.

MC type of shoulder dislocation
Anterior > posterior > inferior

Anterior dislocation of shoulder

Subtypes
1. Preglenoid
2. Subcoracoid (MC)
3. Subclavicular
4. Intrathoracic

Mechanism of injury & features

- Fall on an outstretched hand
- Abduction & external rotation
- Direct trauma

Clinical features.
1. Attitude of limb: Arm by the side of body
   - Abduction & external rotation

Other injury
1. Axillary nerve injury (MC nerve to be injured)

Tests
1. Hamilton's ruler test - ruler over lateral aspect of arm
   - check for touching the acromion & lateral epicondyle of humerus

2. Dugas test - touch opposite shoulder
3. Callaway's test - vertical axillary circumference
4. Axillary nerve function
   - Motor:
     - Deltoid
     - Teres minor
   - Sensory:
     - Regimental badge area (paresthesia/burning sensation)
Radiology of shoulder dislocation

- AP - head is dislocated anterior or posterior

Management

1. Reduce the dislocation

   - MC technique modified Kocher's technique
   - Other: Stimson Hippocratic

2. Bandage - Velpeau bandage

Complication of shoulder dislocation

1. MC complication - recurrent shoulder dislocation

2. MC early complication - Axillary nerve injury (circumflex branch)

Hill Sach's lesion

Due to recurrent shoulder dislocation

- Head of humerus hits the glenoid repeatedly
- Indentation on the posterolateral head of humerus
- Hill Sach's lesion (2nd MC)
Posterior dislocation

- mechanism of injury → High voltage electric shock ECT, Seizure.
  Fall on outstretched hand, Direct trauma.

  X-Ray Light bulb Sign
  (adducted & internally rotated)

  Lesions
  - Reverse Bankart
  - Reverse Hill Sachs’
  - Posteroinferior
  - Antero-medial

Inferior dislocation

- a/k/a Luxatio erecta.
- Extremely rare
- mechanism of injury → Hyperabduction injury

  Arm by the side of the body

Tests for shoulder instability
1. Anterior:
   - Fulcrum test
   - Crank test
   - Apprehension test

   Abduct & external rotate shoulder

2. Posterior - jerk test

3. Inferior - Sulcus test
Surgeries for shoulder instability

- Putti-Platt
  - Double breasting capsule using Subscapularis

- Latarjet
  - Cut the Coracoid and reposition it in front of shoulder joint
UPPER LIMB TRAUMA - ARM & ELBOW

Proximal humerus fracture

- M.C. in post menopausal, osteoporotic females
- Mechanism - Fall on outstretched hand
- M.C. # - Surgical neck #

Neer Classification - I - Undisplaced
   - II - 2 parts
   - III - 3 parts
   - IV - 4 parts - worst prognosis

- M.C. complication → Stiffness
- M.C. → Axillary nerve

Rx : Undisplaced # - Conservative - Arm pouch
     Arm Sling
     Unstable # - Surgery: Open Reduction with Internal Fixation (ORIF)

Shaft of humerus fracture

- M.C. Site: Junction of upper 2/3rd & 1/3rd
     Holstein & Lewis #

- M.C. Nerve injury - Radial Nerve Injury
     Wrist drop → Cockup Splint
management

1) # with no Radial nerve palsy - Conservative
   i. U-Slab
   ii. Hanging cast.

2) # with radial nerve palsy - Neuropraxia
   - Recovers fully in 3 months
   - not recovering
     - Nerve Conduction Study
       - recovering
         - wait & watch
       - not recovering
         - Surgical exploration

3) Open # - ORIF with exploration of nerve

Fracture around elbow

- 3 point bony relationship
- maintained in Supracondylar Humerus #
- Disturbed in - Olecranon #
  - medial condylar #
  - lateral condylar #
  - Inter condylar #
  - Elbow dislocation

Fracture of lateral condyle of humerus

- 3 point bony relationship - disturbed
- Physeal injury +
- intraarticular #
- **Type IV - Salter Harris #**
- **Deformity - 1. Cubitus valgus - lateral deviation of forearm, carrying angle ↑**
  - Tardy ulnar nerve palsy
- **Complications - 1. Elbow Stiffness - m.C.**
  - Non union
- **# Of Necessity: 1. Intraarticular #**
  - Neck of femur #
  - Galeazzi #
  - Monteggia #

**Supracondylar fracture of humerus**

- m.C. # around elbow in children
- mechanism of injury - fall on outstretched hand
- extension type - m.C.

**Gartland classification**
- **Type I - undisplaced**
- **Type II - incomplete**
- **Type III - Complete / displaced → Flexion type**
  - **Extension type**
  - **Posterior type (m.C.)**
  - **Posterior lateral**

**Displacement in Supracondylar #**
- 1. Proximal migration
  - a. medial tilt
  - 3. medial shift
  - 4. internal rotation
  - 5. posterior tilt
  - 6. posterior shift

- **m.C. injured nerve: AIN (Anterior Interosseous Nerve) > median Nerve > radial > ulnar**

- **m.C. artery injured: Brachial artery**
Brachial artery injury

↓

Ischaemia of muscles

Volkmann's ischaemic contracture

Compartment Syndrome

Volkmann ischemic contracture.

R: Reduce #

Type I - Conservative with POP
Type II - POP / Closed Reduction / ORIF
Type III - ORIF with K - Wire

- Baumann's Angle - helps to assess the reduction intraoperatively.

Complications of supracondylar fracture

Early Complications - 1. Brachial artery injury
   a. Volkmann ischemia
   3. Compartment syndrome
   4. Volkmann ischemia contracture.

Late Complications - 1. Malunion - Cubitus varus deformity
   Gunstock deformity
   a. Myositis ossificans

Compartment Syndrome

Ischemia → Inflammation → Swelling of muscle inside the facial
   Compartments.

Compression of small structure in the compartment.

Veins > artery

Further ischemia.

- MC. cause of Volkmann ischemia in children - Supracondylar #
  Other causes - Burns
  Soft tissue injury
  Tight POP

- MC. cause of compartment syndrome in children - Supracondylar #

- MC. cause of compartment Syndrome overall - Tibial diaphyseal
Clinical features - 1. Pain on passive stretch - most imp.
   - a. Pallor
   - 3. Parasthesia
   - 4. Paralysis
   - 5. Pulselessness

- Manometer - To measure the pressure inside compartment.
  - $P < 10 \text{ mm Hg}$
  - $P > 30 \text{ mm Hg}$ → Compartment Syndrome

$R_x$: Fasciotomy

Volkmann's ischemic contracture

<table>
<thead>
<tr>
<th>Ischemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibrosis of forearm muscle</td>
</tr>
<tr>
<td>Flexion contracture of wrist &amp; fingers</td>
</tr>
<tr>
<td>Sensory loss &amp; Motor paralysis in the forearm &amp; hand</td>
</tr>
</tbody>
</table>

$R_x:$ -
1. Mild deformities: passive stretching
   - using a Turn buckle Splint
   - (Volkmann's Splint)

2. Moderate deformities:
   - Muscle Sliding (Max Page) operation.

3. Severe deformities: Bone shortening

Malunion / Cubitus varus deformity
- M/C. Complication
- Gunstock deformity
- Elbow function: normal
- $R_x$: Modified French Osteotomy.

Myositis Ossificans
- Due to trauma / massage
- M/C. Muscle involved: Brachial
- M/C. Joint involved: Elbow > Hip

$R_x$: 1. Active phase - NSAIDS (Indomethacin)
   - 2. Latent phase - Active physiotherapy
   - 3. If elbow movements not restored - Excise the mass surgically
Elbow dislocation

- m.C. Dislocation in children.
- ulno - humeral
- m.C. posterior / posterola...
- Attitude following dislocation - Flexion at elbow
- X-ray: Coronoid process behind the humerus

- m.C. nerve injured - ulnar nerve.

Terrible triad of elbow
- Hotchkiss triad
  1. Posterior elbow dislocation
  2. Coronoid #
  3. Radial head #

Pulled elbow / Nursemaid's elbow
- Self limiting Subluxation
- Distal subluxation of radial head out of annular ligament.

- mechanism of injury - Axial traction of extended and pronated elbow
- 2 to 5 yr age
- Attitude : Extension and pronation
- X ray - Normal
- Reduction - Flexion + forceful supination
UPPER LIMB TRAUMA: FOREARM, WRIST AND HAND

Forearm trauma

1. Both bones forearm fracture.
   Radius + ulnar shaft

   Adults
   • Open reduction
   + Internal fixation (ORIF)
   with plates.

   children
   • Open reduction
   + Internal fixation (ORIF)
   with plates.

   Position of cast
   • Upper 1/3rd #: supination.
   • Lower 1/3rd #: pronation.
   • Middle 1/3rd #: mid-prone position.

2. Monteggia fracture
   Fracture of upper 1/3rd of ulna + dislocation of radial head.
   • #: of necessity (requires surgery)
   • Treatment: ORIF of ulna.

   Classification of monteggia.

   a. Bado classification
   Type i: MC
   Type ii: anterior dislocation of radial head
   Type iii: posterior dislocation
   Type iv: lateral dislocation
   Treatment: ORIF of ulna.

   Complication:
   Pin palsy
   Features: Finger and thumb drop
   No sensory loss.

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**Galeazzi fracture**

- Reverse monteggia / peckmont #
- Lower 1/3rd radius fracture +
  - Distal radius - ulnar joint dislocation
- Interosseous membrane tear
- Distal radius - ulnar joint ( dryj )
  - Stabilised by Triangular fibrocartilage complex.
- Of necessity
  - Treatment: ORIF of radius

**Essex lopresti and night stick fractures**

**Essex lopresti #**

**Mechanism of injury:**
- Axial force acting on forearm.

**Components:**
1) dryj disruption
2) interosseous membrane tear
3) radial head #

**Treatment:**
- ORIF
- Radial head excision (comminuted #)
  - Contraindicated in children

**Night stick fractures**
- Isolated # of shaft of ulna.
- Medicolegal importance: indicates self - defense injury
- Treatment: ORIF with plating.

**Fractures of wrist**

**Distal end of radius #**

**Classified by abraham colles.**
- Colles #
- Smith #
- Barton #
- Chauffeur’s #

**Warning:** Not all points are covered in the notes, especially conceptual explanations. Please use the notes in conjunction with Marrow Edition 4 videos.
**Colles fracture**

<table>
<thead>
<tr>
<th>Colles #</th>
<th>smith #</th>
<th>Barton #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra-articular</td>
<td>Extra-articular</td>
<td>intra-articular</td>
</tr>
<tr>
<td>Distal Fragment</td>
<td>displaced</td>
<td>Dorsal</td>
</tr>
<tr>
<td>Displaced dorsally</td>
<td>ventrally</td>
<td></td>
</tr>
</tbody>
</table>

- **Colles #**:  
  - Distal end of radius at cortico - cancellous junction  
  - Extra-articular  
  - Common in elderly post-menopausal women  
  - Mechanism: Fall on out-stretched hand - wrist in extension (Smith #: wrist in flexion)  
  - Displacement of distal fragment:  
    - Dorsal tilt/shift  
    - Lateral tilt/shift  
    - Impaction  
    - Supination  
  - Dinner fork deformity
Treatment:
1. Colle's cast: below elbow cast
   Position: pronation
   Ulnar derivation
   Palmar flexion of wrist
   R/K/A hand shaking cast

2. Closed reduction - internal fixation (crif) with K-wires.
3. ORIF with plates

Complications:
- Stiffness (MC) of finger
- Malunion (ARMC)
- Complex regional pain syndrome (CRPS)
- Rupture of extensor pollicis longus tendon
- Carpal tunnel syndrome → median nerve injury
- Non-union → rare

Smith's fracture and Barton fracture

Smith fracture
- Reverse Colles
- Distal segment displaced ventrally
- Mechanism:
  Fall on outstretched hand with wrist in flexion
- Extra-articular
- Garden spade deformity
- In young people

Treatment:
- Pop cast: above elbow
- ORIF with plates

Barton
- Intra-articular of distal end of radius rim leading to carpal subluxation (dorsal or ventral)
- Treatment: ORIF with plates
Chauveur's fracture
- Driver's # / backfire #
- Isolated radial styloid #
- Intra-articular #
- R: orif with plates

Carpal bone fractures

m. C carpal bone #: scaphoid

Scaphoid #
- Mechanism: fall on outstretched hand
- Adolescents / young adults
- Clinically → pain / tenderness in anatomical snuff box

X-ray:
- Oblique wrist view (best)

MRI: (if not visualised on X-ray)

Treatment:
- m. C → # of waist of scaphoid
- undisplaced # → glass holding cast
  - Dorsiflexion and radial Deviation of wrist

Upper Limb Trauma:
Forearm, Wrist and Hand

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Displaced # → ORIF with
- Herbert screw
  - Headless screw
  - Differential threading

Types of scaphoid #

Vascularity: distal to proximal.

1. # of waist of scaphoid (mc)
2. # of distal 1/3rd (mc in children)
3. # of proximal 1/3rd: ↑ chance of nonunion ↓ avn (avascular necrosis)

m.C complication of waist of scaphoid #:
- Non-union > AVN (mc: proximal pole)

Carpal bones:

Normally:
- Distal end of radius, lunate
- And capitate in one line

Carpal bone instability:
- Terry thomas sign.
  - Normal distance between lunate & scaphoid: < 2mm.
  - Distance > 3mm → scapho - lunate dissociation.

• m.C carpal bone to dislocate = lunate
  → median nerve injury
Lunate v/s perilunate dislocation

Lunate

- Isolated lunate: dislocation
- Capitate \(\perp\) radius: in alignment
- Spilled coffee cup sign

perilunate

- Radius \(\perp\) lunate: in alignment
- Carpal bones: dislocation
- Tavernier's maneuver

Fractures of hand

Bennett's & Rolando #: 

- # Base of 1st metacarpal
- Intra-articular # at trapeziometacarpal articulation.

Bennett's #

- Partial #
- Displacement \(\oplus\)
  (Due to pull of Abductor pollicis longus)

Rolando #

- Complete comminuted #
- Undisplaced #


Boxer's #:
- Extra-articular # at neck of 5th metacarpal
- Treatment: James plaster
  - Applied in position of ease / safe immobilization.

Fracture of finger

mallet finger
- Aka baseball finger
- Avulsion of extensor digitorum communis tendon from soft tissue or bone
- Flexed dip
- Inability to actively extend dip
  Passive extension  
- Treatment: mallet splint
Jersey Finger
• Avulsion of flexor digitorum profundus tendon from base of distal phalanx on ventral side

• Inability to flex dip (actively) passive flexion - normal.

• X-ray - normal.
  - Bony fragment at base of distal phalanx

Bowler's Thumb
• Perineural fibrosis of ulnar digital nerve of thumb in bowlers.

• Features: tingling, numbness, swelling around base of thumb.

• Treatment: use of gloves / pads to protect nerve
  Nerve splint
  Neurolysis
LOWER LIMB TRAUMA - I

Normal pelvis

X-ray of the hip

- Inferior margin of superior
  Pubic ramus & medial part
  of femoral head & neck
  Disrupted in
  Dislocation
  Pathologies

Neck - shaft angle.
- Normal - 135 - 130°
- Coxa valga
- Coxa vara

Pelvis #
- Flat / cancellous bone + venous supply
  - Blood loss - 155 - 2L
  - Bleeding
  - Soft tissue injury
    - M/C urethra
Clinical features of urethral injury

1. Unable to void
2. Pain
3. Blood at urethral meatus
4. Hematuria

Classification of pelvis fracture

<table>
<thead>
<tr>
<th>Tile classification</th>
<th>Vertically stable &amp; horizontally stable</th>
<th>Vertically stable unstable rotationally</th>
<th>Both unstable</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Eg, Duverney’s #</td>
<td>Eg, open book #</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Iliac ring #</td>
<td>straddle #</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>malgaignes #</td>
<td>Bucket handle</td>
</tr>
</tbody>
</table>
Acetabular fracture

Columns

Wall

Anterior   Posterior  Anterior   Posterior

Judet’s classification

- Anterior wall #
- Anterior column #
- Posterior wall # (mc)
- Posterior column #
- Bicolumnar # (spur sign)

Judet view - used specially for acetabulum

Spur sign - seen in bicolumnar ‘T’ shaped or transverse # of acetabulum

Trendelenburg test

- Test to assess abduction of hip
- Abductors are-
  - Gluteus medius
  - Gluteus minimus
  - Superior gluteal nerve
  - On nerve / muscle damage
  - unable to tilt pelvis back to neutral
  - Sinking
  + ve Trendelenburg test

left side affected    vice versa

Right side hip tilts down

Trendelenburg gait: uses the whole body to lift the healthy side up
Waddling gait: due to bilateral failure of abductors
Thomas test

- For flexion contracture of hip
  - Disappearance of lumbar lordosis
  - Reveals flexion contracture of hip

**Thompson Test:***
- Integrity of tendo achilles
- A/K/A Symonds' Thompson test

Dislocation of hip

Types

- Simple
- Complex
  - (≠ ≥ dislocation)

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior</td>
<td>Force from greater trochanter</td>
</tr>
<tr>
<td>Anterior</td>
<td>Force from greater trochanter</td>
</tr>
<tr>
<td>Posterior</td>
<td>Force from greater trochanter</td>
</tr>
<tr>
<td>Central</td>
<td>Force from greater trochanter</td>
</tr>
</tbody>
</table>

- Posterior dislocation
- Central dislocation

Complications of dislocation

Overall - avascular necrosis of head of femur.

- Posterior
  1) Sciatic nerve injury
  2) Vascular sign of Narath

- Anterior
  1) Femoral nerve injury
Blood supply of femur

**GT** - Greater trochanter
**LT** - Lesser trochanter
**RV** - Retinacular vessels
**LEA** - Lateral epiphyseal artery
**MEA** - Medial epiphyseal artery
**FVA** - Foveolar artery
**FA** - Femoral artery
**PFA** - Profunda femoris artery
**MFCX** - Medial femoral circumflex
**LFCX** - Lateral femoral circumflex
Intra & extracapsular #

<table>
<thead>
<tr>
<th>Neck of Femur #</th>
<th>Intertrochanteric #</th>
</tr>
</thead>
<tbody>
<tr>
<td>a/k/a intracapsular #</td>
<td>a/k/a extracapsular #</td>
</tr>
<tr>
<td>1. 50-60 yrs</td>
<td>1. 70-80 yrs</td>
</tr>
<tr>
<td>2. $\theta &gt; \Phi$</td>
<td>2. $\theta &gt; \Phi$</td>
</tr>
<tr>
<td>4. Mild pain</td>
<td>4. Mod-severe pain</td>
</tr>
<tr>
<td>5. Trivial fall</td>
<td>5. Mod-severe fall</td>
</tr>
<tr>
<td>6. Shenton's line broken</td>
<td>6. Shenton's line broken</td>
</tr>
<tr>
<td>7. Shortening $&lt;1^\circ$</td>
<td>7. Shortening $&gt;1^\circ$</td>
</tr>
<tr>
<td>8. External rotation $&lt;45^\circ$</td>
<td>8. External rotation $&gt;45^\circ$</td>
</tr>
<tr>
<td>9. AVN &gt; Non union</td>
<td>9. Malunion / coxa vara</td>
</tr>
</tbody>
</table>

Classification of fractures of femur

(i) Anatomical
(ii) Garden's
(iii) Pauwells

1. Anatomical

more proximal the fracture, worse the prognosis
Wolff's Law: Bone formation occurs in areas of stress.

Worst prognosis - type IV
- Type I - Incomplete / valgus impacted #
- Type II - Complete partially displaced #
- Type III - Complete partially displaced #
- Type IV - Complete fully displaced #

Pauwels Classification

- More the angle more unstable is the fracture
- Angle made by # line & horizontal line
- I <30°
- II 30-50°
- III >50°

Management of fracture of femur

- Age of the patient
  - <65y
    - Fracture age
      - <3wks
        - CRIF with cannulated cancellous screws
      - >3wks
        - MRI
        - Replacement
          - Hemi
          - Total
        - Non-Viable
        - Viable Head
  - >65y
Hemiarthroplasty

1. Austin Moore → a fenestrations
2. Thompson
3. Bipolar

Treatment of intertrochanteric fracture

- PFN: Proximal Femoral Nail
- DHS: Dynamic Hip Screw

Complications:

- NOF #: Non Union
  - Lacks cambium layer
  - Synovial fluid interferes with fracture healing.
- IT #: Malunion - Coxa vara
  - Trendelenburg gait
Shaft of femur fracture

• Winquist & Hansen classification
  for shaft of femur
• Most complication: stiffness of knee joint
• Other complication:
  - Delayed union
    - Non union
    - Shock → loss of blood
      - 1 - 1.5 L
  - Fat embolism syndrome

• Fat embolism syndrome:
  - usually takes 48 hours to manifest
  - doesn't occur in children → no fat in medullary cavity

  Triad
  Respiratory symptoms: Dyspnea or tachypnea.
  Neurological symptoms: Confusion or disorientation
  Petechial rash: In axilla, neck, periumbilical area,
  Conjunctiva of lower lid, front and back of chest, shoulder

• Differential Diagnosis: ARDS
• Gurv's criteria for diagnosis of fat embolism syndrome:
  • Usually a clinical diagnosis
  major Criteria:
  - Axillary / sub conjunctival petechiae
    - PaO₂ below 60 mm Hg
    - CNS depression
    - Pulmonary oedema
  minor criteria:
  - Tachycardia
  - Fever
  - Anemia
  - Thrombocytopenia
  - Fat globules in sputum
  - Fat globules in urine - Gurv test
  - ↑ ESR
  - Retinal emboli

1 major + 4 minor = Fat embolism

• Myositis ossificans: massage following # (classical history)
• Compartment syndrome: Swelling in the joint, pain on passive stretching
SPORTS INJURIES

Structures around knee joint

Collaterals:

1. Medial collateral ligament
   - A/V/A tibial collateral ligament
   - MC ligament to be injured (Less mobile)
     - Because it is attached to medical meniscus

2. Lateral collateral ligament
   - A/V/A fibular collateral ligament
   - Popliteus tendon (present inside knee joint)

- Menisci and cruciate ligaments are intracapsular
- Lateral collateral ligament & medial collateral ligament
  - Extra capsular
  - Provide coronal plane stability
  - Resist valgus and varus force

- Valgus force: MCL in tension
- Varus force: LCL in tension

- Provocative test for MCL- Valgus stress test
  - Knee at 30° flexion
- Provocative test for LCL- Varus stress test

- IOC for collateral ligament injury - MRI

- Treatment: conservative, a brace should be applied
  - Not healing / complete tear, surgical intervention is required
Meniscal injury

- A meniscus - medial and lateral meniscus
  - Predominantly have collagen I
  - Intracapsular, intrasynovial structure
  - Medial meniscal injuries: more common
    - It is less adherent to medial collateral ligament
    - It occupies less surface area of the tibia.

- A source of nutrition:
  1. Peripheral area (red zone): blood.
  2. Central area (white zone): synovial fluid intraarticularly.

  Transition zone is called as Red white zone.

- Tear in red zone can be repaired and heals better due to abundant blood supply.
- A tear in white zone
  - Rx: Excision of the torn piece

- Menisci are cushions of the knee joint.
- Twisting/ rotational/ tortional force on knee joint

  Meniscal injury:
  - In flexed/ semiflexed knee

  Any kind of meniscal injury

  As rotation is possible around knee in flexed/ semiflexed position

- MC meniscal tear: medial meniscus (type - vertical tear)
- Vertical/ longitudinal tear extending up to posterior horn and anterior horn

  Bucket handle tear

  MC type of meniscal tear.

Reason:
1. Less mobility
2. Adherence to the MCL
3. The weight bearing axis of the knee
Clinical presentations:
- Fusion of Knee / Locking of Knee (pathological)
  Due to injured piece of meniscus in between the knee joint
- Delayed effusion
- "Bulge sign" / "Bulge test"
  For minimal fluid collection (<20-30 ml)

Provocative tests of meniscal injury

1. mcmurray's test
2. Apley's grinding test
3. Thessaly test
4. Ege's test

IOC: MRI
Gold standard investigation: Arthroscopy

Cruciate ligaments of knee

- a cruciate ligaments:
  Anterior cruciate ligament (ACL)
  Posterior cruciate ligament

- provide sagittal plane stabilization
- intracapsular & extrasynovial
- in case of ACL / PCL tear: instability of knee.
ACL

→ MC to be injured
→ Prevents anterior translocation of tibia.
→ Prevents hyperextension of knee
→ Primary rotational stabilizer - internal rotation
→ Patients with ACL tear have difficulty in going up the hill/stairs.
→ ACL usually tears in the substance.

PCL

→ Thicker and longer than ACL.
→ Prevents posterior translocation of tibia.
→ External rotation stabilization.
→ Patients with PCL tear have difficulty in going down the hill/stairs.
→ Patients with ACL tear have difficulty in going up the hill/stairs.
→ Avulsion from bone
→ In dash board injuries

Provocation tests for cruciates

1. Anterior Drawer test:
   → Test for ACL tear
   → Hip flexed to 45°, knee flexed to 90°
   ↓ Pulled anteriorly.
   → If ACL injured- tibia will translocate easily towards anterior side.
2. Lachman test:
   - Test for ACL tear
   - Knee flexed to 15-30°
   - Tibia pulled anteriorly
   - In ACL injury: knee will easily translocate anteriorly.
   - Preferred over anterior:
   - Best test for acute/chronic ACL tear.
   - Most sensitive test.

3. Posterior drawer test:
   - Test for PCL tear
   - Knee flexed to 90°
   - Pushed posteriorly.

Tests for cruciates

- ACL
  1. Lachman's test - sensitive
  2. Anterior drawer test
  3. Pivot shift test - specific
  4. Lellis's test

- PCL
  1. Posterior drawer test
  2. Sag test
  3. Reverse pivot shift test

- IOC: MRI
- Gold standard: Arthroscopy.

Twisting injury to knee mechanism

- Fixed leg, flexed knee, valgus/ lateral force/abduction force
  - Femur internally rotated
  - Injury to MCL (1st one to get injured)
  - ACL & medial meniscus injury

- O'Donoghue Triad:
  - MCL, ACL and medial meniscus injury
  - AKA Painful/Terrible/Unhappy triad of knee.
O'Donoghue test:
Test to assess cause of pain in the neck between cervical spine sprain v/s cervical spine strain.

- IOC: MRI
- Rx: reconstruction
  - Arthroscopy
    - Patients have rotational instability around knee joint
    - Tendon grafts used:
      - Hamstrings
      - Semitendinosus
      - Gracilis
      - Patellar tendon

Arthroscope / portals

- Arthroscope used for knee:
  - 4mm/30° arthroscope,
  - Angle of inclination of camera: 30°

- MC arthroscopy knee >> shoulder
- 2 standard portals - Anteromedial portal (instrumentation)
  - Anterolateral portal (visualising - camera)

Dial test:
- Helps us to identify injury to Posterior lateral corner of the knee.

Ankle sprain

- MC method of ankle injury
  - Inversion of plantarflexed foot
  - Lateral ligaments stretched
- MC injured lateral ligament: Anterior talofibular ligament
- MC injured ligament around knee: MCL
- MC mechanism of injury - Inversion of the foot
- MC injured tendon in the body - Supraspinatus tendon
Bulge sign:
- Occurs in fusion of knee joint in medial meniscal injury
- 15-30 ml of fluid accumulation

Insall-Salvati Ratio:
1. Length between the tibial tuberosity and lower pole of patella
   \[ \text{length of patellar tendon} - TL \] (tendon length)

2. Length of patella - PL (patella length)
   \[ \frac{TL}{PL} = 0.8 - 1.2 \] - normal

- If the 'TL' value increases - ratio also increase (>1.2)
  suggest patella at higher level.

- If patella at lower level
  ratio decreases (< 0.8)

"Patella alta"
"Patella baja"
Paediatric Bone: Characteristics

- Increased water content in bone
- Soft & flexible
- Thick periosteum
- Resilient to stress
- Good potential for remodelling - especially metaphyseal end

Force → long bone → Bend (Plastic deformation)

- Outer surface: Convex
  - Force → Tension force

- Inner surface: Concave
  - Force → Compression force

On ↑ force → Concave surface: Buckle # / Torus#

- Convex surface: unicortical #/Green stick #

- mc in forearm: Radius > ulna
  - Distal part of radius

- mc # in children: Green stick fracture
- mc # overall: Clavicle fracture
- mc # at birth: Clavicle fracture

Treatment: • Plastic deformities: POP
  - Torus #: POP
  - Green stick #: Osteoclasis followed by POP
Growth Plate Injuries

**Physis - Growth plate**
- Radiolucent
- Interstitial growth
- Direction of growth: Epiphysis to metaphysis

- Weakest layer in the growth plate: Hypertrophic layer
- If germinial layer is injured → No growth

**Salter- Harris Classification of growth plate injury:**

Type I: # line splits the growth plate (split#) → Good prognosis
Type II: # line goes above towards metaphysis → Good prognosis
Type III: # line goes towards epiphysis → Injures germinial layer → Poor prognosis
Type IV: All 3 layers of bone injured → Poor prognosis
Type V: Compression / Impaction injury → Crushed growth plate → Worst prognosis
Type VI: Perichondrial ring injury

- Mc type → Type II
- Best prognosis → Type I
- Thurston Holland fragment / sign → Intact metaphyseal fragment in Type II

**Examples:**
- Type I → Slipped Capital Femoral Epiphysis (SCFE)
- Type II → Supracondylar humerus#
- Type III → Lower end of tibia # in children
- Type IV → Lateral condyle of humerus #
  (↑ of necessity)
- Type V → Limb length discrepancy or deformity with previous history of fall from height.
Treatment: Shaft of femur fracture & fat embolism syndrome

Fat embolism syndrome: Treatment
- Prevention: Immobilize immediately
- Treatment: Damage control orthopaedic principle.
  - External fixator → stabilize
  - Intermittent positive pressure ventilation → O₂
  - Steroids, Heparin, Dextran

Shaft of femur #: Treatment
- < 6 month → Pavlik Harness
- 6m to 5yr → Hip Spica Cast (TOC)
  (< 2yr = Gallows Traction)
  Weight < 12 Kg
- 5 - 10 yr → Flexible Nails
  • Enders Nail / Titanium
  Elastic Nail system (TENS)
  • Use plates if unstable
- > 10yr → Intramedullary interlocking
  Nail → Closed reduction
  Internal fixation

Warning: Not all points are covered in the notes, especially conceptual explanations. Please use the notes in conjunction with Marrow Edition 4 videos.
Patellar fracture

- Patella - largest sesamoid bone
- Proximal pole of patella
  ↓
  Tendon of Quadriceps

- Types of patellar #
  • Transverse → MC
  • Undisplaced #
  • Lower / upper pole #
  • Comminuted displaced #
  • Comminuted undisplaced #
  • Vertical #
  • Osteochondral #

- X Ray: Skyline view, AP / Lateral view

- Treatment:
  Open Reduction with Internal Fixation
  +
  Tension band wiring (MC)
  ↓
  Convert the distractive forces into compressive forces.
  Also used in - Olecranon #
  - Conservative treatment:
    cylinder cast
Tibial fracture

- **Bumper #**:
  - # of lateral condyle of tibia
  - Force: Axial loading and valgus force
  - Intra articular # → # of Necessity
  - Treatment → open reduction + internal fixation with plates

- **Shaft of Tibia #**:
  - Treatment: Close Reduction with internal fixation with interlocking medullary nail or rod (Best treatment)
    - Conservative treatment - undisplaced #
      → Patellar tendon bearing cast + Closed Reduction

- **Runner #**:
  - Stress fracture of Fibula
  - Occur at lower end of Fibula
- Toddlers:
  - Seen in children following accidents
  - Spiral fracture of tibia
  - Can be missed: not visible in X-ray
  - Pain on walking
  - Treatment → POP cast

Fracture around ankle

- Radiological anatomy of ankle:
  - X-ray views:
    - Lateral view
    - Mortise view: Tibia, fibula, medial malleolus, talus with ankle joint

- Bimalleolar / Potts / Dupuytrens
  - # of medial & lateral malleolus

- Trimalleolar
  - A/A/A cotton
  - Medial, lateral, posterior malleolar
• **Anatomy of lower end of Tibia:**

  - Fibula
  - Tibia
  - Anterior inferior tibiofibular ligament
  - Lefort Wagstaffe tubercle
  - Tillaux chaput tubercle

• **Tillaux chaput #**
  - Avulsion of Anterior-inferior tibiofibular ligament from tibial tubercle

• **Lefort wagstaffe #**
  - Avulsion # of fibular inserting of Anterior-inferior tibiofibular ligament from Lefort wagstaffe tubercle

• **Ankle sprain:**
  - Foot goes into inversion
  - Lateral ligaments of ankle joint - stretched
  - Injured ligament in the body

  **Ottawa Ankle Rules:**
  To determine X-ray requirement in ankle injury
  - Tenderness at medial malleolar area
  - Tenderness at lateral malleolar area
  - Weight bearing on the foot is difficult immediately

  Any one of the above → Take X-ray

• **Pilon / Plafond #**
  - Ceiling of ankle shattered
Calcaneum fracture

- Mc Tarsal Bone #
- Bohler's angle ↓
- Crucial angle of Gissane ↑

• Aim on reducing the # is to ↑ Bohler's Angle

• Lovers #:
  - Bilateral Calcaneum #
    + Vertebral Compression Burst #
  - mechanism - fall from height ↓ landing on feet

• Jumpers # / suicide Jumpers #:
  - H shaped # in the sacrum

Fracture of talus

• Aviators #
  # Neck of Talus complications:
  - Subtalar arthritis (MC)
  - Ankle arthritis
  - AVN of body of Talus
  → MRI = IOC
Hawkins sign: Subchondral lucency
- Blood supply:
  - from Body of Talus viable

Fracture of foot

Choparts Joint: Inter tarsal / mid Tarsal joint
- Choparts - #, dislocation, Amputation is at this area.

Lisfranc joint: Tarsal metatarsal joint
- In lisfranc # dislocation - gap between 1\textsuperscript{st} and 2\textsuperscript{nd} metatarsal is widened
- Lisfranc $\rightarrow$ #, dislocation, amputation at this area.

Robert Jones #:
- # at metaphyseal diaphyseal junction of 5\textsuperscript{th} metatarsal at the level of the 4\textsuperscript{th} - 5\textsuperscript{th} inter metatarsal articulation
  - Zone II
  - Poor vascularity
  - undergo non union

Pseudo Jones #:
- AV/A/Avulsion # (due to pull of peroneus brevis tendon) $\rightarrow$ zone I

Stress #: zone III
Toddlers #:
- In children, following an accident
- Spiral # of the tibia → undisplaced #
- Pain on waking

Treatment → POP cast

Battered baby syndrome: Inconsistent history given by parents.
- multiple # at different stages of healing.
- metaphyseal # (mc)
- Advice whole body scan to find out all the fractures.

Congenital muscular torticollis

- A-wry neck

1° - Congenital
   (mc)

• Contracture of sternocleidomastoid (due to fibrosis)
• Causes:
  - Intrauterine packaging defect (IUPO)
  - Development dysplasia of hip
  - Congenital muscular torticollis
  - Knee dislocation
  - Metatarsus adductus
  - CTEV

• Birth injuries → Temporary ischemia of sternocleidomastoid

Compartment syndrome

• Right side > left side
• Clavicular head of sternocleidomastoid - more affected
• MC type of knee dislocation in children → Hyperextension
- 90% self-resolving by 1 year of age
  - if not plagiocephaly

- Treatment:
  - Conservative stretching (<1 year of age)
  - Surgery (after 1 year) → Release the contracture

**Klippel-Feil Syndrome (KFS)**

- Triad
  - Low set hairline
  - Short webbed neck
  - Restriction of neck movements

- KFS Association
  - Scoliosis (60%) → MC
  - Sprengel deformity (shoulder)
  - Genitourinary abnormality
  - Heart abnormality
  - Ocular abnormality
  - Spine abnormality

- Advice: Avoid contact sports which can lead to neck injuries.

**Sprengel Shoulder**

- Congenital, undescended, hypoplastic scapula
- Occurs due to persistent omovertebral bar

- Restriction of upper limb function
- Treatment: Surgical release of omovertebral bar
  - Woodward operation (done at 3-8 years)
- Association
  - Klippel Feil Syndrome (mc)
  - Scoliosis
  - Genitourinary abnormalities
  - Heart abnormalities

Madelung deformity

- \( \sigma > 0^* \)
- 50% of cases - bilateral.
- Defect - Distal end of the radius growth plate fuses early \( \rightarrow \) defect in growth (but ulna continues to grow normally)
- Deformity :
  - ulna is more prominent than the radius.
  - volar subluxation of hand \(-\) Dinner fork deformity.

Ulnar variance:

- \( \sigma \rightarrow \) ulna longer than radius
- \( \sigma \rightarrow \) Radius slightly longer than ulna.

- Madelung deformity show \( \sigma \) ulnar variance.
- Dinner fork deformity - Children \( \rightarrow \) Madelung deformity
- Elderly \( \rightarrow \) Colles #

Treatment: Darrach’s Procedure - Reset excessive grown ulna.

Warning: Not all points are covered in the notes, especially conceptual explanations. Please use the notes in conjunction with Marrow Edition 4 videos.

Limb deficiencies, Cleidocranial dysostosis

- Limb deficiencies:
  - Amelias: Complete absence of limb
  - Phocomelia: Seal limbs
    long bones - Absent,
    short bones - Present
    (S/E of Thalidomide)
- Hemimelia:
  - Half of the long axis of the limb is absent.
  - Partial / Complete absence of bone.
  - Eg. Tibial Hemimelia.
  - Radial Hemimelia → Radial club hand (Radius, Scaphoid, Trapezium & Thumb are absent)

- Syndromes associated with radial club hand:
  - Holt-Oram Syndrome
  - Fanconi Syndrome
  - TAR Syndrome
  - VACTERL Syndrome

Treatment
Aim: To bring the hand back to central axis & replace the lost thumb.

- Centralization of hand over ulna + Pollicization
- Pollicization
  - Index finger positioned in the place of thumb

- Cleidocranial dysostosis:
  - Congenital absence of clavicle
  - Both shoulder can be approximated to each other.

- Poland Syndrome:
  - Congenital absence of muscle
  - Pectoralis (MC)
PAEDIATRIC ORTHO: HIP

Hip joint: Ball and socket joint

In Children - Hip has a growth plates - below the Head of femur
- below the Greater trochanter

Epiphysis on the femoral head: capital femoral epiphysis

Blood supply of head of femur

Femoral artery
  ↓
Potential femoris artery
  ↓
Medial femoral circumflex artery
  ↓
Lateral femoral circumflex artery
  ↓
Forms: ring around the femoral neck in the intertrochanteric region

Retinacular vessels ascend towards the Head

Lateral Epiphyseal vessels → Medial Epiphyseal vessels
Supplies the bulk of the head
Vessels derive their nutrition from the foveolar artery

Blood supply is retrograde from distal to proximal.

Three sources of blood supply to femoral head in adults:
- Retinacular
- Metaphyseal
- Foveolar

No role in blood supply in 4-8 y of age

1. Shenton's line / arch:
- Line drawn from the inferior margin of the superior pubic ramus running laterally towards the medial part of the head and neck of the femur.
2. Neck Shaft Angle:
- Normal neck shaft angle = 130° - 130°
- In children = 140°, it decreases with age
- If the angle is less - coxa vara
  - Trendelenberg
  - Limitation in abduction + internal rotation
- If the angle is more - coxa valga

X-ray of paediatric hip

Acetabulum = Triradiate Cartilage

Hilgenreiner's line:
- Horizontal line
- Passing through the centre of one triradiate cartilage to the other.
- The Head of the femur will be below Hilgenreiner's line

Perkin's line:
- Perpendicular line at the lateral edge of the acetabulum
- Head of the femur lies in the inner and lower quadrant of the hip
- In Developmental Dysplasia of Hip (DDH) - Head of the femur → upper and outer quadrant

Acetabular angle:
- Angle tangential to the surface of acetabulum making an angle to the Hilgenreiner's line.
- Significance:
  - more the angle = more the chances of Head to get dislocated
  - DDH
Kien's line:
- Draw a line on the lateral border of the neck of femur and extend it proximally.
- It normally intersects the head of femur.

Coxa vara

- Decrease in the neck shaft angle.
- Usually <90°
- Attitude of limb: adduction + external rotation
- (obligate external rotators)
- Limitation: abduction + internal rotation

Axis deviation:
- Flex the hip and knee
  - Knee goes to the same side
  - Coxa vara
- Trendelenburg gait

Causes of Coxa vara:

Infantile Coxa Vara:
- Pathology: Growth discrepancy between capital femoral epiphysis growth plate and greater trochanter growth plate.
- Defect in the fair bank:
  - Head of the femur does not grow
  - Greater trochanter keeps growing
  - Neck shaft angle decreases.

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Acquired coxa vara:

1. Perthes disease:
   - MC type of osteochondritis
     - Capital femoral epiphysis
   - Transient ischemic insult
   - Delay in growth.
   - Greater trochanter growth exceeds the head of femur (Secondary regeneration)

ii. SCFE:
   - Split fracture at the growth plate of epiphysis
   - Head of the femur slips
   - Neck shaft angle ↓

Coxa vara

- Also known as Adolescent coxa vara.

Legg Calve Perthe's disease

- Also known as coxa plana.
- Idiopathic, Spontaneous osteonecrosis / osteochondritis of femoral head.
- Age: 4 - 8 years, m > F
- MCC of osteochondritis
- > 6 yrs: Poor prognosis
- B/L: 10 - 13%
- Most commonly associated with - Protein C & S deficiencies
  - Thrombophilia
  - Trauma
  - Extreme movements of Hip
  - Coagulopathy.

- Vascular insult to femoral head
  - Avascularity
  - Ischemic fragmentation of the bone
Attempt to Regenerate

Normal regeneration of Head
(if head is adequately covered by Acetabulum)

Abnormal regeneration of Head

- Coxa magna
- Coxa breva
- Coxa plana

- Painless limp after activity.
- Limitation of abduction and internal rotation
- Obligate external rotators → Cattarell Sign

Head at risk signs on x-ray:
- Gage’s sign
- Metaphyseal cyst
- Lateral calcification
- Lateral subluxation

Treatment:
Aim: To contain the Head of femur inside the acetabulum.
- No weight bearing on Head of femur.
- Abduct and internal rotate the Hip
  - Cast: Petrie or Broomstick Cast
- Femoral Varus Derotation osteotomy (VDRO)

Slipped capital femoral epiphysis

Split fracture at the growth plate of Epiphysis (Type I Salter Harris Fracture)
Head remains inside the Acetabulum
neck of femur slips (hence a misnomer)
• E/L - 40%
• E/L - 60% - if associated with endocrinopathy
• mcc - idiopathic
• mc Endocrinopathy associated : Hypothyroidism.
  Hypogonadism
  Increased Growth Hormone

• Risk factors:
  - Increased weight

![Sex Hormones](https://via.placeholder.com/150)
(Sex Hormones
(Helps in fusion of Growth plate)
↓
↓ Sex hormone
Bones continue to grow without adequate fusion
↓
At puberty - sudden surge of GH.
↓
Increases the vulnerability of growth plate to fracture
↓
Split fracture of Growth plate

• Normal age of presentation: At puberty
  • males : 13 - 17 y
  • females : 11 - 14 y
  m > f
  • Restricted abduction and internal rotation
  • Coxa vara.
  • Outward facing toe gait
  • Axis Deviation
  • History of young child, excessive weight - rule out SCFE.
  IOC: MRI
  Trethowan's sign: Hlen's line doesn't intersect the femur
  ↓
  SCFE

Treatment:
  - Fixation with insitu pinning

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Developmental dysplasia of hip

- Spontaneous subluxation of femoral head out of acetabulum
- Epidemiology:
  1: 1000 live births
  F > m
  B/L: 20%
  Left side > B/L > Right side
  - Usually seen in first born female child with malpresentation.
  - Positive family history
  - Usually Caucasians
- MCC: Idiopathic
- MC risk factor: Frank breech with extended knee

![Risk Factors Diagram]

Before birth | At Birth | After Birth
--- | --- | ---
- Oligohydramnios | Frank breech with Abnormal positioning |
- IUFD | Extended Knee of baby |
- High Relaxin |
- Mc part affected in DDH: Acetabulum > Femoral Head

- Other pathologies that can cause DDH:
  - Inverted limbus
  - Loose and long ligamentum teres
  - Interpositioned iliopsoas tendon
  - Excessive pulvinar fat
  - Capsular constriction
  - Transverse acetabular ligament.

Clinical features:
- Female child - abnormal thigh and Hip folds
- Vascular sign of Narath:
  - Inability to feel the pulsations of femoral artery against the femoral head.
  - Seen in DDH.
- Barlow's and Ortolani:
- Perform
- Barlow's test
  - Adduct the Hip
  - Dislocatable Hip
  - Head dislocated
- Ortolani (Performed on Dislocated Hip) test
  - Abduct the Hip
  - Femoral Head goes inside the acetabulum
Allis test / Galeazzi test: > 3 months of age
Flex and hold the Hip and Knee of child
Pathological side appears lower compared to the normal side
Seen in U/L DDH

- KiIsic test = B/L DDH
- U/L DDH - Trendelenburg lurch / gait
- B/L DDH - Waddling gait

- Screening IOC - USG for < 6 months
  - Performed in at risk population
  - First born, female child with fetal malpresentation (Breech with extended knee) and positive family history
  - On USG - DDH - \( \alpha \) angle ↓
  - \( \beta \) angle ↑

- Confirmation of Diagnosis and planning of treatment - MRI
- On x-ray:
  - Shenton's line - disrupted
  - Head of femur in upper and upper-quadrant
  - Acetabular angle is more than normal.

Treatment:
Aim: to restore head of femur inside the acetabulum
- Treatment depends on age of presentation.

1. < 6 months: Pavlik Harness brace
   von rosen splint
ii. 6 months - 18 months: Attempt closed reduction
   ↓ not possible
   Open Reduction - Smith Peterson Approach
   ↓ Bachelor's cast

iii. 18 months - 36 months: Femoral Osteotomy - VDRO

iv. >3 years: VDRO + Pelvic osteotomy
   ↓
   Salter and Pemberton's Osteotomy
   (mo)

v. >10 years: Total Hip Replacement
   (history of DDH + secondary osteoarthritis)
Physiological and pathological varus/valgus

- **Varus**: when the limb moves towards the midline.
- **Valgus**: when the limb moves away from the midline.
- Medial deviation of leg - *Genu varum*
- Lateral deviation of leg - *Genu valgus*

### Physiological Varus

- Baby will have physiological varus
- Corrects itself by 2 years
- Physiological valgus (maximum at 4 yrs)
- Corrects overtime by 7 - 10 years
- Residual valgus of 5° - 7°

### Pathological Causes of Varus and Valgus

- Injury to medial growth plate
- Lateral condyle continues to grow

### Diagram

- Femur
- Medial growth plate injury
- Genu varus
Injury to the lateral growth plate.

- Medial condyle continues to grow:
  - Genu valgus.

Femur lateral growth plate injury

Management:

- Young child (growth plate can still grow)
  - Fuse healthy growth plate: epiphysiodesis.
    - "Stapling"

- If child has already grown (no potential of growth)
  - Osteotomy (cut and realign bones)

MC cause of bilateral genu valgum:
- Idiopathic > Rickets
- In children:
  - Rheumatoid arthritis > Osteoarthritis
- In adults:
  - Osteoarthritis > Rheumatoid arthritis

MC causes of bilateral genu varum:
- In children: Rickets > Idiopathic
- In adults:
  - Osteoarthritis > Rheumatoid arthritis

MC causes of wind swept deformity:
- In children: Rickets
- In adults: Rheumatoid arthritis
Blount’s disease:
- A/V/A infantile tibia vera.
- proximal medial tibial physis
  - abnormality
  - medial condyle of tibia does not grow.
- on X-ray: “metaphyseal beaking sign”
- Triad:
  1. Bilateral idiopathic genu varum.
  2. Genu recurvatum (hyperextension).
  3. Internal rotation of tibia.
- In genu recurvatum of knee
  - “knee goes further beyond 0° of extension”
- Clinical sign: “Siffert Katz sign”
  - Knee will be unstable on flexion.

Congenital dislocation of knee:
- Mc congenital dislocation of knee is hyperextension of knee - genu recurvatum.
- Tibia is angulated anteriorly.
- Associated with intrauterine packaging defect.
  - Developmental dysplasia of hip, CTEV, metatarsus adductus, congenital dislocation of knee, congenital muscular torticollis.

Foot anatomy
Joint:
1. Ankle / Tibiotalar joint
2. Subtalar / Talocalcaneal joint
3. Midtarsal / Talonavicular and calcaneocuboid joint

Movements:
- At ankle joint - movements that occur are ankle dorsiflexion and ankle plantar flexion
- At subtalar joint - inversion and eversion of foot
- At midtarsal - forefoot adduction and abduction
- Exaggeration of arch = high arched foot
- If medial arch is lost = flat foot
- When arch increases = Cavus = heel goes to varus
- When arch decreases = Planus = heel goes to valgus

Deformities:
- Foot remains in ankle dorsiflexion = Calcaneus deformity
- Foot in plantar dorsiflexion = Equinus deformity
- Foot in inversion = varus deformity
- Foot in eversion = valgus deformity
- When arch increases in median longitudinal arch = Pes cavus
- When arch decreases in median longitudinal arch = Pes planus

Congenital Talipes Equino Varus (CTEV):
- Congenital abnormality of leg, ankle, foot.
- MC congenital anomaly of foot.

Epidemiology:
- 1: 1000 live births
- M > F
- First born male child
- 50% bilateral
- Associated with breech, oligohydramnios
- Twin pregnancy not a risk factor
- MC cause of CTEV = Idiopathic - 1° CTEV (Bilateral)
- a° CTEV:
  1. Neural tube defect, Neural dysraphisms
  2. Polo
3. Arthrogryposis multiplex congenita (AMC)

Pathoaanatomy

→ Hypoplastic / Small Talus: Leads to dislocation of

Talonavicular joint

Tendoachilles
plantar flexion
Equinus

Tibialis posterior
Inversion
Varus

CTEV

→ Everything will be pulled on to medial side.
- Medial side concavity → medial column shortened.
- Lateral side convexity → Lateral column elongated.
→ Bones between talus and calcaneum goes into malalignment
→ The Talocalcaneal angle (kites angle)

Normally < 30°

decreased / parallel

Anterioposterior view

C - Cavus - Exaggeration of medial longitudinal arch.
A - Adduction - Talonavicular / midtarsal joint.
V - Varus - Talocalcaneal / Subtalar joint.
E - Equinus - Ankle joint

+ Internal rotation of tibia.

"Plumb line test" - check for alignment
Clinical Features:
- Born with deformed foot.
  Screening test: Dorsiflexion test.
  - If the toe is touching shin while flexion of the foot, then foot is normal.

Treatment

- Ideal time to start treatment for CTEV - as soon as possible.
- The best person to start treatment is doctor not mother.
- Manipulation techniques: Kites - not used now.
  Ponseti - best method

- Ponseti method of serial manipulation and casting
  order of manipulation: C → AV → E
- Adduction and varus corrected together.
- Fulcrum of correction - Talar head.
- After manipulation & correction
  apply cast → for 1 week only above knee
  Remove & reapply cast every week.
- By 8-9 weeks → deformity corrected in 90% of babies
- If equinus is corrected 1° and the order is not followed, it leads to breakage at midtarsal joint

  "Rocker bottom foot"
  Due to CTEV deformity posteromedial soft tissue gets contracted.
  Osteotomy for adduction and varus.

Posteromedial soft tissue release after 1 year for adduction and varus.
Age wise management of CTEV

0-1 years:
- Ponseti technique (C → AV → E)
  - Once deformity gets corrected, Dennis Brown splint is applied
  - After 1 yr - CTEV shoes for walking and Dennis Brown splint at night
  - Combined duration of usage of shoes & splint - not less than 23 hours/day, continued till 5 years of age.

1-3 years:
- Posteromedial soft tissue release (PMSTR) with Turco’s procedure.
- Structures released:
  1. Tendo achilles
  2. Tibialis posterior
  3. Flexor hallucis longus
  4. Flexor digitorum longus

3-5 years:
- PMSTR + Bony procedure to correct adduction deformity
  - Dillwyn Evans procedure
  - Lateral column shortening procedure
  - done by calcaneocuboid fusion

5-8 years:
- PMSTR + Dillwyn Evans procedure + Bonu procedure to deformity → Dwyer osteotomy

8-10 years:
- Removal of multiple tarsal bone in wedge form
  - "wedge tarsectomy"
> 10 years:
1. Triple arthrodesis
   - Joints fused:
     • Talonavicular joint (most important)
     • Calcaneocuboid joint
     • Talocalcaneal joint

→ MC complication: Pseudoarthrodesis of talonavicular joint, if done < 10 yrs

2. Ilizarov / Joshi’s External Stabilization System (JESS)
   → Rocker bottom foot occurs because of:
     i) Vertical talus (congenital)
     ii) Improper correction of CTEV
   → When arch of foot is lost it is called Pes planus / Plano- Valgus deformity.

Achondroplasia

MC Cause: Disproportionate dwarfism.

Trunk - Normal
Limbs - Short

"Proximal limb shortening"

"Rhizomelic shortening"

→ Mutation in FGFR3 gene on chromosome 4
→ Autosomal Dominant
→ Sporadic
→ enchondral ossification affected.
→ Normal - IQ and sexual development.

Deformities:
1. Brachydactyly - Fingers do not grow
2. Starfish hand
3. Trunk
4. Frontal bossing of skull
5. Saddle nose
6. Champagne glass pelvis