Orthopedics PP comprehensive summary

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Anatomy

I. Upper Limb Anatomy

1. Shoulder and Rotator Cuff

- **Muscular Innervation:** The **axillary nerve** supplies the deltoid muscle. The **long thoracic nerve** innervates the serratus anterior.
- **Abduction Mechanics:** Abduction is a multi-stage process: 0°–15° is handled by the **supraspinatus** (suprascapular nerve), 15°–90° by the **deltoid** (axillary nerve), and >90° by the **trapezius** (accessory nerve) and **serratus anterior** (long thoracic nerve).
- **Rotator Cuff Components:**
    - **Supraspinatus:** The most common tendon to be torn due to poor blood supply.
    - **External Rotators:** Infraspinatus and teres minor.
    - **Internal Rotator:** Subscapularis.

2. Hand and Wrist

- **Median Nerve:** Supplies the palmar surface of the **radial 3½ fingers** and the thenar muscles (thumb opposition, abduction, flexion). It passes through the **carpal tunnel**.
- **Ulnar Nerve:** Innervates the **intrinsic muscles** of the hand, including the interossei responsible for finger abduction. It also supplies the hypothenar muscles.
- **Radial Nerve:** Responsible for **wrist and finger extension**.

II. Lower Limb Anatomy

1. Hip and Femur

- **Vascular Supply:** The **femoral neck** is supplied by retinacular branches of the **medial femoral circumflex artery**, which are functional end-arteries, making neck fractures high-risk for **avascular necrosis (AVN)**. Conversely, the **intertrochanteric region** is well-vascularized by an anastomosis of femoral circumflex arteries, leading to better healing.
- **Muscular Actions:** The **iliopsoas** is a hip flexor, the **gluteus medius/minimus** are abductors, and the **gluteus maximus** is an external rotator.

2. Knee and Leg

- **Ligamentous Stability:** Varus stress at 30° isolates the **LCL**, while at 0° it tests the entire lateral side (LCL, ACL, and posterolateral structures).
- **Nerve Supply:**
    - **Deep Peroneal Nerve:** Controls **dorsiflexion**, toe extension, and sensation in the first web space.
    - **Tibial Nerve:** Controls **plantarflexion**.
- **Vascular Hazards:** The **popliteal artery** is at high risk of injury during posterior knee or ankle dislocations.

3. Ankle and Foot

- **Ankle Stability:** The **syndesmosis** is the most important structure for maintaining the stability of the ankle joint.
- **Foot Deformity (Clubfoot):** Deformity occurs across four joints: the ankle (**plantarflexion/equinus**), subtalar (**varus**), talonavicular (**adduction**), and calcaneocuboid (**cavus**).

III. Peripheral Nerve Structure & Clinical Signs

- **Nerve Layers:** The **epineurium** serves as a cushion for the nerve against external pressure.
- **Classical Nerve Pathologies:**
    - **Radial Nerve Injury:** Results in **wrist drop**.
    - **Median Nerve Injury:** Results in a weak "OK sign" and the **"pointing index" sign**.
    - **Ulnar Nerve Injury:** Results in **Froment's sign**, Wartenburg's sign, hypothenar atrophy, and a claw hand.
    - **Common Peroneal Nerve Injury:** Results in **foot drop**.

IV. Functional Anatomy: The Gait Cycle

Understanding muscle activity during walking is essential for orthopedic review:

- **Initial Contact/Loading: Tibialis anterior** eccentrically contracts to prevent foot slap.
- **Mid-stance:** The **gastrocnemius and soleus** are most eccentrically contracted; **hip abductors** (gluteus medius/minimus) stabilize the pelvis.
- **Pre-swing:** The **iliopsoas** and **rectus femoris** begin concentric contraction to initiate hip flexion.
- **Swing Phase:** Foot drop (due to peroneal nerve injury) leads to a **high steppage gait**, characterized by extreme hip and knee flexion to clear the ground.

Bone Tumors

I. General Diagnostic Features

- **Benign Lesions:** Typically show **well-defined margins** (narrow transition zone), absence of cortical destruction, and no periosteal reaction. A sclerotic rim often indicates a long-standing, stable lesion.
- **Malignant Lesions:** Characterised by **ill-defined margins** (wide transition zone), **cortical destruction**, and aggressive **periosteal reactions**. They may also present with an associated soft tissue mass shadow.

II. Benign Bone Tumours

Osteoid Osteoma

- **Definition:** A common benign lesion that can occur anywhere in the skeleton.
- **Radiology:** Appears as a small (<1.5 cm), well-circumscribed **lytic lesion called a "nidus,"** which is surrounded by a thick area of reactive **sclerosis**.
- **Clinical Hallmark:** Presents with intense **nocturnal pain** that is specifically **relieved by NSAIDs** (like aspirin or ibuprofen) but not paracetamol. This is due to high prostaglandin release from the tumour.

III. Primary Malignant Bone Tumours

1. Osteosarcoma

- **Demographics:** Typically affects adolescents and occurs in the **metaphysis** (the area near the growth plate), most commonly around the **knee**.
- **Clinical Signs:** Characterised by rapid growth, warmth, and tenderness.
- **Radiology:** High-grade lesions showing a **"sunburst" or "sunray" pattern**. A classic sign is **Codman's triangle**, which is the elevation of the periosteum away from the bone.

2. Ewing's Sarcoma

- **Demographics:** Usually found in the **shaft (diaphysis)** of long bones in very young patients, typically in their first or second decades of life.
- **Clinical Signs:** Patients may present with constitutional symptoms like fever or weight loss.

- **Radiology:** Distinctive **"onion skin"** periosteal reaction.
- **Treatment:** This tumour is highly sensitive to both radiation and chemotherapy.

IV. Secondary (Metastatic) Bone Tumours

Metastatic lesions are **more common than primary bone tumours** and generally occur in patients over 50 years old, primarily affecting the axial skeleton.

- **Prostate Cancer:** Typically produces **sclerotic (bone-forming) lesions** and carries a relatively good prognosis.
- **Breast Cancer:** Often results in **mixed** (both lytic and sclerotic) lesions.
- **Lung Cancer:** Characterised by **lytic (bone-destroying) lesions**; notably, these can occur distal to the knee or elbow and generally have a poor prognosis.
- **Kidney Cancer:** Presents as **lytic, hypervascular** lesions.
- **Thyroid Cancer:** Generally associated with a poor prognosis.

V. Summary Table

Tumour Type	Typical Location	Key Radiological Sign	Notable Clinical Feature
Osteoid Osteoma	Any bone	Nidus with sclerosis	Night pain relieved by NSAIDs
Osteosarcoma	Metaphysis (Knee)	Sunburst & Codman's Triangle	Adolescent patients; tender mass
Ewing's Sarcoma	Diaphysis (Shaft)	Onion skinning	Young children; systemic symptoms
Prostate Mets	Axial skeleton	Sclerotic/Blastic lesions	Elderly males; good prognosis
Lung Mets	Axial or Distal	Lytic lesions	Poor prognosis; occurs in limbs

Bone healing

I. Primary (Direct) Bone Healing

Primary bone healing occurs only under conditions of **absolute stability**, where there is virtually no motion at the fracture site.

- **Requirements:** A fracture gap of **less than 2 mm** and motion of **less than 1 mm** (or even a few micrometres).
- **Key Feature:** There is **no callus formation** visible on X-rays.
- **Surgical Tools:** Absolute stability is achieved using **compression plates**, **lag screws**, or **tension band wiring**.

II. Secondary (Indirect) Bone Healing

Secondary bone healing is the more common form of healing and occurs when there is **relative stability**.

- **Mechanism:** The bone heals through a process that involves the formation of a **callus**.
- **Surgical/Non-Surgical Tools:** Relative stability is provided by **casts**, **slings**, **K-wires**, **intramedullary (IM) nails**, **functional bracing**, or **external fixators**.
- **Healing Sequence:** This type of healing follows a specific biological progression, typically involving inflammation, soft callus formation, hard callus formation, and eventually remodeling.

III. Fracture Patterns and Healing Speed

The geometry of the fracture significantly impacts how quickly it heals:

- **Oblique Fractures:** Often heal the **fastest** or best because they provide the **largest contact area** between bone fragments.
- **Transverse Fractures:** Generally take **longer to heal** than oblique or spiral fractures because they result from high-energy injuries that cause **more soft tissue damage**.
- **Segmental Fractures:** These are the **slowest to heal**. Because the bone is broken in two separate places, the middle "floating" piece often has a **compromised blood supply** and poor contact with the main bone ends, increasing the risk of nonunion.

IV. Pediatric Bone Healing and Remodeling

Children's bones have a much higher healing and remodeling capacity than adult bones because their skeleton is less dense, more porous, and has a **thick, active periosteum**.

The "Power of Remodeling" in children depends on:

- **Years of Remaining Growth:** This is the **most important factor**; the younger the child, the better the remodeling potential.
- **Position in the Bone:** Fractures **nearer to the physis** (growth plate) remodel much better than those in the mid-shaft. For example, a **proximal humerus fracture** in a young child has excellent remodeling potential.
- **Plane of Motion:** Remodeling is most effective in the **sagittal plane** (the plane in which the adjacent joint normally moves, such as elbow flexion/extension). Remodeling is poorest in the **transverse plane** or for coronal plane deformities (varus/valgus).

V. Complications and Inhibitors of Healing

- **Heterotopic Ossification (HO):** This is the complication where **ectopic bone forms within soft tissues**. It is most common after major trauma, hip arthroplasty, or in patients with spinal cord or traumatic brain injuries who are immobilized.
- **Compartment Syndrome:** High pressure within muscle compartments can lead to ischemia and necrosis, severely compromising healing. The **earliest sign** is intense pain during **passive stretching** of the involved muscles.
- **Infection:** Open fractures or surgical sites can develop infections (osteomyelitis). In **chronic osteomyelitis**, the presence of **sequestrum** (dead bone) is a pathognomonic X-ray finding.

Gait Disorders

I. Fundamentals: The Normal Gait Cycle

- **Initial Contact/Loading:** The **tibialis anterior** contracts eccentrically to prevent "foot slap".
- **Mid-stance:** The **gastrocnemius and soleus** are at their most eccentrically contracted; simultaneously, **hip abductors** (gluteus medius/minimus) must contract to stabilize the pelvis.
- **Pre-swing:** The **iliopsoas** and **rectus femoris** begin concentric contraction to initiate hip flexion and clear the limb.

II. Specific Gait Disorders and Their Causes

1. High Steppage Gait (and Slapping Gait)

- **Cause:** Weakness of the dorsiflexors, typically due to **common peroneal (deep peroneal) nerve injury**.
- **Mechanism:** Because the patient cannot dorsiflex the ankle, the foot remains in plantarflexion, effectively "lengthening" the limb.
- **Presentation:** To clear the ground, the patient performs **extreme flexion of the hip and knee** during the swing phase.
- **Slapping Gait:** If the patient cannot control the descent of the foot, it hits the ground all at once with a characteristic "slapping" sound instead of a normal heel strike.

2. Trendelenburg Gait

- **Cause:** Weakness of the **hip abductors** (gluteus medius and minimus) or an unstable fulcrum (e.g., hip dislocation).
- **Mechanism:** The abductors on the standing (affected) leg fail to keep the pelvis level.
- **Presentation:** The **pelvis tilts downward on the opposite side** (the side where the leg is in the swing phase).

3. Antalgic Gait

- **Definition:** A "painful limp" where the patient spends as little time as possible bearing weight on the affected limb.
- **Common Associations:** Hip pathologies like **Legg-Calvé-Perthes disease** or **Slipped Capital Femoral Epiphysis (SCFE)**, and knee osteoarthritis.

4. Waddling Gait

- **Presentation:** An exaggerated side-to-side movement of the pelvis.
- **Cause:** Typically associated with **bilateral** hip disorders, such as bilateral **Developmental Dysplasia of the Hip (DDH)** or bilateral **SCFE**.

III. Gait Deformities in Pediatric Orthopedics

- **Developmental Dysplasia of the Hip (DDH):**
    - **Unilateral:** Presents as a **limp** and positive Trendelenburg sign.
    - **Bilateral:** Presents with a **wide perineum**, increased **lumbar lordosis**, and a **waddling gait**.
- **Slipped Capital Femoral Epiphysis (SCFE):**
    - Characterised by an antalgic limp and walking with the affected foot **externally rotated**.
    - A classic sign is **obligatory external rotation** of the hip when it is brought into flexion.
- **Legg-Calvé-Perthes Disease:**
    - Commonly presents in young boys as an **antalgic limp** often accompanied by referred pain to the knee.

IV. Neurological & Compensatory Gait Patterns

- **Circumduction Gait:** Instead of lifting the leg high, the patient swings the leg out in a **semicircle** to clear the ground.
- **Hip Hiking:** The patient lifts the **pelvis** on the affected side to clear the foot, rather than flexing the knee.
- **Spastic Gait:** Occurs in Upper Motor Neuron (UMN) lesions like a stroke. Initially, the limb may experience **flaccid paralysis** (loss of tone) for 1–6 weeks before **spasticity** and increased tone develop.
- **High Steppage Gait vs. Peripheral Vascular Disease:** In elderly patients, leg pain without motor weakness (like foot drop) is more likely due to **arterial insufficiency** than a primary neurological gait disorder.

Peripheral Nerve Injuries

I. Nerve Anatomy and Physiology

- **Structural Layers:** A peripheral nerve consists of several layers; the **epineurium** is the outermost layer that functions to **cushion the nerve** against external pressure.
- **Recovery Patterns:** Following an upper motor neuron lesion (such as a stroke), muscles initially experience **flaccid paralysis** (loss of tone and reflexes) for approximately **1–6 weeks** before **spasticity** develops.

II. Upper Limb Nerve Injuries

1. Radial Nerve

- **Function:** Controls **wrist and finger extension**.
- **Injury Sign:** Characterised by **wrist drop** and weakness in finger extension.
- **Common Associations:** Often injured in humeral shaft fractures.

2. Median Nerve

- **Function:** Provides sensation to the **palmar surface of the radial 3½ fingers** and controls **thenar muscles** (thumb opposition, abduction, and flexion).
- **Injury Signs:**
    - **"Pointing index" sign** (weakness in index finger flexion).
    - **Thenar atrophy** (wasting of the thumb base).
    - **Weak "OK sign"** (specifically the anterior interosseous branch).
- **Carpal Tunnel Syndrome (CTS):** This is a compression of the median nerve at the wrist. **Severe CTS** is indicated by **objects falling from the hand** (grip weakness), thenar wasting, and a positive **Tinel sign** within 3 seconds.

3. Ulnar Nerve

- **Function:** Innervates the **intrinsic muscles** of the hand (interossei) responsible for **finger abduction**.
- **Injury Signs:**
    - **Claw hand** deformity (affecting the ring and little fingers).
    - **Hypothenar atrophy**.

- **Froment's sign** and **Wartenburg's sign**.

4. Other Brachial Nerves

- **Axillary Nerve:** Supplies the **deltoid** muscle; often tested during shoulder abduction (15°–90°).
- **Long Thoracic Nerve:** Supplies the **serratus anterior** muscle.

III. Lower Limb Nerve Injuries

1. Sciatic Nerve

- **Clinical Significance:** The most commonly injured nerve in **posterior hip dislocations** due to its anatomical position directly behind the hip joint.

2. Common (and Deep) Peroneal Nerve

- **Function:** Controls **dorsiflexion**, toe extension, and sensation in the first web space.
- **Injury Sign:** Results in **foot drop**.
- **Gait Impact:** Causes a **high steppage gait**, where the patient must perform **extreme hip and knee flexion** during the swing phase to prevent the toes from dragging on the ground.

3. Tibial Nerve

- **Function:** Primarily responsible for **plantarflexion**.

IV. Summary Table for Memorisation

Nerve	Key Action	Classical Injury Sign
Radial	Wrist/Finger Extension	**Wrist Drop**
Median	Thumb Opposition/OK Sign	**Thenar Atrophy / Pointing Index**
Ulnar	Finger Abduction	**Claw Hand / Froment's Sign**
Peroneal	Ankle Dorsiflexion	**Foot Drop / High Steppage Gait**
Axillary	Shoulder Abduction	Deltoid weakness
Sciatic	Knee flexion/Leg movement	Common in **Posterior Hip Dislocation**

Principles of Fractures

The management of fractures is guided by the fundamental triad of **reduction, immobilisation, and rehabilitation**. The choice of treatment and the resulting type of bone healing are primarily determined by the **stability of fracture fixation**.

I. The Principle of Stability and Healing

The method used to immobilise a fracture determines whether the bone heals directly (primary) or through a callus (secondary):

- **Absolute Stability (Primary Healing):**
    - **Requirements:** Achieved when there is a fracture gap of **less than 2 mm** and motion of less than 1 mm.
    - **Tools:** Immobilisation is performed using **compression plates, lag screws, or tension band wiring**.
    - **Outcome:** Bone heals via **primary bone healing**, which is characterised by the **absence of callus formation** on X-rays.
- **Relative Stability (Secondary Healing):**
    - **Tools:** Provided by methods such as **casts, slings, K-wires, intramedullary (IM) nails, functional bracing, or external fixators**.
    - **Outcome:** Bone heals via **secondary bone healing**, which is specifically defined by the **formation of a callus** visible on imaging.

II. Reduction and Rehabilitation

- **Anatomical Reduction:** This is mandatory for **intra-articular fractures** to ensure joint congruity. While many displaced fractures can be closed-reduced, some conditions like **Slipped Capital Femoral Epiphysis (SCFE)** should not be reduced via manipulation due to the high risk of avascular necrosis.
- **Early Rehabilitation:** Guided rehabilitation is encouraged early in the process and should not always be delayed until radiographic union is complete.

III. Factors Affecting Healing Speed

The geometry and nature of the fracture significantly impact the "biology" of healing:

- **Oblique Fractures:** These are expected to heal the **best and fastest** because they provide the **largest contact area** between bone fragments.
- **Transverse Fractures:** These result from high-energy injuries and cause more soft tissue damage, meaning they often require a **longer time to heal** than oblique or spiral patterns.
- **Segmental Fractures:** These are the **slowest to heal** because the "floating" middle segment often has a **compromised blood supply**, leading to a higher risk of non-union.

IV. Pediatric Principles: The Power of Remodeling

Children possess a unique healing capacity due to their **thick, active periosteum** and more porous bones. Their ability to "straighten" a deformed bone (remodeling) depends on:

- **Remaining Growth:** This is the **most important factor**; younger children have much higher remodeling potential.
- **Proximity to the Physis:** The **nearer a fracture is to the growth plate**, the better it remodels.
- **Plane of Motion:** Deformities remodel best if the angulation is in the **sagittal plane** (the same plane as the adjacent joint's normal movement). Remodeling is poor for coronal plane (varus/valgus) deformities.

V. Critical Complications to Monitor

- **Compartment Syndrome:** An emergency where internal pressure rises. The **earliest sign** is intense **pain upon passive stretching** of the muscles.
- **Open Fracture Infection:** The most critical steps for prevention are the **early administration of antibiotics** and timely irrigation and debridement.
- **Heterotopic Ossification (HO):** The formation of bone in soft tissues. It is a known complication for patients undergoing **total hip replacement** or those **immobilised** due to spinal cord or traumatic brain injuries.

Upper Limb Fractures

Management of upper limb fractures is grounded in the mechanism of injury, specific anatomical vulnerabilities, and the physiological capacity for bone healing and remodeling.

I. General Mechanisms and Pediatric Principles

- **FOOSH (Fall on Outstretched Hand):** This is the most common mechanism leading to upper limb fractures. It can result in various patterns, including **oblique** (bending force), **spiral** (twisting force), or **transverse** (direct force) fractures.
- **The Power of Remodeling:** In children, the capacity to correct deformities is high but depends on specific factors. The **most important factor** is the years of remaining growth.
    - **Location:** Growth potential is highest **away from the elbow** (proximal humerus and distal radius/ulna).
    - **Plane of Motion:** Remodeling is most effective in the **sagittal plane** (the plane of normal joint motion, like elbow flexion/extension) and poorest in the **coronal plane** (varus or valgus deformities).

II. Shoulder and Humerus

1. Shoulder Dislocations

- **Posterior Dislocation:** Often caused by violent muscle contractions during **seizures or electrocution**.
    - **Radiological Sign:** Characterised by the **"lightbulb sign"** on X-ray.
- **Age-Related Complications:**
    - **Young patients:** Most likely to sustain a **Bankart lesion** (labral avulsion).
    - **Middle-aged patients:** More likely to have associated **Greater Tuberosity fractures**.
    - **Elderly patients:** High risk for **rotator cuff tears**.

2. Humeral Fractures

- **Proximal Humerus:** Fractures in this area, such as a surgical neck fracture in a young child, have very **high remodeling potential**.
- **Humeral Shaft:** These are frequently associated with **radial nerve injury**, leading to motor deficits.
- **Supracondylar Fractures:** Common in children; dorsal angulation in the sagittal plane remodels well, while coronal plane angulation (varus/valgus) often requires surgery because it does not remodel effectively.

III. Elbow and Forearm

1. Radial Head and Essex-Lopresti

- **Essex-Lopresti Injury:** A complex pattern involving a **radial head fracture**, disruption of the **interosseous membrane**, and instability of the **distal radioulnar joint (DRUJ)**.
- **Clinical Pitfall:** A common error is failing to examine the **DRUJ** when a comminuted radial head fracture is identified.

2. Distal Radius

- **Median Nerve Association:** Distal radius fractures (like Colles' fractures) can cause **median nerve compression**.
- **Pediatric Patterns: Salter-Harris Type II** is common, where the fracture extends through the growth plate and then up through the metaphysis. The distal radius is a site of very high growth potential and remodeling capacity in children.

IV. Hand and Wrist Conditions

1. Carpal Tunnel Syndrome (CTS)

- **Cause:** Compression of the **median nerve** at the wrist.
- **Severe Signs:** Indicated by **objects falling from the hand** (grip weakness), **thenar wasting**, and a positive **Tinel sign** within 3 seconds.

2. Hand Infections

- **Mechanism:** Most commonly caused by **direct inoculation** (puncture wounds, bites, or lacerations) rather than spreading from other sites.

V. Nerve Injury Correlation Table

Nerve	Action at Risk	Classical Sign/Deformity
Radial	Wrist/Finger extension	**Wrist drop**
Ulnar	Finger abduction (interossei)	**Claw hand**, **Froment's sign**, Wartenburg's sign, hypothenar atrophy
Median	Thumb opposition/Flexion	**Pointing index sign**, **Thenar atrophy**, weak "OK" sign
Axillary	Shoulder abduction	Deltoid weakness

VI. Healing Principles

- **Absolute Stability:** Achieved via **compression plates, lag screws, or tension band wiring**. This results in **primary bone healing** and the **absence of callus formation**.
- **Relative Stability:** Achieved via **IM nails, K-wires, external fixators, or casts**. This results in **secondary bone healing** and **callus formation**.

Lower Limb Fractures

I. Injuries of the Knee Joint

Injuries in this region often involve ligamentous disruptions or specific avulsion fractures that indicate underlying instability.

- **Anterior Cruciate Ligament (ACL) Injuries:** Acute ACL tears typically present with a "pop" followed by **immediate swelling (hemarthrosis)**. The **Lachman test** is the most sensitive physical examination maneuver for diagnosis, followed by the anterior drawer and pivot shift tests.
- **Segond's Fracture:** This is an avulsion fracture of the **lateral tibial plateau**. It is highly significant because its presence is **95% predictive of an associated ACL injury**.
- **Patellar Dislocation:** Dislocation typically occurs **laterally** and is often associated with a **lateral femoral condyle fracture**. Loose bodies found in the joint space following a dislocation most commonly originate from the **medial patellar facet**. Risk factors for dislocation include an increased Q-angle, femoral anteversion, and vastus medialis dysplasia.
- **Extensor Mechanism Ruptures:**
    - **Quadriceps Tendon Rupture:** Usually occurs in patients **over 40**. Risk factors include **hyperparathyroidism**, diabetes, rheumatoid arthritis, and chronic steroid use.
    - **Patellar Tendon Rupture:** More common in the 3rd and 4th decades and presents with a high-riding patella (patella alta).
- **Pediatric Growth Plate Injuries:** An injury causing growth arrest on the **medial side** of the proximal tibial physis results in **Genu Varum** (bow-legs), while a **lateral side** arrest results in **Genu Valgum** (knock-knees).

II. Fractures of the Tibial and Fibular Shaft

Management of leg shaft fractures prioritises the prevention of vascular compromise and compartment syndrome.

- **Fracture Patterns and Healing:**
    - **Segmental Fractures:** These involve the bone being broken in two separate places, leaving a "floating" middle segment. They are the **slowest to heal** due to compromised blood supply to the central fragment.
    - **Transverse Fractures:** Result from high-energy injuries and take longer to heal than oblique or spiral patterns because they cause more extensive soft tissue damage.
- **Compartment Syndrome:** This is a critical emergency most frequently associated with **segmental tibial fractures**. The **earliest and most reliable sign** is intense **pain upon passive stretching** of the involved muscles.
    - If the deep peroneal nerve is affected within a compartment, the patient will experience a **loss of dorsiflexion** (foot drop) and loss of sensation in the first web space.
- **Nerve Injuries:** Injury to the fibular neck can damage the **common peroneal nerve**, resulting in foot drop and a characteristic **high steppage gait**, where the patient must excessively flex the hip and knee to clear the ground during the swing phase.

III. Ankle Fractures and Stability

The stability of the ankle joint is the primary concern when determining if a fracture requires surgical intervention.

- **The Syndesmosis:** This distal tibiofibular ligamentous complex is the **most important structure** for maintaining the stability of the ankle.
- **Danis-Weber Classification:** This system classifies lateral malleolus (fibular) fractures based on their position relative to the syndesmosis:
    - **Type A:** Fracture below the level of the syndesmosis; usually stable.
    - **Type B:** Fracture at the level of the syndesmosis; stability is variable.
    - **Type C:** Fracture above the level of the syndesmosis; indicates a **disrupted syndesmosis** and an inherently unstable injury that usually requires **Open Reduction Internal Fixation (ORIF)**.

- **Tillaux Fracture:** A "transitional" fracture seen in adolescents (Salter-Harris Type III) involving an avulsion of the **anterolateral distal tibia epiphysis**. It occurs because the lateral side of the growth plate is the last to close.
- **Vascular Emergencies:** A posterior ankle dislocation with **absent distal pulses** suggests a **popliteal artery injury**. Immediate **reduction** is the necessary first step to restore arterial flow.

IV. Nerve and Vascular Associations

Injury	Associated Nerve/Vessel Injury	Clinical Result
Posterior Hip Dislocation	**Sciatic Nerve**	Common nerve injury in this dislocation
Knee Dislocation	**Popliteal Artery**	Diminished distal pulses; requires urgent reduction
Fibular Neck Injury	**Common Peroneal Nerve**	**Foot drop** and loss of web space sensation
Leg Compartment Syndrome	**Deep Peroneal Nerve**	Loss of dorsiflexion and toe extension

- **Prosthetic Infection:** After knee or hip replacement, **Staphylococcus aureus** is the most common cause of early-onset infection (<3 months), while **Staphylococcus epidermidis** is associated with delayed-onset (3–24 months).

Hip Fractures

I. Femoral Neck Fractures (Intracapsular)

These fractures occur within the joint capsule and are subject to unique biological constraints.

- **Vascular Supply:** The region is supplied by **retinacular branches** of the medial femoral circumflex artery, which are **functional end arteries**.
- **Healing Environment:** The **intracapsular synovium** disperses the fracture hematoma, and there is generally **lower osteogenic activity** in this region.
- **Key Risks:** Due to the vulnerable blood supply and poor hematoma preservation, there is a **high risk of avascular necrosis (AVN)** and **non-union**.
- **Management Principles:**
    - **Younger patients:** Require **anatomical fixation** to preserve the natural joint.
    - **Elderly patients:** Typically treated with **hip replacement**.

II. Intertrochanteric (IT) Fractures (Extracapsular)

Located between the greater and lesser trochanters, these fractures occur outside the joint capsule in well-vascularised bone.

- **Vascular Supply:** Supplied by metaphyseal branches from the medial and lateral femoral circumflex arteries; these are **not end arteries**, providing a robust blood supply.
- **Healing Potential:** The region is composed of **abundant cancellous bone** with **high osteogenic potential**, leading to faster healing and a **low risk of AVN**.
- **Evans Classification:**
    - **Stable:** The lesser trochanter is not displaced, there is no comminution, and the medial cortices remain aligned.
    - **Unstable:** Characterised by displacement, comminution, or multiple fracture lines.
- **Main Complication:** The primary concern is **malunion** (specifically varus collapse and limb shortening) rather than non-union.

III. Subtrochanteric Fractures

These fractures occur below the lesser trochanter and are defined by the intense muscle pull that displaces the fragments.

- **Proximal Fragment Deformity:** Pulled into **abduction** (by gluteus medius/minimus), **flexion** (by iliopsoas), and **external rotation** (by gluteus maximus).
- **Distal Fragment Deformity:** Pulled into **adduction and varus**, which results in significant shortening of the affected limb.

IV. Clinical Pearls for Hip Fracture Management

- **Mortality:** In elderly patients, mortality following a hip fracture is most strongly associated with comorbid **renal failure**.
- **Diagnostic Pitfall:** In elderly, postmenopausal women with osteoporosis, a hip fracture may not be visible on initial plain X-rays; **MRI** is the preferred next step for its high sensitivity in detecting these **insufficiency (stress) fractures**.
- **Associated Nerve Injury:** The **sciatic nerve** is the most commonly injured nerve in **posterior hip dislocations** due to its anatomical position directly behind the joint.
- **Pediatric Consideration:** In **Slipped Capital Femoral Epiphysis (SCFE)**, surgical **in situ screw fixation** is the preferred treatment; manual manipulation for reduction is contraindicated as it is highly associated with **AVN**.

Spine Fractures

I. Common Types of Spinal Fractures

- **Compression (Wedge) Fractures:** These are often seen in elderly patients with osteoporosis following low-energy trauma. They typically present as sudden onset back pain; if suspected, a dorsolumbar X-ray is the mandatory next step to rule out a wedge fracture.
- **Burst Fractures (Axial Compression):** These result from **axial loading**, such as falling from a height and landing on one's feet. They are considered **unstable** (often involving the anterior and posterior columns) and frequently require surgical intervention to prevent paralysis.
- **Flexion–Distraction (Chance) Fractures:** Known as **"seatbelt injuries,"** these fractures are highly associated with **small bowel injuries** (specifically the 2nd part of the duodenum and ligamentum teres). Clinicians must rule out intra-abdominal injuries in these patients.

II. High-Risk Locations and the "Line of Gravity"

- **Junctional Areas:** Most fractures occur where the spine transitions between kyphosis and lordosis. The **T10–L2** region is the most common site (65%), with **T11–L2** being the most unstable and prone to injury.
- **The Line of Gravity:** Axial loading can cause severe fractures at any point along this line, which spans from the **base of the skull, C7, T12**, the sacroiliac joint, the femoral head, the medial condyle of the femur/tibia, and the **calcaneus**.
- **Diagnostic Tip:** If a patient presents with a calcaneus fracture after a fall, the clinician should search for other fractures along the points of the gravity line (like T12).

III. Clinical Evaluation and "Red Flags"

- **Trauma Protocol:** Spinal injuries are frequently missed; they should be expected in any high-energy trauma or comatosed patient. Examination includes inspecting the back for **bruises, haematoma, or deformities** and palpating for **tenderness or crepitations**.

- **Red Flags (Indications for MRI):** Urgent MRI is mandatory if the following are present:
    - **Night pain or rest pain** (suspicion of malignancy or infection).
    - History of **malignancy**.
    - **Progressive neurological deficits** (suggesting cord compression).
    - New-onset **urinary incontinence** (suspicion of cauda equina syndrome).

IV. Spine Pain Mechanics: Flexion vs. Extension

Understanding what movement exacerbates pain helps differentiate pathologies:

- **Pain worse with Flexion:** Often indicates **disc prolapse** or muscular pain.
- **Pain worse with Extension:** Suggests **spinal canal stenosis**, facet joint arthropathy, or **spondylolisthesis**. Spinal canal stenosis is notably relieved by flexion.

V. Disc Herniation (Radiculopathy) Patterns

While not always a fracture, disc prolapse mimics spinal trauma signs:

- **L4/L5 Prolapse (L5 Root):** Presents with weakness in the **extensor hallucis longus (EHL)**, numbness in the **1st web space**, and a positive **straight leg raise (SLR)** <30°.
- **L2/L3 Prolapse (L3 Root):** Presents with **quadriceps weakness** and a reduced patellar reflex, but typically has a **negative SLR** test.

VI. Summary for Memorisation

Fracture Type	**Mechanism**	**Key Association**
Chance (Seatbelt)	Flexion-Distraction	**Small bowel injury**
Burst	Axial Loading	**Instability / Surgery required**
Compression	Low energy / Osteoporosis	**Elderly patients / Sudden pain**
T10–L2	Junctional Stress	**Most common fracture site (65%)**

Fractures in Children

I. Unique Anatomical Properties of Pediatric Bone

The pediatric skeleton possesses distinct biological characteristics that differ significantly from adults, influencing how bones break and heal.

- **Porosity and Flexibility:** Pediatric bone is significantly **less dense and more porous** than adult bone.
- **Energy Absorption:** These bones have a **lower modulus of elasticity** (less stiffness) and lower bending strength, which allows them to absorb more energy before a complete failure occurs.
- **Periosteal Strength:** Children have a **thick, active periosteum** that provides stability and aids in rapid healing.
- **Tissue Strength Ratios:** In children, **ligaments and tendons are relatively stronger than bone**; consequently, traumatic forces are more likely to result in a fracture than a ligamentous tear.
- **Reduced Comminution:** Due to increased cancellous bone, fractures have a reduced tendency to propagate, leading to **less comminuted patterns** than those seen in adults.

II. Pediatric-Specific Fracture Patterns

Children exhibit unique fracture types, including incomplete injuries and specific injuries to the growth plate (physis).

- **Incomplete Fractures:** Classic pediatric patterns include **Greenstick fractures** (where only one side of the bone cortex breaks) and **Torus or Buckle fractures** (where the bone compresses or bulges).
- **Salter-Harris (SH) Classification:** This system categorises fractures involving the **physis (growth plate)**:
    - **Type I:** A fracture **straight across** the growth plate; it generally has an **excellent prognosis** with minimal risk of growth arrest.
    - **Type II:** The fracture extends through the growth plate and then **above into the metaphysis**; this is the most common SH pattern.
    - **Type III:** The fracture extends through the growth plate and **below into the epiphysis**, such as a **Tillaux fracture**.
    - **Type IV:** The fracture runs **through** the metaphysis, physis, and epiphysis.
    - **Type V:** A **crush or compression injury** to the growth plate; this type carries the **worst prognosis for healing** and growth.
- **Tillaux Fracture:** This is a "transitional" SH Type III fracture of the **anterolateral distal tibia epiphysis** seen in adolescents (ages 14–16) as the growth plate begins to close.

III. The Power of Remodeling

Children have a remarkable ability to spontaneously correct bone angulation through remodeling, though this potential is governed by specific factors.

- **Remaining Growth:** The **most important factor** for remodeling potential is the number of **years of remaining growth** the child has left.
- **Proximity to the Physis:** Remodeling is most effective when the fracture is located **nearer to the physis**.
- **Anatomical Growth Potential:** Remodeling is better in areas with higher growth potential; in the upper limb, this is **away from the elbow** (e.g., proximal humerus and distal radius), while in the lower limb, it is **around the knee**.

- **Plane of Motion:** Deformities remodel best when the angulation is in the **sagittal plane** (the same plane as the adjacent joint's normal flexion and extension).
- **Poor Remodeling Scenarios:** Remodeling is least effective for deformities in the **transverse plane** or for **coronal plane (varus/valgus)** angulations, such as a distal humerus varus deformity.

IV. Clinical Red Flags: Non-Accidental Injury (Child Abuse)

Clinicians must maintain a high index of suspicion for non-accidental trauma when certain fracture patterns are identified.

- **Suspicious Patterns:** Fractures highly associated with abuse include **wrinkle (metaphyseal) fractures** caused by twisting, **posteriomedial rib fractures**, and **skull fractures**.
- **Age-Specific Concerns:** A **transverse fracture** of the humerus or femur in a child **under three years old** is suspicious for direct trauma from abuse.
- **Historical Clues:** Signs of abuse include identifying **multiple fractures at different stages of healing**, a history that does not match the developmental stage of the child, or a significant delay in seeking medical treatment.

V. Management Considerations

- **Compartment Syndrome:** This emergency is a risk in children with **tibial fractures**, especially those that are **segmental or comminuted**.
- **Stability and Healing:** The type of healing is determined by **fixation stability**; relative stability (casts, nails) leads to **secondary healing with callus**, while absolute stability (compression plates) leads to **primary healing without callus**.

Pediatric Spine

I. Classifications of Pediatric Scoliosis

Scoliosis in children is categorized into three primary structural types based on its underlying cause:

- **Congenital Scoliosis:** This results from developmental defects present at birth. It is classified into:
    - **Failure of Formation:** Manifests as wedge-shaped or **hemi-vertebrae**.
    - **Failure of Segmentation:** Results in **congenital bar or block vertebrae**.
    - **Clinical Note:** Progression of the curve depends on the specific type of vertebral deformity, and **treatment is typically surgical**.
- **Neuromuscular Scoliosis:** Also known as secondary scoliosis, it occurs due to a muscle imbalance or spasticity between the sides of the spine. Common causes include **Poliomyelitis, Cerebral Palsy, and Neurofibromatosis**. Management is surgical.
- **Idiopathic Scoliosis:** This is the most common form and is classified by the age of onset:
    - **Infantile:** 0–3 years.
    - **Juvenile:** 3–9 years.
    - **Adolescent (AIS):** 10–18 years; this is the **most common type**.

II. Adolescent Idiopathic Scoliosis (AIS)

AIS is a complex three-dimensional deformity of the spine that often presents during the pubertal growth spurt.

- **Clinical Presentation:** AIS is usually **painless**. While uneven shoulders may be present, they are not a universal finding.
- **The Adams Forward Bend Test:** This is the gold standard for clinical screening. It demonstrates the **rotational component** of the deformity, which appears as a rib prominence or "hump".
- **Common Curve Patterns: Right thoracic curves** are the most common in AIS. Left thoracic curves are highly unusual and require further investigation (e.g., MRI) to rule out spinal tumours.
- **Risk of Progression:** The likelihood that a curve will worsen depends on the patient's **sex** (higher risk in females), the **magnitude and type of the curve**, and the patient's remaining **growth potential**. **Menarche** serves as a significant prognostic indicator for the cessation of rapid curve progression.

III. Radiological Measurement and Maturity

Precision in measuring the spinal curve and determining skeletal age is vital for deciding on a treatment plan.

- **Cobb's Angle:** This is the standard measure for the degree of curvature, calculated using full-length erect X-rays.
    - **Mild:** 10°–30°.
    - **Moderate:** 30°–45°.
    - **Severe:** >45°.
- **Surgical Indications:** Curves between **50° and 90°** generally require surgery to prevent further progression. Curves **under 50°** are typically managed conservatively.
- **Risser's Sign:** This is an indirect measure of **skeletal maturity** based on the ossification of the iliac apophysis. It is graded from 0 to 5:
    - **Grades 1–2:** Corresponds to the growth spurt.
    - **Grade 5:** Indicates that **skeletal maturity is reached** and the end of spinal growth.

IV. Pediatric Spine Trauma and the "Line of Gravity"

Spinal injuries in children can occur due to high-energy axial loading. Clinicians use the "Line of Gravity" to search for associated fractures.

- **The Gravity Line:** This theoretical line connects key anatomical points: **Base of skull, C7, T12**, sacroiliac joints, femoral head, medial condyles of the femur/tibia, and the **calcaneus**.
- **Clinical Application:** If a child sustains a fracture at one point along this line (e.g., a **calcaneus fracture** from a fall), the clinician must search for other "severe" fractures along the rest of the line, such as a **T12 burst fracture**.
- **Common Fracture Sites:** Most spinal fractures occur in junctional areas where the spine transitions between kyphosis and lordosis; the **T10–L2** region accounts for 65% of these injuries.

Pediatric Hip

I. Developmental Dysplasia of the Hip (DDH)

DDH refers to a spectrum of structural abnormalities ranging from shallow acetabula to full hip dislocations.

- **Clinical Presentation in Infants (<6 months):**
    - **Ortolani and Barlow tests:** These are standard neonatal screening tools to detect instability.
    - **Signs:** Limitation of hip **abduction** (>20°), apparent limb shortening, and an abnormal deep long groin crease.
- **Clinical Presentation in Toddlers (Walking Age):**
    - **Bilateral DDH:** Characterised by a **wide perineum**, increased **lumbar lordosis**, and a **waddling gait**.
    - **Unilateral DDH:** Presents with a **limp**, positive Trendelenburg's sign, and **limb-length discrepancy (LLD)**.
- **Radiological Markers:**
    - **Acetabular Index Angle (AIA):** Normal is <30° at birth and <25° by 6 months; values higher than this indicate dysplasia.
    - **Positioning:** The ossific nucleus of the femoral head is typically located in the **upper outer quadrant** in DDH, rather than the lower inner quadrant. There may also be delayed or absent ossification of the femoral nucleus.
- **Management:**
    - **Pavlik Harness:** First-line treatment for infants <6 months, typically worn for 8–12 weeks until AIA is <30°.
    - **Surgical Intervention:** Open reduction is reserved for cases where closed treatment fails or for older infants (>6 months). Double or triple napkins/diapers have no role in treatment.

II. Slipped Capital Femoral Epiphysis (SCFE)

SCFE is a displacement through the hypertrophic zone of the growth plate and is the **most common hip disorder in adolescents**.

- **Epidemiology:** Most common in males aged 12–14 years; risk factors include **obesity**, hypogonadism, or being excessively tall and thin.
- **Clinical Presentation:**
    - **Pain:** Often unexplained antalgic limp with pain referred to the **groin, thigh, or knee**.
    - **Physical Exam:** A pathognomonic sign is **obligatory external rotation** of the hip when it is brought into flexion. Patients typically walk with the foot externally rotated and show decreased internal rotation.
- **Radiology:** Standard AP and frog-leg lateral views are used. **Trethowan's sign** occurs when Klein's line (drawn along the superior border of the femoral neck) fails to intersect the proximal femoral epiphysis.
- **Management:**
    - **In Situ Screw Fixation:** This is the preferred treatment to prevent further slipping.
    - **Contraindication: Manual manipulation for reduction is strictly contraindicated** as it is highly associated with **Avascular Necrosis (AVN)**.

III. Legg-Calvé-Perthes Disease (LCPD)

LCPD is an idiopathic avascular necrosis of the femoral head occurring in children.

- **Epidemiology:** Most commonly affects **young boys typically <9 years old**.
- **Clinical Presentation:** Patients present with a limp and pain in the groin, hip, thigh, or knee (referred pain). Physical exam reveals an antalgic gait with **decreased abduction and internal rotation**.
- **Radiological Features (by stage):** Widening of the joint space, sclerosis, and **fragmentation/focal resorption** of the femoral epiphysis. A pathognomonic X-ray finding is **Caffey's sign (the Crescent sign)**, which indicates a subchondral fracture.
- **Prognostic Factors:**
    - **Favorable:** Younger age at presentation (<6 years).
    - **Unfavorable:** Female sex (due to earlier skeletal maturity), obesity, and advanced stages of the disease (e.g., **Group C** where <50% of the lateral pillar height is maintained).

IV. Summary Table for Memorisation

Feature	DDH	SCFE	Perthes (LCPD)
Typical Age	Neonate / Toddler	Adolescent (12–14y)	Young Child (<9y)
Key Patient	Females often	Obese Males	Young Boys
Gait Sign	Trendelenburg / Waddling	Externally Rotated Foot	Antalgic Limp
Unique Sign	AIA >30° / Wide Perineum	**Obligatory Ext. Rotation**	**Crescent Sign**
Key Risk	Shallow Acetabulum	**AVN (if manipulated)**	Femoral Head Collapse
Management	Pavlik Harness / Surgery	**In situ Screw (No reduction)**	Observation / Bracing

Pediatric Foot

I. Clubfoot (Congenital Talipes Equinovarus- CTEV)

Clubfoot is a rigid, structural deformity that can be detected on prenatal ultrasound as early as 16 weeks.

- **The CAVE Mnemonic:** Deformity occurs across four joints, summarised by the CAVE mnemonic:
    - **C - Cavus (High Arch):** Occurs at the calcaneocuboid joint.
    - **A - Adductus (Forefoot Adduction):** Occurs at the talonavicular joint.
    - **V - Varus (Hindfoot Varus):** Occurs at the subtalar joint.
    - **E - Equinus (Plantarflexion):** Occurs at the ankle joint.
- **Clinical Signs:** True pathologic clubfoot is **rigid**. The equinus deformity often prevents or masks the formation of a deep medial foot crease.
- **Management:**
    - **Ponseti Casting (Serial Casting):** This is the gold standard ("golden method") for treatment.
    - **Bracing Compliance:** The recurrence rate is high without strict, long-term adherence to bracing following casting.

II. Congenital Vertical Talus (Rocker-Bottom Foot)

This is a rigid flatfoot deformity characterised by an **irreducible dorsal/dorsolateral dislocation** of the navicular on the talus.

- **Anatomical Features:** It involves a vertically oriented talus, calcaneal eversion, and an attenuated spring ligament.
- **Clinical Presentation:** Patients present with a fixed hindfoot equinovalgus, rigid midfoot dorsiflexion, and a forefoot that is abducted and dorsiflexed.
- **Prognosis:** It carries a **worse prognosis than clubfoot** and is frequently bilateral.
- **Management:** Treatment is **primarily surgical**. It typically starts with serial casting (reverse Ponseti), followed by a small surgical procedure before the application of the final cast.

III. Pes Planus (Flat Foot) and Tarsal Coalition

Understanding the difference between flexible and rigid flat feet is vital for pediatric assessment.

- **Flexible Pes Planus (Physiologic):**
    - Most common in toddlers and usually resolves as the medial arch develops (typically by ages 4–6).
    - **Clinical Test:** The medial arch reforms when the child stands on their tip-toes (toe-raising) or through the Jack test (great toe extension).
    - **Management:** No treatment is required if it is painless.
- **Rigid Pes Planus:**
    - Characterised by a foot that cannot be corrected passively.
    - **Causes:** Major causes include Congenital Vertical Talus or **Tarsal Coalition**.
- **Tarsal Coalition:**
    - An abnormal connection (bony, fibrous, or cartilaginous) between tarsal bones.
    - **Calcaneo-navicular coalition:** Most common; typically presents with pain and rigidity at ages 8–12 ("anteater nose" sign on X-ray).
    - **Talo-calcaneal coalition:** Typically presents at ages 12–15 ("C sign" on X-ray).
    - **Diagnosis:** CT scan is necessary to confirm and rule out multiple coalitions.

IV. Tillaux Fracture (Adolescent transitional fracture)

This is a specific "transitional" injury seen in adolescents (ages 14–16) as the growth plate begins to close.

- **Classification:** It is a **Salter-Harris Type III** fracture of the anterolateral distal tibia epiphysis.
- **Mechanism:** An external rotation injury avulses the last open part of the growth plate (the anterolateral side) because the medial side has already fused.
- **Management:** It is a bi-planar fracture that generally requires **open reduction and internal screw fixation**.

V. Summary Table for Memorisation

Condition	Key Feature	Rigidity	Management
Clubfoot (CTEV)	**CAVE** (Ankle equinus)	Rigid	Ponseti Casting
Vertical Talus	Talonavicular dislocation	Rigid	Primarily Surgical
Flexible Flat Foot	Arch reforms on tip-toes	Flexible	Observation / No Rx
Tarsal Coalition	Painful, stiff flat foot	Rigid	Conservative then surgery
Tillaux Fracture	Anterolateral tibial avulsion	Trauma	Open Reduction / Screw

Shoulder Disorders

I. Functional Anatomy and Innervation

- **Muscular Nerve Supply:** The **axillary nerve** supplies the **deltoid muscle**. The **long thoracic nerve** (SALT) supplies the **serratus anterior**.
- **Abduction Mechanics:** Arm abduction occurs in distinct phases involving different muscles and nerves:
    - **0°–15°:** Initiated by the **supraspinatus** (suprascapular nerve).
    - **15°–90°:** Primarily the **deltoid** (axillary nerve).
    - **>90°:** Requires the **trapezius** (accessory nerve) and **serratus anterior** (long thoracic nerve).

II. Rotator Cuff Disorders

- **Most Common Injury:** The **supraspinatus** is the **most frequently torn tendon**, even with relatively minor trauma, due to its poor blood supply and susceptibility to degenerative changes.
- **Clinical Examination Tests:**
    - **Supraspinatus:** Tested via the **Drop arm sign**, **Empty bottle sign** (or empty can test), and impingement tests.
    - **External Rotators (Infraspinatus and Teres Minor):** Specifically assessed using the **Horn blower sign**. A complete tear of the external rotators will result in a positive Horn blower test.
    - **Subscapularis (Internal Rotator):** Tested using the **Hands on belly test**, **Lift off test**, and the **Napoleon sign**.

III. Shoulder Dislocations

Dislocations are classified by the direction of the humeral head displacement and carry age-specific risks.

- **Posterior Shoulder Dislocation:**
    - **Mechanism:** Often caused by violent contractions of the internal rotators during **seizures or electrocution**.
    - **Radiological Hallmark:** The characteristic X-ray finding for this injury is the **"lightbulb sign"**.
- **Age-Related Complications:**
    - **Young Patients:** Most commonly sustain a **Bankart lesion** (an avulsion of the labrum). This carries a high risk for recurrence.
    - **Middle-Aged Patients:** More likely to suffer from **fractures**, such as a greater tuberosity fracture (in anterior dislocations) or fractures of the greater/lesser tuberosity (in posterior dislocations).
    - **Elderly Patients:** Predominantly experience **rotator cuff tears**.

IV. Inflammatory and Stiffness Conditions

- **Frozen Shoulder (Adhesive Capsulitis):**
    - This is an idiopathic disorder where the shoulder capsule becomes inflamed and stiff due to abnormal tissue adhesions.
    - It is more common in women and characterised by constant pain that is often worse at night or in cold weather.
    - **Clinical Marker:** The **first movement to be lost** is typically **external rotation**.
- **Calcific Tendonitis:**
    - This condition involves deposits of crystalline calcium phosphate (hydroxyapatite) within the shoulder tendons.
    - **Clinical Mimicry:** It often **mimics shoulder septic arthritis** because it presents with sudden, severe pain, swelling, warmth, and occasionally a mild fever with elevated inflammatory markers.

V. Pediatric Shoulder Fractures

- **Remodeling Potential:** Children have a high capacity for bone remodeling, especially in the **proximal humerus**.
- **Factors for Success:** In the upper limb, remodeling is best "away from the elbow," meaning a **proximal humerus fracture** has better potential than a distal one.
- **Plane of Motion:** Deformities remodel best if the fracture angulation lies in the **sagittal plane** (the same plane as normal joint flexion/extension). For example, a proximal humerus fracture with **varus deformity** in a young child is one of the "best to heal" because of this high remodeling potential.

Hand Disorders

I. Nerve Injuries of the Hand

Diagnosing hand disorders requires a precise understanding of the innervation provided by the three main peripheral nerves.

1. Median Nerve

- **Sensory Distribution:** Provides sensation to the **palmar surface of the radial 3½ fingers** (the thumb, index, middle, and radial half of the ring finger).
- **Motor Function:** Controls the **thenar muscles**, which are responsible for **thumb opposition, abduction, and flexion**.
- **Clinical Signs of Injury:**
    - **Thenar Atrophy:** Wasting of the muscle at the base of the thumb.
    - **Pointing Index Sign:** Weakness in flexing the index finger due to loss of nerve supply to the flexor digitorum superficialis and profundus.
    - **Weak "OK Sign":** Difficulty forming a circle with the thumb and index finger, specifically associated with the anterior interosseous branch.
    - **Wrist Flexion and Thumb Abduction:** Weakness in these specific movements.

2. Ulnar Nerve

- **Motor Function:** Innervates the **intrinsic muscles** of the hand, most notably the **interossei muscles** responsible for **finger abduction**.
- **Clinical Signs of Injury:**
    - **Hypothenar Atrophy:** Wasting of the muscles on the ulnar side of the palm.
    - **Claw Hand:** A characteristic deformity typically affecting the ring and little fingers.
    - **Froment's Sign:** A compensatory thumb flexion when attempting to pinch, indicating adductor pollicis weakness.
    - **Wartenburg's Sign:** An involuntary abduction of the little finger.

3. Radial Nerve

- **Motor Function:** Responsible for **wrist and finger extension**.
- **Clinical Signs of Injury:**
    - **Wrist Drop:** Inability to extend the wrist.
    - **Finger Extension Weakness:** Loss of motor power to straighten the fingers.
    - **Sensory Loss:** Numbness over the **dorsal (back) aspect of the hand**.

II. Carpal Tunnel Syndrome (CTS)

CTS is the most common compression neuropathy of the hand, involving the **median nerve** as it passes through the carpal tunnel.

- **Symptoms:** Characterised by **pain and numbness**, which are frequently worse at **night** and can cause sleep disturbances.
- **Signs of Severe CTS:**
    - **Grip Weakness:** Indicated by **objects falling from the hand**.
    - **Thenar Wasting:** Significant muscle loss at the thumb base.
    - **Tinel Sign:** A positive response (tingling) within **3 seconds** of percussion over the nerve.
    - **Motor Deficits:** Pronounced weakness in thumb movements.
- **Diagnosis:** Physical exam maneuvers include **pain upon compression of the wrist**. Nerve conduction studies are used to confirm the severity.

III. Hand Infections

- **Primary Mechanism:** Most hand infections occur through **direct inoculation**. This typically involves:
    - **Puncture wounds** (e.g., from thorns, needles, or splinters).
    - **Lacerations** and direct trauma.
    - **Bites** (human or animal).
- **Microbiology of Bites:**
    - **Human Bites (Clenched-fist injuries):** Most commonly associated with ***Eikenella corrodens***, though they are often polymicrobial.
    - **Animal Bites:** Most commonly associated with ***Pasteurella***.

IV. Complex Fractures and Deformities

- **Essex-Lopresti Injury:** This is a triad of injuries identified by a **comminuted radial head fracture**, disruption of the interosseous membrane, and **instability of the distal radioulnar joint (DRUJ)**.
    - **Clinical Pitfall:** A common error is failing to examine the **DRUJ** when a radial head fracture is identified.
- **Distal Radius Fractures:** These are common "FOOSH" (fall on outstretched hand) injuries. In children, they may present as **Salter-Harris Type II** fractures, extending through the growth plate and metaphysis. They are frequently associated with **median nerve compression**.
- **Hallux Valgus (Bunion):** Although a foot condition, it is noted for its importance; the primary indication for **operative treatment is a painful deformity**.

V. Memorisation Guide: Nerve vs. Deficit

Nerve	Key Action	Classical Clinical Sign
Radial	Extension	**Wrist Drop**
Median	Opposition / Flexion	**Thenar Atrophy / Pointing Index**
Ulnar	Abduction	**Claw Hand / Froment's Sign**

Knee Disorders and sport injuries

I. Ligamentous Injuries

- **Anterior Cruciate Ligament (ACL) Injury:**
    - **Mechanism:** Typically occurs during a **sudden twisting motion**.
    - **Clinical Presentation:** Patients often report a **"pop"** followed by **immediate swelling (hemarthrosis)**, severe deep pain, and a feeling of the knee "giving way".
    - **Diagnostic Tests:** The **Lachman test** is the most sensitive; others include the anterior drawer and pivot shift tests.
    - **Segond's Fracture Association:** This is an **avulsion fracture of the lateral tibial plateau**. Its presence is **95% predictive of an ACL injury**.
- **Collateral Ligament Injuries:**
    - **LCL (Lateral Collateral Ligament):** Evaluated using the **varus stress test**. A positive test at **30° flexion** isolates the LCL; a positive test at **0°** indicates a more extensive injury involving the LCL, ACL, and posterolateral structures.
    - **MCL (Medial Collateral Ligament):** Presents with **medial pain and tenderness**. Unlike the ACL, it is **not typically associated with immediate swelling**.

II. Meniscal and Cartilage Injuries

- **Meniscal Tears:** Characterised by **delayed knee swelling** rather than immediate hemarthrosis.
- **Clinical Examination:** The diagnosis is confirmed using the **McMurray test**, which involves performing knee flexion combined with internal or external rotation.

III. Patellofemoral Injuries

- **Lateral Patellar Dislocation:**
    - **Clinical Features:** Often presents with lateral displacement of the patella, a **"J sign"**, and patellar apprehension.
    - **Loose Bodies:** Radiographs may show multiple loose bodies in the joint space. These fragments most commonly originate from the **medial patellar facet**, which strikes the lateral femoral condyle during the injury.
    - **Associated Fractures:** It is frequently associated with a **lateral femoral condyle fracture**.
    - **Predisposing Factors:** An **increased Q angle** is a major risk factor, which can be caused by **femoral anteversion** (internally rotated thigh), external tibial rotation, or vastus medialis dysplasia.

IV. Extensor Mechanism Injuries

- **Quadriceps Tendon Rupture:**
    - Usually occurs at the tendon's insertion into the patella in patients **over 40**.
    - **Risk Factors:** Highly associated with **hyperparathyroidism** (due to weakened collagen), diabetes, renal failure, and steroid use.
    - **Clinical Sign:** Results in a significant **limitation in knee extension**.
- **Patellar Tendon Rupture:**
    - Most common in the 3rd and 4th decades.
    - **Clinical Presentation:** Patients present with **patella alta** (elevated patella height), a palpable gap below the patella, and an **inability to perform an active straight leg raise**.

Musculoskeletal Infection

I. Osteomyelitis (Bone Infection)

1. Acute Osteomyelitis

- **Mechanism of Pain:** The characteristic deep, throbbing pain in acute osteomyelitis is primarily caused by **increased intraosseous pressure**.
- **Pathophysiology:** Infection within the rigid medullary cavity triggers inflammation, leading to the accumulation of pus and oedema. Because bone cannot expand, this pressure rises, compressing venous outflow and irritating nociceptors.
- **Progression:** This increased pressure can lead to decreased perfusion, ischemia, and eventually bone necrosis.

2. Chronic Osteomyelitis

- **Definition:** Infection that has persisted for more than three weeks.
- **Common Organism:** ***Staphylococcus aureus*** is the most common causative organism.
- **Pathognomonic Radiological Signs:**
    - **Sequestrum:** This is a segment of **dead bone** that has become detached from its blood supply due to ischemia and necrosis. It appears as a hyper-dense area on X-rays and is considered **pathognomonic** for chronic osteomyelitis.
    - **Involucrum:** This refers to a layer of **new bone formation** created as the body reacts to the elevation of the periosteum.
    - **Rarefaction:** These are hypo-dense areas on imaging caused by increased blood flow to the infected region.

II. Prosthetic and Post-Operative Infections

The timing of an infection following a total joint replacement (such as a knee replacement) or internal fixation is critical for identifying the most likely causative organism:

- **Early Onset (<3 months post-placement):** Most commonly caused by ***Staphylococcus aureus***.
- **Delayed Onset (3–24 months post-placement):** Most commonly caused by ***Staphylococcus epidermidis***.
- **Late Onset (>24 months post-placement):** Usually caused by ***Staphylococcus aureus***, often via hematogenous spread from another site.

III. Soft Tissue and Hand Infections

1. Mechanism of Injury

- Hand infections are rarely the result of lymphatic or hematogenous spread; the most common mechanism is **direct inoculation**.
- Bacteria are introduced directly into the tissue through **puncture wounds** (e.g., thorns, needles, splinters), **lacerations**, or **bites**.

2. Specific Organisms by Source

- **Human Bites (Clenched-fist injuries):** While often polymicrobial, the most common specific organism associated with human bites is ***Eikenella corrodens***.
- **Animal Bites:** Most frequently associated with ***Pasteurella***.
- **Soil Contamination:** Open fractures or wounds contaminated by soil are at high risk for anaerobic infections, specifically **Clostridium**, which requires coverage with **penicillin**.

IV. Prevention and Clinical Mimics

- **Open Fracture Prevention:** The most critical step in preventing infection in an open fracture is the **early administration of antibiotics**, followed by timely irrigation and debridement.
- **Clinical Mimic (Calcific Tendinitis):** This condition can **mimic shoulder septic arthritis** because it presents with sudden, severe pain, restricted motion, swelling, warmth, and occasionally a mild fever with elevated inflammatory markers.
- **Septic Arthritis Differential:** Septic arthritis must be ruled out in patients presenting with acute knee pain, deformity, and joint effusion, particularly when there is no clear history of trauma.

V. Memorisation Guide: Infection Summary

Condition/Source	Key Feature / Sign	Most Likely Organism
Acute Osteomyelitis	**↑ Intraosseous Pressure**	Variable
Chronic Osteomyelitis	**Sequestrum (Dead Bone)**	***S. aureus***
Early Prosthetic Infx	<3 months post-op	***S. aureus***
Delayed Prosthetic Infx	3–24 months post-op	***S. epidermidis***
Human Bite	Clenched-fist injury	***Eikenella corrodens***
Animal Bite	Direct inoculation	***Pasteurella***
Soil Contamination	Anaerobic environment	***Clostridium*** (Give Penicillin)

Osteoarthritis

Osteoarthritis (OA), also known as osteoarthrosis, is a degenerative joint condition characterized by the progressive breakdown of articular cartilage and changes to the underlying bone.

I. Risk Factors

The development of osteoarthritis is influenced by a variety of systemic and mechanical factors:

- **Systemic Factors:** These include **older age**, **female gender**, and **genetic inheritance**. Race and ethnicity also play a role.
- **Lifestyle and Metabolic Factors: Obesity** (specifically a BMI > 31) is a significant risk factor. Other contributors include **metabolic syndrome** and potentially **diabetes (DM)**.
- **Mechanical Factors:** A history of **previous joint injury or trauma** and other local mechanical stressors are major risk factors.
- **Important Exclusion: Osteoporosis is not a risk factor** for developing osteoarthritis. However, the sources suggest that patients with advanced OA may actually be at a higher risk for developing osteoporosis. Rheumatoid arthritis (RA) is also associated with an increased risk of OA.

II. Clinical Presentation

Patients with osteoarthritis typically present with "mechanical" joint pain that progresses over time.

- **Symptoms:** Pain is often aggravated by activity and may be specifically noted during **knee flexion**. In early stages, the pain may not significantly interfere with a patient's activities of daily living.
- **Physical Exam Signs:** A hallmark clinical finding, particularly in the knee, is **medial joint line tenderness**.

III. Radiological Findings (X-ray)

1. **Narrowing of the joint space:** This indicates the loss of the protective cartilage layer.
2. **Osteophyte formation:** Bony outgrowths that develop at the joint margins.
3. **Subchondral sclerosis:** An increase in bone density appearing as a "whitening" of the bone just beneath the joint surface.
4. **Subchondral bone cysts:** Fluid-filled sacs that form within the bone as the disease advances.

- **Note: Periarticular osteopenia** is not a feature of osteoarthritis and its presence should suggest a different diagnosis.

IV. Management Strategies

1. Initial and Conservative Management

- **Lifestyle Modifications:** The best first step in management is **weight reduction**.
- **First-Line Analgesia: Paracetamol** is the preferred initial medication for pain management. **NSAIDs** may also be used as part of initial therapy.
- **Therapeutic Support: Physiotherapy** and physical therapy are highly recommended.
- **Interventional Relief: Intra-articular corticosteroid injections** can be utilized to provide temporary symptomatic relief in mild to moderate cases.

2. Surgical and Definitive Management

- **Indications:** Surgery is considered for advanced cases or when conservative therapies (such as analgesia and physical therapy) have failed to manage symptoms.
- **Procedures: Total knee arthroplasty (replacement)** is the definitive treatment for advanced knee OA. Similar joint replacements (Total Hip or Total Shoulder Arthroplasty) are indicated for advanced disease in those respective joints.

3. Critical Contraindications

- **NSAIDs** are strictly **contraindicated** in patients with **active peptic ulcer disease**, particularly those with a history of bleeding or perforation. In these elderly patients, if conservative therapy fails, the clinician should progress more rapidly toward surgical options like arthroplasty.

Osteomalacia & Osteoporosis

I. Osteoporosis

Osteoporosis is characterized by **reduced bone mass** with **normal mineralisation**.

- **Clinical Presentation:** It is typically an **asymptomatic ("silent") disease** and does not cause bone pain unless a fracture occurs.
- **Fracture Patterns:** It predominantly causes **axial fractures**, such as vertebral compression fractures, though the hip and distal radius are also classic sites.
- **Diagnosis and Imaging:**
    - The **DEXA scan** is the best imaging modality for diagnosis.
    - It is defined by a **T-score of ≤ –2.5 SD** compared to a young woman.
    - Plain X-rays are often insensitive for early detection of insufficiency fractures in these patients; **MRI** is preferred for its high sensitivity in such cases.
- **Risk Factors:** Factors include **female gender**, **postmenopausal state**, advanced age, **thinness** (low BMI), smoking, alcohol use, Caucasian ethnicity, rheumatoid arthritis, and chronic steroid use.
    - **Note: Obesity is not a risk factor**; being thin is a primary risk. Additionally, osteoporosis is **not** a risk factor for osteoarthritis.
- **Management (Medications):**
    - **Bisphosphonates:** Induce **osteoclast apoptosis**.
    - **Denosumab:** A **monoclonal Ig2 against RANKL**.
    - **Raloxifene:** An **estrogen receptor agonist**.
    - **Vitamin D:** Increases intestinal **calcium and phosphate absorption**.

II. Osteomalacia

Osteomalacia is a metabolic bone disease defined by **defective mineralisation**, which results in a large amount of **unmineralized osteoid** despite variable or normal bone mass.

- **Age of Onset:** Unlike osteoporosis, it can occur at **any age** and is not limited to postmenopausal women.
- **Clinical Presentation:** Patients typically experience **generalized bone pain** and tenderness.
- **Fracture Patterns:** Characterised by **appendicular fracture predominance** (fractures of the limbs).
- **Laboratory and Diagnostic Findings:**
    - **Alkaline Phosphatase (ALP):** Levels are typically **elevated** because defective mineralisation stimulates increased osteoid production and osteoblastic activity.
    - **Tetracycline Labeling:** Markedly **reduced or absent (abnormal)** on bone biopsy because the process requires normal mineralisation to bind tetracycline to calcium.
    - **Serum Calcium/Phosphate:** Often low or normal.

III. Key Differences for Memorisation

Feature	Osteoporosis	Osteomalacia
Definition	Reduced mass, **normal** mineralisation	Variable mass, **defective** mineralisation
Pain	Asymptomatic until fracture	**Generalized bone pain**
Fracture Site	**Axial** predominance (e.g., Spine)	**Appendicular** predominance (Limb)
Alkaline Phos.	**Normal**	**Elevated**
Best Test	**DEXA Scan**	**Bone Biopsy** (Tetracycline labeling)
Biopsy Result	Normal labeling	**Abnormal** (Reduced/Absent) labeling

Low Back Pain

low back pain (LBP) is a highly common condition where approximately **85% of cases are due to musculoskeletal causes** and most (60%) resolve spontaneously within six weeks.

I. Clinical Evaluation (The "Look, Feel, Move" Protocol)

When assessing a patient with low back pain, clinicians follow a structured physical examination:

- **Look:** Check for **deformity**, such as a spine tilt. A tilt away from the pathology suggests a nerve compressed from above, while a tilt toward it suggests compression from below. Presence of deformity often indicates significant pathology like disc prolapse.
- **Feel:**
    - Palpate the **interspinous spaces** and **paraspinal muscles**. If both are tender, it is highly suggestive of **disc prolapse**.
    - Use the **iliac crest** as a landmark for the **L4/L5** level.
    - Note any **guarding** (muscle spasm) in the paraspinal muscles.
- **Move:** Assess how movement affects the pain to differentiate the cause:
    - **Pain worse with Flexion:** Suggests **disc prolapse** or **muscle spasm**.
    - **Pain worse with Extension:** Suggests **spinal canal stenosis**, facet joint arthropathy, or spondylolisthesis.

II. Specific Pathologies and Radiculopathy

The sources distinguish between different spinal conditions based on clinical signs and affected nerve roots:

Condition	Primary Trigger	Key Physical Signs
Disc Prolapse	Flexion	Pain relieved by lying down; Straight Leg Raise (SLR) is often positive.
Spinal Canal Stenosis	Extension	**Pain is relieved by flexion**; most common cause of LBP severe at extension.
Spondylolisthesis	Extension	Pain increases specifically with extension.
Compression (Wedge) Fracture	Sudden onset	High suspicion in **elderly patients** even without red flags; requires a **dorsolumbar X-ray**.
L4/L5 Prolapse (L5 Root)	Flexion	**Positive SLR (<30°)**; weakness in **extensor hallucis longus (EHL)** and numbness in the 1st web space.
L2/L3 Prolapse (L3 Root)	Flexion	**Negative SLR**; quadriceps weakness and reduced patellar reflex.

III. Red Flags and Indications for MRI

Urgent imaging via **MRI** is mandatory if "red flags" are identified, as these suggest serious underlying conditions such as malignancy, infection, or cauda equina syndrome. Indications include:

- **Night pain** or pain at rest.
- History of **malignancy**.
- **Progressive neurological deficits**.
- New-onset **urinary incontinence**.

IV. Management Principles

For mechanical LBP without radicular symptoms or red flags, the focus is on conservative care and rapid return to function:

1. **Activity and Rest:** Bed rest should be limited to a maximum of **2 days**. Patients should be encouraged to return to daily activities and work as soon as pain allows.
2. **Pharmacotherapy:** Initial treatment includes **analgesia (NSAIDs)** and muscle relaxants.
3. **Physiotherapy:** Use **cold packs** for analgesia in the early stages and **hot packs** later to increase blood supply to the tissues.
4. **Education:** Patients should be educated on the best positions for sitting and lifting to prevent recurrence.
5. **Surgery:** Most patients with disc prolapse (93%) only require conservative treatment; only **7% require surgery**.

Note on Differential Diagnosis: In elderly patients with leg pain but **no motor weakness**, clinicians should consider **arterial insufficiency** rather than a simple disc prolapse.

Scoliosis

Scoliosis and kyphosis are spinal deformities characterised by abnormal curvatures.

I. Scoliosis

Scoliosis is a three-dimensional deformity involving a lateral curvature of the spine. It is divided into three primary structural types.

1. Classifications of Scoliosis

- **Congenital Scoliosis:** Resulting from defects present at birth.
    - **Failure of Formation:** Results in wedge-shaped or **hemivertebrae**.
    - **Failure of Segmentation:** Results in **congenital bar or block vertebrae**.
    - **Management:** Typically requires **surgical treatment**; progression depends on the specific vertebral deformity.
- **Neuromuscular (Secondary) Scoliosis:** Caused by muscle imbalance or spasticity. Common causes include **Poliomyelitis, Cerebral Palsy, and Neurofibromatosis**. Treatment is surgical.
- **Idiopathic Scoliosis:** The most common form, classified by age of onset:
    - **Infantile:** 0–3 years.
    - **Juvenile:** 3–9 years.
    - **Adolescent (AIS):** 10–18 years; the **most common type**.

2. Adolescent Idiopathic Scoliosis (AIS)

- **Clinical Presentation:** Usually **painless**. While uneven shoulders or asymmetry may be present, they are not universal rules.
- **The Adam's Forward Bend Test:** The gold standard for clinical screening. It demonstrates the **rotational component** of the deformity, which appears as a rib prominence or "hump".
- **Curve Patterns: Right thoracic curves** are the most common. **Left thoracic curves are highly unusual**; if seen, they require further investigation (e.g., MRI) to exclude spinal tumours.

- **Progression Risk Factors:**
    - **Patient Sex:** Females have a higher risk of progression.
    - **Growth Potential:** Rapid progression is most likely during the **pubertal growth spurt**.
    - **Menarche:** This is a key prognostic factor; its onset indicates the end of rapid skeletal growth and a reduced risk of further progression.

3. Measurement and Skeletal Maturity

- **Cobb's Angle:** Measured on full-length erect X-rays to determine curve severity:
    - **Mild:** 10°–30°.
    - **Moderate:** 30°–45°.
    - **Severe:** >45°.
- **Management Thresholds:** Curves between **50°–90°** usually require surgery to prevent progression. Curves **<50°** are managed conservatively.
- **Risser's Sign:** A 0–5 scale measuring the ossification of the iliac apophysis to judge skeletal maturity. **Grade 5** indicates that skeletal maturity is reached and spinal growth has ended.

II. Kyphosis

Kyphosis refers to the forward (posterior) curvature of the spine, typically in the thoracic region.

- **Stability:** In the context of spinal trauma and disorders, **kyphosis is considered stable**, whereas lordosis (inward curvature) is unstable.
- **Junctional Areas:** Most spinal fractures occur in the transition zones where the spine changes between kyphosis and lordosis.
- **Common Site:** The **thoracolumbar junction (T10–L2)** is the most common site for these injuries (65%), as it is a transition zone under high mechanical stress.

III. Memorisation Summary Table

Feature	Details to Remember
Adam's Test	Shows **rotational deformity** (rib hump) in Scoliosis.
Cobb's Angle	Standard for severity; **>50° typically requires surgery**.
Common Curve	**Right thoracic** is common; **Left thoracic needs MRI** for tumours.
Risser Sign	**Grade 5** = end of spinal growth/skeletal maturity.
Progression Risk	Higher in **females** and before **menarche**.
Fracture Site	Transition zones (Kyphosis/Lordosis) specifically **T10–L2**.
Hemivertebra	Example of congenital "failure of formation" scoliosis.

Orthopedic Rehabilitation

Orthopedics rehabilitation focuses on restoring function and preventing the systemic and local complications of immobility.

I. The Physiology of Deconditioning (Immobility)

"Deconditioning" refers to the functional impairment or loss resulting from long periods of immobility. It affects multiple organ systems:

- **Muscular System:** Muscle loss and weakness occur rapidly.
    - **Rate of loss:** 1% every day of decreased effort; 5–10% after one week; **50% after one month**.
    - **Heart Muscle:** Cardiac muscle also undergoes atrophy.
- **Skeletal System:** Bones require **mechanical strain** to maintain strength; without it, they weaken.
    - **Immobilization Hypercalcemia:** Occurs due to increased bone remodelling during bed rest.
- **Cardiovascular System (CVS):**
    - Leads to increased baseline heart rate (HR), increased submaximal HR, and **decreased cardiac output (CO)**.
    - Risks include **DVT** and orthostatic hypotension.
- **Joints and Soft Tissue:**
    - **Joint Stiffness:** Lack of movement reduces blood supply from the synovial fluid to the cartilage, leading to **ischemic changes**.
    - **Contracture:** Permanent shortening of a muscle or joint (e.g., in spastic cerebral palsy), leading to a loss of passive range of movement.
- **Respiratory System:** Increased risk of **atelectasis and pulmonary embolism (PE)**.

II. Muscle Tone Evolution Following Acute Injury

The status of muscle tone changes over time following an acute neurological or traumatic event (e.g., a stroke):

- **Initial Phase (0–2 weeks):** Muscles typically exhibit **flaccid paralysis**, characterized by a loss of muscle tone, absent reflexes, and weakness.
- **Later Phase (1–6 weeks): Spasticity** (increased tone) usually develops as part of the evolution of an upper motor neuron (UMN) lesion.

III. Gait Cycle and Muscle Mechanics

Understanding how muscles contract during walking is vital for rehabilitation programming.

- **Contraction Types:**
    - **Concentric:** Muscle **shortens** while generating force.
    - **Eccentric:** Muscle **elongates** while still generating force.
- **Key Muscle Phases:**
    - **Mid-stance:** The **gastrocnemius and soleus** are most **eccentrically contracted**.
    - **Pre-swing:** The **iliopsoas** initiates **concentric contraction** to begin hip flexion. The **rectus femoris** is also active in this phase.
    - **Terminal swing:** The hamstrings contract eccentrically to slow the limb down before heel strike.

IV. Pathological Gaits and Nerve Injuries

Gait Type	Characteristic Feature	Underlying Cause
High Steppage Gait	**Extreme hip and knee flexion** during the swing phase to clear the ground.	**Deep peroneal nerve injury** (foot drop/dorsiflexor weakness).
Trendelenburg Gait	The **pelvis drops** on the opposite side of the weak limb during the stance phase.	Weakness of the **hip abductors** (Gluteus medius/minimus).
Circumduction Gait	The leg swings out in a semicircle rather than being lifted high.	Various neurological or mechanical restrictions.
Hip Hiking	The pelvis is lifted vertically to help the limb clear the ground.	Compensation for inadequate knee or hip flexion.

V. Heterotopic Ossification (HO)

HO is the formation of bone tissue outside the skeleton within soft tissues.

- **Clinical Presentation:** Pain around the site and a **decreased range of motion**.
- **High-Risk Patients:** Those with **musculoskeletal trauma**, spinal cord injury, **severe burns**, traumatic brain injury (neurogenic HO), or those undergoing **Total Hip Replacement (THR)**.
- **Note:** Ankylosing spondylitis is considered less likely than the above to cause HO in an immobilized patient.

VI. Core Rehabilitation Principles

- **Conditioning Exercises:** These aim to **lower resting blood pressure**.
- **Intraarticular Fractures:** These always require **anatomical reduction** for optimal functional recovery.
- **Timing of Rehab:** Guided rehabilitation should **not be delayed** until radiographic union is complete; early movement is encouraged to prevent deconditioning.