

Orthopaedics Decoded for Undergraduate

Edited by

Dr Kuldip Singh Sandhu

Assistant Professor

**Department of Orthopaedics, Government Medical College
Patiala, Punjab, India**

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Singh Sandhu

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Foreword

Orthopaedics is a fascinating and ever-evolving branch of medicine that deals not only with bones and joints, but with the movement, function, independence, and quality of life of an individual. For medical undergraduates, developing a sound understanding of the musculoskeletal system is essential, as orthopaedic problems constitute a significant proportion of clinical practice across all levels of healthcare.

“Orthopaedics Decoded for Undergraduates” has been thoughtfully conceived as an undergraduate-oriented book to provide students with a clear, structured, and clinically relevant understanding of orthopaedics. The book aims to bridge the gap between basic concepts and their practical application at the bedside. It covers the essential principles of general orthopaedics, fracture healing, common injuries, bone and joint disorders, clinical examination, diagnosis, and principles of management in a manner that is accessible to undergraduate medical students.

Salient Features of the Authors

The authors bring together a valuable combination of clinical experience, academic interest, teaching expertise, and practical understanding of orthopaedic problems. Their experience in teaching medical students and working in a tertiary-care clinical environment has helped shape the book around the needs of undergraduate learners.

The authors have particularly focused on:

- Student-oriented presentation of important orthopaedic concepts.
- Emphasis on fundamental principles and clinical correlation rather than unnecessary complexity.
- Integration of clinical examination, investigations, diagnosis, and management principles.
- Presentation of topics in a simple, systematic, and examination-friendly format.

- Inclusion of concepts that encourage students to develop clinical reasoning and problem-solving skills.
- Emphasis on understanding the patient as a whole, rather than focusing exclusively on radiographs or individual bones and joints.
- A practical approach derived from real-world clinical experience in a tertiary-care hospital setting.
- Contribution from authors and chapter contributors with experience in orthopaedic education and clinical practice.

The strength of this book lies in its attempt to make orthopaedics understandable, clinically meaningful, and interesting for the undergraduate student. Rather than being merely a collection of facts, it encourages the learner to connect anatomy, pathology, biomechanics, clinical examination, imaging, and treatment into a coherent approach to the patient.

I am confident that “Orthopaedics Decoded for Undergraduates” will serve as a useful companion for undergraduate medical students during their classroom teaching, clinical postings, examinations, and early clinical practice. It may also provide a valuable foundation for those who subsequently choose orthopaedics as a career.

I congratulate the authors and all chapter contributors for undertaking this important academic endeavour. I hope this book inspires students to look beyond memorisation and develop a deeper appreciation of the science and art of caring for patients with musculoskeletal disorders.

I wish the book every success and commend it to medical students, teachers, and all those beginning their journey in orthopaedic education.

Dr Kuldeep Singh Sandhu

*Assistant Professor
Department of Orthopaedics,
Government Medical College Patiala, Punjab, India
Email: kd27sand@gmail.com*

Chapter Contributors

Dr Jagdeep Singh Rehncy

A well renowned Trauma and Arthroplasty surgeon and working as Associate Professor in Government Medical College Patiala, having experience of more than 25 years. He has done many National and International fellowships with keen interest in hip perservation and published many peer reviewed articles in National and International journals.

Dr Daljinder Singh

He is working as Associate Professor in Government Medical College, Patiala and having keen interest in Teaching and Arthroplasty with more than 20 years of experience in his field. He has published many peer reviewed articles in National and International journals.

Dr Anshul Dahuja

He is working as Associate Professor in Guru Gobind Singh Medical College, Faridkot, having keen interest in Trauma and Arthroscopy. He is having more than 10 years of experience and published many peer reviewed articles in National and Internatiuonal journals.

Dr Kuldeep Singh Sandhu

He is working as Assistant Professor in Government Medical College, Patiala and a well renowned Trauma and Arthroplasty surgeon having experience of more than 20 years. He has done Trauma & Orthropedic (T&O) fellowship from Leeds, UK and many Inland fellowships. He has published many peer reviewed articles in National and Internmtional journals.

Dr Arvind Kumar

He is working as Assistant Professor in Government Medical College, Patiala and having experience of more than 20 years. His clinical experience and acumen is at parexcellence. He

is having keen interest in teaching as well as in shoulder replacement and published many research articles in National and International journals.

Dr Jaspreet Singh

He is working as Assistant Professor in Government Medical College, Patiala. He is a well renowned Trauma and Spine surgeon having more than 20 years experience. He has published many peer reviewed articles in National and International journals.

Dr Nitish Bansal

He is a well renowned Truma and Arthroscopy surgeon and working as Assistant Professor in Government Medical College, Patiala. He is having more than 10 years of experience in his field and published many peer reviewed articles in national and International Journals.

Dr Mahesh Goel

He is working as Assistant Professor in Government Medical College, Patiala, having morethan 10 years of experience with keen interest in Teaching and Arthroplasty. He has published many research articles in National and International journals.

Dr Dharminder Singh

He is working as a Assistant Professor in Government Medical College, Patiala and having more than 10 years of experience in his field. He is having keen interest in Teaching and Peadiatric Orthopedics and published many articles in National and International journals.

Dr Ranbir Singh

He is working as Assistant Professor in Government Medical College, Patiala. He having more than 10 years of experience in his field and published many articles in national and Internatioinal journals.

Dr Annie Sandhu

Dr Annie Sandhu is a Medical Graduate from All India institute of Medical Sciences, Rishikesh, Uttarakhand and passed with distinctions in Medicine and Obstetrics & Gynaecology. Her clinical experience and acumen is at par excellence. She has attended many National and International conferences and published many research articles.

Chapter 1:

General Orthopedic

Dr Annie Sandhu and Dr Kuldip Singh

BONE: A primary structural element of musculoskeletal system and this must be mechanistically strong enough to support the daily living. Bone is an ANISOTROPIC i.e. fiber orientation deliver specific material properties along distinct loading directions means different material properties depending on loading direction. Bone should have sufficient strength, stiffness and durability to transmit forces /load and supports joint motion. Mechanical competency of bone and implant depends on their material and structural properties and these properties of bone and implant or Fixation construct accommodates mechanical function during fracture healing. Bone's mechanical properties characterize their deformation and failure of material under loading and these properties are measured by stress and strain, stress is measured in pascal (Pa) while strain has no units. Ultimate strength of cortical bone in compression is 50% greater than in tension.

So, bone is transversely anisotropic i.e. its stiffness is 50% higher when loaded in longitudinal direction i.e parallel to osteon orientation ($E=17$ GPa) than in transverse direction (12GPa). Transverse anisotropic behavior of cortical bone is also evident in greater ultimate strength in longitudinal direction (193MPa) than transverse direction (133MPa). Internal and external forces that are offset from fracture site generate Bending moments, further the Lever arm is Offset from fracture, the Larger will be bending moment around fracture. Short fixation construct with a small Lever arm require a proportionally greater load to counterbalance the destabilizing forces than construct with a Long lever arm.

Young's modulus of elasticity of bone(E) represents deformation in response to loading within LINEAR or Elastic working.

Material	Compression stress	Ultimate stress
SS	200GPa	900 GPa
Titanium	110 GPa	860 GPa

Materials like stainless steel (SS) and Titanium have same properties regardless of direction of loading and their strength is described by SINGLE E-modulus of elasticity value.

YIELD strength of bone is when permanent change begins in itself and Ultimate strength is when bone breaks. Complete elastic reversal of bone occurs if load is removed. Cortical bone is having 4 times less strength than stainless steel (SS). If repetitive loading below ultimate strength continues then it will lead to Micro cracks causing fatigue failure (important in femur Non-union).

A fractured bone should be bio mechanically fixed i.e. Biology (less invasive and promotes environment for healing) and mechanically (sufficient strength, durability and early mobilization).

In a Bio mechanically sound fixation construct, there is a race between bone healing and construct failure and both are mutually exclusive. An applied splint provides relative stability leading to natural bone healing and callous formation. However, if there is deficient mechanical stability will cause prolonged immobilization. In contrast compression plating is Invasive and provides absolute stability which suppresses natural bone healing.

A diaphyseal bone resembles principle structure of hollow cylinder. As individual ages, diameter of femoral diaphysis increases and thickness of cortex decreases. According to principal of second moment of Inertia:-the bending stiffness of Tubular bone increases as outer diameter increases even as cortical thickness and material property of bone decrease. Bone mineral density plays an important part in determining the structural properties of bone. This aggregate increase in

strength realized by increasing the diameter of shaft is enough to protect elderly from Osteoporotic diaphyseal femoral fractures. In contrast, Trabecular thinning in vertebrae can't be compensated by structural changes of vertebrae body resulting increased risk of fractures

The material property of single Trabecular bone spicule and similar sized cortical bone are comparable, with stiffness and strength measurements differing by less than 10-15%. The structural stiffness and strength of Trabecular bone is defined by its POROSITY which depends upon on individual and anatomic location, ranges from 30-90%. Clinically, density of Trabecular bone is measured radiographic densitometer and can vary by One order of magnitude, from about 0.1 to 1.0 g/cc.

The corresponding stiffness and strength of Trabecular bone vary upon to three orders of magnitude, means that Even a small decrease in density can significantly weaken structural properties of Trabecular bone.

BIOMECHANICS OF FRACTURES:

Fracture of a bone results when loads differ in both magnitude and direction than the loads normally experienced during locomotion or activities of daily living. Severity of fracture depends on magnitude of load, as tensile fracture requires lowest load, while compression requires greatest load. Transverse fracture occurs by loading bone in tension. Bone is strong in compression and weak in shear. The surrounding tissues also affects fracture pattern and severity by absorbing energy and changing the loading direction.

1) Types of fractures:

A) OBLIQUE FRACTURES: These are oriented diagonally to Long axis of bone and occurs due to three loading patterns: -

- Pure Axial compression- Oblique fracture because bone is strong in compression and weak in shear and axial compression bone fails in along plane of maximum shear i.e 45 deg like Tibial planfold

- Bending and axial forces causing Short oblique fractures
- Torsion and bending - also produced short oblique due to Bending component but due to torsional force dominant produced long oblique rather than short oblique

B) TRANSVERSE FRACTURES: Which are perpendicular to Long axis of bone. Bone is weak in tension and transverse fractures are typically LOW energy relative to complex fractures.

- Caused by Loading bone in tension
- If there is Internal loading, it will cause- avulsion fractures

May also occur due to Low energy Bending force in absence of compression force.

C) BUTTERFLY FRACTURES: these are produced by combined bending and compression forces:

- The Bending force creates a tension at far side of neutral axis and compression at nearside of neutral axis.
- The fracture begins as a Transverse tension on far cortex and compression in near cortex results in shear with typical 45 deg oblique fracture lines.
- The combination of oblique compression fracture line joining with Transverse tension fracture line produces butterfly Fragment.

D) SPIRAL FRACTURE: occurs as a result of Torsional force:

- The Fracture has long sharp ends with Vertical component and the resulting orientation depends on Direction of Torsional load.
- IF upper fragment is fixed and Clockwise Torsional load is applied to Lower segment then, resulting fracture will be Right Handed in direction.

E) COMMINUTED FRACTURE:

- High energy fracture with multiple fragments and having worst prognosis.
- The mechanical energy absorbed in producing a fracture is directly correlates to amount of Inter fragmentary surface area created during impact loading.

2) Load Transfer:

Joint motion is controlled by forces and moments acting across joints. Force represented by Vectors depicting Magnitude and Line of action of force. Joint forces and resulting moments are induced by External loads (held in hand) and Internal loads (muscle forces). Internal forces tend to be far greater than external forces due to small lever arm by which muscles act it and balance the external moments around joint. If a force of F is acting at distance of d from joint then it will create a Rotational Moment around joint. $M = F \cdot d$. A Fracture fixation construct must resist both these deforming loads to maintain alignment as fracture consolidates.

Internal and external forces that are offset from fracture site generate Bending moments. The further the Lever arm is offset from fracture, the Larger will be bending moment around fracture. Therefore, construct with a small lever arm or working length results in high loads at bone implant interface and increase the Risk of implant or fixation failure.

Conversely a Long Implant with a Long working Length has greater mechanical advantage than a shorter plate and will induce smaller stress riser at Implant- bone interface.

Chapter 2:
Fracture Healing and Its Histogenesis
Dr Jaspreet Singh and Dr Daljinder Singh

FRACTURE HEALING:

The fractures may be displaced due to force of injury, gravity, or pull by muscles. The fractures usually unite as long as sufficient contact is there. It may heal even if reduction is imperfect, but bone to bone contact is more than 50%. most commonly fractures are splinted not to get union of bone, but to 1) alleviate pain 2) maintain reduction 3) to get early Limb function.

Healing occurs as primary or secondary i.e. healing by callus formation or by direct union

A) Healing by Callus:

There are five stages of fracture healing.

1) Haematoma formation: when fracture occurred, there is haematoma formation due to torn blood vessels in and around bone. Bone is deprived of blood supply and it dies or two millimetres back from bone ends.

2) Inflammatory and cellular proliferation: Inflammatory cells appear in the haematoma with initiation and differentiating of mesenchymal stem cells from periosteum. Inflammatory mediators like cytokines and growth factors are involved resolving the haematoma and new capillaries grow into the affected part.

3) Callus formation: The differentiating stem cells provide chondrogenic and osteogenic cells which starts forming new bone formation. The cell population of osteoclasts derived from new blood vessels causes mop up of dead bone. This cellular mass having islands of immature bone and cartilage is called Callus. When immature bone becomes densely mineralized and fractures usually unites at about 4weeks.

4) Consolidation: With continuing osteoclastic and osteoblastic activity, the newly formed woven bone is transformed into a lamellar bone. This takes several months and fractures must be protected till consolidation.

5) Remodelling: The newly formed bone is reshaped by a continuous process of alternate resorption and formation. Thick lamellar bone is formed where stresses are high. (Wolfs Law)

B) Healing by Direct union:

If fracture is absolutely immobilized either due to impaction or by external or internal metal implant, then there will be no callus formation at fracture site. But osteoblastic new bone formation occurs between bone fracture fragments. The gaps between fracture fragment surfaces were invaded by new capillaries and osteoprogenitor cells which are growing inwards from edges. The new bone is formed on these exposed surfaces. (Gap healing) When the crevices are very narrow i.e. less than 200 nm then ontogenesis produces lamellar bone. And wider gaps are first filled with woven bone which are remodelled with lamellar bone. The bone remodelling units i.e. osteoclast followed by osteoblasts penetrate at 3-4 weeks.

In impacted fractures and fixed with implants, internal bridging may occasionally occur without any intermediate stages (contact healing). In rigid fixation, bone depends entirely upon metal implant for long periods for integrity, so there is absence of callous formation.

CLASSIFYING INJURY:

Patients with open fractures may have multiple injuries. A rapid assessment of patient for open wound and any life threatening injury has to be dealt emergently.

Gustilo's has classified open fractures depending upon type of fractures, soft tissue injury and degree of contamination.

Type-1: the wound is less than 1cm, clean puncture wound through which a bone spike has protruded. No crushing of soft tissues and fracture is not comminuted. (Low energy injury)

Type-2: Wound is more than 1CM, but there is no skin flap. No more than moderate crushing or comminution is there. (Low to moderate injury)

Type-3: There is a large lacerated wound with extensive damage to skin and soft tissues. Contamination is significant. (High energy injury) It is divided into three types:

3A: Fractured bone is adequately covered by soft tissues despite lacerations.

3-B: Extensive periosteal stripping and fracture is not covered.

3-C: this has arterial injury along with extensive soft tissue damage.

Chapter 3:

Physeal Injuries:

Dr Nitish Bansal and Dr Dharminder Singh

PHYSEAL INJURIES:

These injuries are usually seen in boys than girls and most common in infancy or ages of 10-12 years. A child presents with pain and tenderness near joint arouses suspicion.

These injuries are through growth plate or physis of bone and accounts for about 10% of injuries in children. Physis is relatively weak part and fracture usually runs transversally through hypertrophic Or calcified layer of growth plate. Sometimes these fracture extends to edges with a triangular slip of bone. Usually these have little effects of longitudinal growth of bone because this occurs through the germinal and proliferating layers of physis. The bone growth may be disturbed if the fracture traverses through reproductive layers of injured part.

These injuries are usually caused by fall and traction, mostly during sporting activities or playground tumbles. Salter and Harris classification is given below:

Type -1: it is the transverse fracture through the hyper trophic or calcified zone of growth plate. It has good prognosis, except in proximal femur (due to vascularity). Usually growth disturbance does not occurred even in displaced fracture fractures.

Type-2: This is common injury, fracture occurred through physis and metaphysis but usually associated with triangular metaphyseal split of bone on its edge (Thurston Holland Fragment) Called as a Flag sign. It is seldom associated with abnormal growth.

Type-3: This is an intra articular fracture involving split of epiphysis and then extension into either side through

hypertrophic layer of physis. It damages reproductive layer and produces growth disturbance.

Type-4: in this, fracture splits the epiphysis and extends into the metaphysis. These are mostly displaced resulting in asymmetrical growth. It has to be reduced accurately and need open reduction.

Type-5: This is a longitudinal injury producing compression (crush) of growth plate. Usually causes growth arrest of bone.

Type-6: This is an injury to perichondrial ring causing significant growth disturbance.

On X-rays: There may be – widening of physal gap

- incongruity of joint and
- tilting of epiphyseal axis

Treatment: This depends upon the basic classification of fracture. Mostly undisplaced fractures are treated with splinting the affected part or plaster slab for 2-4 weeks. Repeated check x-rays after 4-7 days should be done to check displacements of fragments.

All displaced fractures of type 1, 2 should be reduced as soon as possible and splinted after anatomical reduction. In all type 3 and 4 fractures, an attempt of gentle manipulation under general anaesthesia should be done. If not reduced, then open reduction and anatomically internal fixation with smooth K-wires should be done. Limb has to be splinted for 4-6 weeks.

Complications: If properly reduced, type 1, 2 have an excellent prognosis. While type 3, 4 may cause premature fusion of part of growth plate Or asymmetrical growth of bone ends. Growth retardation and premature fusion is usually seen in type 5, 6 fractures. An established deformity should be treated by corrective osteotomy.

Chapter 4:
Compartment Syndrome and Gas Gangrene
Dr Annie Sandhu and Dr Ranbir Singh

COMPARTMENT SYNDROME:

There are general and local complications of fractures. Shock, fat embolism, blood loss cardiorespiratory failure are general complications. Local complications can be divided into early and late depending upon their appearance. Compartment syndrome is an early complication fractures of a limb. This gives rise to severe ischaemia even if there is no damage to vessels. When fracture occurs, it causes bleeding and oedema on affected limb. This may increase the pressure within one of the osseofascial compartment. This leads to reduced capillary flow which results in muscle ischaemia and further oedema, increase in pressure and more profound ischaemia of limb. A vicious cycle sets up which causes necrosis of nerve and muscle in that compartment. Muscle once infarcted, can never recover and is replaced by the fibrous tissue. (VIC-Volkmann's Ischaemic Contracture) This syndrome can be caused by tight plaster applied on fractured limb. As Ischaemia occurs at capillary level, so pulses may still be felt and skin may not be pale. The classical features of compartment syndrome are FIVE 'P's.

- Pain
- Paraesthesia
- Pallor
- Paralysis
- Pulselessness

The earliest feature is pain which may be bursting in nature with altered sensibility and paresis. Skin sensation should be checked repeatedly. Ischaemic muscles are highly sensitive

to stretch. If affected limb is unduly painful, swollen, or tense, the muscles should be tested by passive stretching. On passive hyperextension of fingers and toes, there will be pain in the calf or forearm. Confirmation of diagnosis can be done by measuring the intracompartmental pressure. A differential pressure- the difference between diastolic pressure and compartment pressure, if it is less than 30 mmHg is an indication for emergent compartment decompression.

Treatment:

If three or more signs are present, the diagnosis is always certain. If clinical signs are soft, then affected limb should be examined at an interval of 30 minutes. The affected limb should be promptly decompressed. Any cast, bandage and dressings should be completely removed. The affected limb should be lie flat, because elevating the limb may further decrease in end capillary pressure. In All impending compartment syndrome cases open fasciotomy should be done immediately. If there is no improvement within 2 hours of splitting dressings then fasciotomy should be performed.

GAS GANGRENE

This necrotising situation of limb is mainly caused by an anaerobic organisms especially *Clostridium welchii*. This organism survive and multiply in tissues having low oxygen tension and dirty wound. Toxins are produced by the bacteria, destroy cell wall and produce tissue necrosis, thus spreading of this disease. Usually patients complain of intense pain with swelling with brownish discharge from wound in 24 hours of injury. Gas formation is not usually marked. Patients may have a peculiar smell with little and no pyrexia. It has to be distinguished from anaerobic cellulitis (superficial gas formation). This differentiation could survive the patient from unnecessary amputation of limb.

Treatment:

Early diagnosis is of prime importance for saving life of patient. The prompt surgical decompression of wound is utmost important. All dead tissue should be excised

completely and wound should be left open. General measures like fluid replacement and intravenous antibiotics should be started immediately. Hyperbaric oxygen has limits the spread of disease. In advanced and fully blown cases, amputation of limb is the only choice to save life of patient.

Chapter 5:

Dislocations

Dr Mahesh Goel and Dr Daljinder Singh

Dislocation means to '*put out of place*' – to displace (bone) from normal connections with another bone.

A) Shoulder dislocation:

A shoulder dislocation occurs when the head of the humerus completely separates from the glenoid cavity of the scapula. Because the glenohumeral joint trades bony stability for maximum range of motion – resembling a golf ball sitting on a tee – it is the most frequently dislocated major joint in the human body.

- **Classification**

- **Anterior** (greater than 95% of cases): The humeral head is displaced forward and slightly downward, typically caused by a force driving the arm into extreme abduction, extension, and external rotation.

- **Posterior** (2% to 4%): The humeral head shifts backward. It is classically associated with seizures, electric shock, or a direct blow to the front of the shoulder.

- **Inferior** (Luxatio Erecta, less than 1%): The humeral head is driven downward below the glenoid, locking the arm in an upright, overhead posture.

- **Clinical Signs**

- **Deformity:** Loss of the normal rounded contour of the deltoid, giving the shoulder a flattened, "squared-off" appearance with a prominent acromion.

- **Pain and Splinting:** Severe localized pain; the patient typically holds the injured arm slightly abducted and supported by the opposite hand.

- **Neurological Deficit:** Numbness over the lateral deltoid (“regimental badge” area) if the axillary nerve is stretched or compressed.

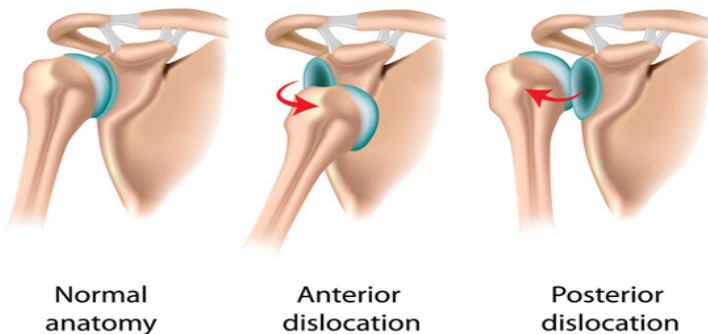
- **Management & Common Complications**

- **Diagnosis & Reduction:** Confirmed via orthogonal X-rays (AP and scapular Y or axillary views) to rule out associated fractures. Prompt closed reduction is performed using gentle traction techniques (such as the Cunningham, Stimson, or traction-countertraction methods) under analgesia or muscle relaxants.

- **Rehabilitation:** Brief immobilization in a sling followed by guided physical therapy to strengthen the rotator cuff and scapular stabilizers.

- **Associated Pathologies:** Recurrent instability is common in patients under 25. Structural damage often includes a Bankart lesion (tear of the anterior-inferior glenoid labrum) and a Hill-Sachs lesion (an impaction fracture of the posterior-lateral humeral head sustained during impact against the anterior glenoid rim).

Shoulder Dislocation



A) Hip dislocations :

Hip dislocations are named according to the direction of femoral head displacement.

Posterior – commonest

Anterior and Central dislocations are lesser commonly seen.

Posterior dislocation usually occurred as dashboard injury in road side accident, when someone seated in car or truck is thrown forward, while striking his knee with dashboard. (Dashboard injury) The femur is pushed upwards and femoral head is forced out of it's socket. It may be associated with a piece of bone from back of acetabulum. Seat belt application can reduce the number of these dislocations.

Clinical features: Patient may have leg is short and in a adducted, internally rotated and slightly flexed position. All cases should be assessed for sciatic nerve injury.

On X-rays, in AP view femoral head will be out of it's socket and above the acetabulum. It may be associated with fragment of acetabular rim or femoral head may be broken off and displaced. A CT scan is the best way to rule out and demonstrating the acetabular fractures.

Thompson and Epstein has classified these injuries into five types.

Type-1: Dislocation with no more than minor chip fractures

Type-2: Dislocation with a single large fragment of posterior acetabular wall

Type-3: Dislocation with comminution fragments of posterior acetabular wall

Type-4: Dislocation with fracture through acetabular floor

Type-5: Dislocation with fracture through acetabular floor and femoral head

Treatment: The dislocation must be reduced on emergent basis under anaesthesia. Mainly closed reduction are done and if after 2-3 attempts reduction is not achieved then open reduction is required.

Reduction Methods: While patients under anaesthesia, the assistant steadies the pelvis for counter traction and surgeon apply traction in the line of the femur as it lies (usually adduction and internal rotation), and then gradually flexes the patients hip and knee to 90 degree, while maintaining traction. In position of 90 degree hip flexion, traction is steadily increased with rotation (either internal or external) to achieve the reduction of hip. Another assistant can help by applying direct medial and anterior pressure to femoral head through buttock. A clunk sound is usually heard in case reduction is achieved.

Then hip should be test for it's stability. By flexing the hip to 90 degrees and applying a longitudinal and posterior directed force, the hip should be screened for any sign of subluxation. Reduction is usually stable in type -1 injury and hip should need to be rested for two weeks. Apply traction and maintain it for few weeks. The weight bearing is to be avoided for certain a period to prevent the collapse of femoral head, which may occur due to unsuspected avascular change.

If post reduction x-rays shows, intra articular bone fragments or larger femoral head pieces then CT scan should be performed to plan for further course of action.

All other dislocations should be treated by immediate open reduction and fixation or depending upon CT pictures. The indications for the surgery are instability, retained fragments or joint incongruity.

COMPLICATIONS: These are divided into early and late.

Early:

- **Sciatic nerve injury:** it is seen in 10-20% of patients. If after reduction, nerve injury has been detected then it should be explored for its entrapment .
- **Vascular injury:** Occasionally superior gluteal vessels is torn and bleeding is profuse.
- **Associated injury:** The femoral shaft fracture should be ruled out in all patients.

Late:

- **Avascular necrosis:** It has been reported in 10% of patients. If reduction is delayed by more than 12 hours then it's incidence rises to 40%. MRI or Bone scan are used to detect early changes. Ischaemia due to disruption of femoral head supply, when hip is dislocated. The consequences of ischaemia are proportional to delay in starting the treatment and reduction is delayed.
- **Myositis ossificans:** This is an uncommon complication.

Chapter 6:

Fracture in Children:

Dr Kuldip Singh and Dr Arvind Kumar

A) FRACTURE OF LATERAL CONDYLE OF HUMERUS

The Lateral condylar epiphysis is largely cartilaginous, which begins to ossify during first year and fuses the humerus shaft at 12-16 years. The child falls on hand with elbow extended and forced into varus. A large fragment of lateral condyle breaks off and pulled by attached wrist extensors. The bone fragment may look deceptively small on X-rays. The muscle pull causes displacements. In severe injury, the elbow may dislocate posterolaterally and condyle is capsized by muscle pull and remain capsized while the elbow is reduced spontaneously this fracture is important because of 1) may damage the growth plate and 2) it always involves the joint. So it's early diagnosis and reduction is of utmost importance to avoid poor outcome.

On examination, the elbow is swollen and tender on lateral condyle. Passive flexion of wrist is painful. It has been classified into two types.

1) A fracture lateral to trochlea and elbow joint is not involved

2) The fracture through the middle of trochlea. This is more common usually grossly displaced and unstable elbow. It carried with it a triangular piece of metaphysis

In addition to standard two X-rays views, an internal oblique view should be done to prevent wrong diagnosis.

Treatment: It depends upon the displacement of fracture fragment. If it is undisplaced, then arm should be splinted in backslab with elbow in 90degree of flexion. It is essential to repeat the X-rays after 5 days to check its displacement.

A displaced fracture should be assessed carefully. An accurate reduction and internal fixation should be done.

Complications: Non union and malunion are two common complications of this fracture. If fragment is capsized then non union is inevitable and growth of elbow is increasingly valgus and tardy ulnar nerve palsy can develop. Even Minor displaced fracture fragment produce malunion that can lead to ulnar nerve palsy in later life.

B) PULLED ELBOW:

This injury is seen usually in 2-3 years old child. In young children the elbow may be injured by pulling on the arm. It is the subluxation of the orbicular ligament which slips up over the head of radius into radiocapitellar joint. A child is brought to clinician with history of jerk by the arm and crying out in pain. Forearm is usually held in pronation and extension. There are no X-rays changes.

A dramatic cure is achieved by forcefully supinating and then flexing the elbow. During this manoeuvre ligament slips back with a snap.

C) CLAVICLE FRACTURES:

It usually occurs by fall on an shoulder or on outstretched hand.. Midshaft clavicle fractures are common. It usually heals without complications. In adults, clavicle fractures are also common accounting for 2.6-4% of fractures and about 35% of all shoulder injuries. Outer fragment is pulled down by weight of arm and inner half is held by up by sternomastoid muscle. AP view and with 30degree cephalic tilt x-rays are required for diagnosis.

Classification: Group-1: Mid third fractures

Group-2: Lateral third fractures

Group-3: Medial third fractures

Treatment: Usually undisplaced fractures are treated conservatively. Non- operative management consists of applying a simple sling in figure of eight with arm pouch.

Malunion is the most common complications for clavicle fractures. In Lateral end fractures and in non unions operative management with plating or intramedullary fixation is required.

D) SUPRA CONDYLAR HUMERUS FRACTURES:

These are commonest fractures in children. They are of two types- flexion and extension type. The most common is hyperextension type (95%) usually caused by fall on the outstretched hand producing posterior displacement of bone. The remaining 5% is flexion type causing anterior displacement of bone. This is usually produced by fall when joint is in flexed position.

Classification:

Type-1: it is usually undisplaced fractures

Type-2: usually posterior cortex is in continuity

2A: injury in which distal fragments are usually less angulated.

2-B: this injury produces both angulation and malrotation

Type-3: this is completely displaced fracture, but posterior periosteum is usually preserved. The fragments may be displaced posterolateral or posteromedial.

The children usually complained of pain with swelling around elbow region. There is always a history of fall. On examination, there will be deformity of elbow joint.

On X-rays, in undisplaced fractures there will be loss of fat pad sign. This sign is a triangular lucency in front of the distal humerus. In normal lateral view, if a line is drawn along anterior cortex of the humerus this will cross the middle of the capitulum. Any deviation from this usually suggests fractures. On AP view measurement of Baumanns angle is helpful in determining fractures. This angle which is subtended by the longitudinal axis of humerus shaft and the line drawn through the coronal axis of the capitellar physis. Normally this angle is less than 80 degree.

Treatment: It usually depends upon the displacements of distal fragments.

Type-1: These type of fractures are usually immobilized in 90 degree of flexion and neutral rotation in a POP splint. X-ray should be repeated after 5-7 days and this splint should be continued for 3 weeks.

Type-2A: These fractures should be reduced under general anaesthesia in a stepwise manoeuvre.

Reduction Procedure: Patient should be under General anaesthesia and 1) traction should be applied along the length of the arm with counter traction above elbow level. 2) correction of tilt Or rotation of arm 3) gradual flexion of the elbow to 120 degree and pronation of forearm, while maintaining traction and giving finger pressure from behind distal fragments to correct posterior tilt.

If this is unstable, then fixation with K -wires should be done. Following reduction, the arm should be held in a collar and cuff. The circulation of limb should be checked regularly during first 24 hours.

Type 2-B and 3: These fractures are usually unstable and require fixation. There is a considerable risk of neurovascular injury. The fractures should be reduced under general anaesthesia and fixed with percutaneous K wires.

Open reduction and internal fixation (ORIF) should be done in highly unstable fractures.

Flexion type of fractures should be reduced by pulling elbow in semi flexed and applying thumb pressure to distal fragments and the extending the elbow carefully while checking neurovascular circulation.

Chapter 7

Fracture in Adults

Dr Anshul Dahuja and Dr Ranbir Singh

1) FRACTURES OF UPPER LIMB:

A) Galeazzi fracture:

A Galeazzi fracture is a fracture of the distal third (or junction of the middle and distal thirds) of the radial shaft accompanied by dislocation or subluxation of the distal radioulnar joint (DRUJ). Historically dubbed the “fracture of necessity” by Campbell, it earned the name because non-operative management in adults almost universally fails due to deforming muscular forces.

• Mechanism of Injury

Primary cause: A fall onto an outstretched hand (FOOSH) with the wrist in hyperpronation and hyperextension.

Alternative cause: A direct high-energy blow to the dorsolateral aspect of the wrist or distal forearm.

Deforming forces: The brachioradialis, pronator quadratus, and extensor/flexor tendons exert traction on the distal radial fragment, causing shortening, rotation, and secondary disruption of the triangular fibrocartilage complex (TFCC) and radioulnar ligaments.

• Clinical Presentation & Diagnosis

Signs: Marked wrist and distal forearm swelling, deformity, tenderness, and painful limitation of forearm pronation and supination.

Physical exam: A prominent, ballotable distal ulna (positive “piano-key sign”) indicates gross DRUJ instability.

Radiography: Full-length anteroposterior (AP) and lateral views of the entire forearm—including both the elbow and wrist joints—are mandatory.

- **Management**

Adults (Operative): Open reduction and internal fixation (ORIF) of the radius using a 3.5 mm dynamic compression plate (typically via the volar Henry approach). Restoring anatomic length and alignment of the radius often reduces the DRUJ spontaneously.

- If DRUJ is stable post-fixation: Immobilization in a long-arm splint/cast in supination for 4 to 6 weeks.

- If DRUJ remains unstable: Transfixing the DRUJ with temporary percutaneous Kirschner wires (K-wires) or repairing the TFCC.

Children (Non-operative): Unlike adults, pediatric Galeazzi injuries usually heal reliably with closed reduction and long-arm cast immobilization in supination due to an intact, robust periosteum.

- **Complications**

Persistent DRUJ instability and chronic wrist pain.

Malunion or nonunion resulting in severe loss of forearm rotation.

Triangular fibrocartilage complex (TFCC) tears and secondary radioulnar osteoarthritis.

Nerve injury, most commonly affecting the anterior interosseous nerve (AIN) or the superficial radial nerve.

A) COLLES' FRACTURE:

It was described by Sir Abraham Colles In 1814. It is an extra articular transverse fracture at corticocancellous junction and 2.5cms above the distal end of radius. Anatomically Distal radius is bearing 80% of load and articulates by three columns. Radial column consisting of radial styloid and scaphoid fossa, intermediate column of lunate fossa and ulnar column of TFCC and distal ulna. It is the most common (80%) of all fractures of older people more than 50 years old. It comprises of about 17.5 % of all adult fractures with female predominance in ratio of 2-3:1. In older it is caused by low

energy trauma and in young adults it is due to high energy trauma. This is having higher incidence in post menopausal osteoporosis women. It is strong predictor of subsequent fractures.

Symptoms: wrist pain, wrist swelling and deformity if displaced.

Examination: ecchymosis and swelling, diffuse tenderness and visible deformity and limited motion due to pain.

On X-rays it had shown six displacements and clinically it produces dinner fork deformity on wrist joint. (LIDS)

- 1) Lateral displacement
- 2) lateral tilt
- 3) Impaction
- 4) Dorsal displacement
- 5) Dorsal tilt
- 6) Supination

Treatment: It consists of non- operative and operative.

Non- operative: It is applied in extraarticular fractures having less than 5mm radial shortening. After closed reduction of fracture, POP back slab or cast is applied on affected part with suggestion of limb elevation and finger movements. If it is applied in extreme flexion and ulnar deviation (Cotton Lodar position) , then it can cause carpal tunnel syndrome.

Operative: It is either a closed reduction and percutaneous pinning (CRPP) or open reduction and internal fixation (ORIF). These procedures are used when there is instability, and volar cortex comminution. External fixator is used in highly comminuted fractures.

Complications:

- 1) Carpal tunnel syndrome:

(Median Nerve): This is seen in 1-12% of Colles patients, in which cast is applied in excessive wrist flexion.

2) Malunion is the most common complication of Colles fracture.

3) EPL and FPL rupture: These are very late complications of this fracture.

B) SCAPHOID FRACTURE:

Scaphoid is the largest carpal bone in proximal row. It has a complex 3-D structure, resembling a boat, skiff or twisted peanut which is oriented obliquely from extremity's long axis and also in line of loading between the thumb and forearm. Articular cartilage covers its 75% surface and it articulates with radius, lunate, trapezium, trapezoid and capitate. Dorsal carpal artery which is a branch of radial artery, enters in a non-articular area on dorsal surface. This supplies 80% of its blood supply in a retrograde blood flow. Superficial palmar branch supplies rest of 20% of area of the bone. This produces vascular watershed which is known for poor healing. It produces a link between proximal and distal carpal row. It flexes with wrist flexion and radial deviation and extends during wrist extension and ulnar deviation.

This is the most common carpal bone fractured, constituting about 15% of wrist injuries. It is 75% of all carpal bone fractures having male to female ratio of 2: 1. It is more common in 3rd decade of life and in contact sports. Axial loading across a hyperdorsiflexed pronated and ulnarly deviated wrist is most common mechanism of injury. The fracture mostly occurred through waist (65%) of bone, proximal third (25%) and distal one third (10%).

Patients usually have history of fall on out stretched hand (FOOSH) having pain, swelling and tenderness in wrist joint. Motion may be restricted and painful. There are various provocative tests to diagnose this fracture (anatomical snuff box tenderness, scaphoid compression test, scaphoid tubercle tenderness volarly).

Radio logically there are 4 views (scaphoid series) to diagnose this. (PA, Lateral and two oblique views) semi pronated obliquely 30 degree wrist extension and 20 degree ulnar deviation).

In doubt cases, repeat Xrays at an interval of 14-21 days should be done. Bone scan and CT scan can be done to rule out fresh fractures. MRI can be performed for evaluating ligament ruptures.

Treatment: It is either non-operative Or operative, depending upon displacement of fracture fragment.

Non-operative: In a stable and non displaced fracture, scaphoid cast in a position of glass holding is applied. If X-rays are normal and there is high level of suspicion, a POP Thumb spica cast is applied and reassessed after 14-21 days.

Operative: Percutaneous screw fixation is done in unstable and non displaced fracture. ORIF is done in displaced and humpback deformity.

Complications:

1) Non-union is usually seen after 3weeks of treatment and seen in 5-10% of cases.

2) AVN without treatment is directly correlated with proximity of fracture fragment to proximal pole. Relative sclerosis of proximal fragment is pathognomic of avascular necrosis.

3) Osteonecrosis is seen in 13-50% of cases.

4) SNAC -scaphoid non-union advanced collapse.

5) Malunion

C) BENNETT's FRACTURE:

There are usually three types of fracture of thumb metacarpal.

1) Impacted fracture

2) Bennett's fracture dislocation

3) Rolando fracture

Bennett fracture occurs at the base of first metacarpal bone usually due to punching. It is oblique fracture and unstable in nature and extends into CMC joint.

On examination, there is swelling in CMC region and thumb looks small. X-rays shows a small triangular fragment in contact with medial edge of trapezium and thumb subluxated proximally.

Treatment: In mildly displaced fracture, after reduction is achieved, plaster is applied over it with first metacarpal held in abduction and extension. In all displaced fractures are surgically fixed with K wiring.

D) MALLET FINGER INJURY:

This is a sudden flexion injury (stubbing the tip of the finger) of the terminal phalanx of finger and finger is not straightened actively afterwards. This causes three types of injuries:

- 1) avulsion of distal part of extensor tendon
- 2) avulsion of small flake of bone from base of terminal phalanx
- 3) avulsion of large dorsal bone fragment.

Treatment consists of immobilization of affected part in slight hyperextension using a finger splint. The splint is applied continuously for 8 weeks and at night for further 4 weeks.

Bony avulsion may also be treated in a splint. However this needs 6 weeks of immobilization, as bone heals quickly. If subluxation of distal phalanx is there, then it should be fixed with K wire or a small screw.

E) GAME KEEPER'S THUMB or SKIER'S THUMB:

The ulnar collateral ligament inserts partially into palmar plate. It is tearing of ulnar collateral ligament of thumb at metacarpophalangeal joint. It occurs either acutely or as chronic injury. If it occurs in twisting the neck of animals in olden days- called a Game keeper's thumb or if it is seen in skiers when they fall on extended thumb, forcing it into hyperabduction called as Skiers thumb. This results in loss of stability which interferes with pinching (prehensile) movements of thumb. If only ligament is torn during injury, then thumb will be unstable on flexion and more or less

stable in extension because palmer plate is intact. In complete ruptures, both the ligament proper and palmer plate are torn and thumb becomes unstable in all positions.

Sometimes, distal attachments does not heal and get trapped in front of adductor pollicis aponeurosis – then it is called a Stener lesion.

On examination, there will be tenderness and swelling precisely over the ulnar side of thumb metacarpo- phalangeal joint. Before doing any stress tests for any instability, an X-rays of affected joint are required to rule out the fracture of bone. If there is no undue laxity in both flexion and extension of thumb, then a serious injury is excluded.

Partial tears are treated with short period of immobilization in a splint followed by finger movements. Pinch should be avoided for 6-8 weeks. Complete tears need operative repair.

FRACTURES OF LOWER LIMB:

1) FRACTURE NECK OF FEMUR

The femoral neck is the commonest site of fracture in elderly, usually women of seventh or eighth decade. It's association with osteoporosis is so manifest that, this is considered as measure of age related osteoporosis. In addition, the older people have weak muscles and poor balancing, which leads to an increased tendency to fall. So all at risk patients should be screened for osteoporosis and prophylactic measures should be taken.

These fracture are common in old people with increased incidence of AVN and having high level of morbidity and mortality. They are increasingly common in aging population having more in females as compared to males. US is having highest incidence of hip fracture rates.

Mechanism of injury: In elderly this fracture usually occurred from a simple fall and even a small force is required in osteoporotic patients. (catching a toe in carpet and twisting the hip into external rotation). The younger individual has history of fall from height or a road side accident.

Diagnosis is usually made with pain in hip region and radiographs with orthogonal views. High energy fractures are seen in young persons and low energy fractures are seen in older patients. In 6-9% of patients these are associated with fractures of shaft of femur. Neck of femur is divided into two parts likely intracapsular and extra capsular. The intracapsular part have poor healings usually due to 1) bathed in synovial fluid which prevents clotting of haematoma 2) lack of periosteal layer (Cambium layer), 3) haematoma formation from ruptured vessels (temponade effect) and disruption of retinacular vessels cuts blood supply to femoral head and no contact with surrounding soft tissues, that all lead to less callous formation and non-union. The elderly patients with unexplained pain in hip should be considered as stress fracture until proved otherwise.

Clinical features: There is usually history of fall which is followed by pain in hip. The patient lies with his limb in external rotation and shortening. The patients with impacted fracture, may still be able to walk and debilitated and handicapped patients may not complain of any pain at all.

Anatomically, neck shaft angle is $130^{\circ} \pm 7^{\circ}$ degree and normal anteversion is $10^{\circ} \pm 7^{\circ}$ degree. Blood supply of femoral head majorly from medial femoral circumflex artery (Lateral epiphyseal artery) and some from Anterior and inferior circumflex arteries. Ligamentous teres artery also supplies some part of head. So, displacement of fracture femoral neck is associated with disruption in its blood supply. There are basically two classifications used for this fracture. Undisplaced and displaced. However, the following classifications are used for better functional outcome of these patients.

Garden classifications:

Type-1: Incomplete and valgus impacted

Type-2: Complete and Undisplaced

Type-3: Complete and partially displaced

Type-4: Complete and fully displaced

Pawells Classification: (This is based on angle of fracture line to horizontal)

- 1-Fracture angle <30 degree from horizontal
- 2- Fracture angle between 30-50 degree
- 3-Fracture angle more than 50 degree

Patients with impacted and stress fractures usually complain of slight pain or pain referred along medial side of thigh and knee. There may be pain on percussion of greater trochanter. Patients with displaced fractures have pain in entire hip region with leg in external rotation and shortening.

X-rays: AP and traction internal rotation AP view, cross leg table lateral view are used for diagnosis. In these patients, two questions must be answered: is there a fracture or is it displaced. Displacement is assessed by abnormal shape of bony outlines and degree of mismatch of the trabecular lines in femoral head and neck. CT scan is used to determine the degree of displacement and comminution of fracture.

Treatment:

Non- operative treatment of undisplaced consists of pain relieving and splintage of the limb and traction. Impacted fractures can be treated non surgically, but they may become displaced, then internal fixation is required.

Anatomically perfect reduction of fracture part is of paramount importance and reduction is assessed by Garden alignment index on fluoroscopy. The trabeculae in femoral head and a line along the medial border of the femoral shaft should subtend an angle of 155-180 degrees. The acceptable reduction is within 20 degree of this ideal. The contour of femoral head and neck forms a smooth 'S' on lateral view. If there is any discontinuity in alignment, it's 'S' shape will be deformed.

Intracapsular fractures are usually treated by surgical procedures like ORIF, CCS, DHS or Arthroplasty. However in high risk and non ambulatory patients are treated non-operatively. Anatomical reduction of fracture is of utmost

importance and has more pronounced effect on healing than surgical procedure. The treatment depends upon the degree of displacement, physiological age of patients and ipsilateral fracture of shaft of femur. Fixation with implants like sliding screw permits dynamic compression at fracture site during axial loading leading to shortening of extremity with lowering physiological function of limb and effects biomechanics of hip.

1) ORIF (Open reduction and internal fixation): This procedure is usually used in displaced and young patients.

A) CCS (Cannulated Cancellous Screw): These are used in non-displaced trans-cervical fracture and Garden type 1 and 2 fractures. Anatomical reduction is required for better functional outcome.

B) DHS (Sliding Hip Screw): This is used in basicervical fractures and in young patients.

2) Prosthetic replacement: This is done in patients having more comminution, debilitated and elderly people. Usually performed in stage 3/4 fractures in older people

Complications:

1) General: The elderly patients are prone to general complications like DVT, pulmonary embolism and bed sores. The peri-operative mortality in these elderly patients is about 20% at 4 months after injury.

2) Osteonecrosis: This is seen in 10-45% of patients. It's increased risk is associated with displacement and AVN still develops in non-displaced and non-anatomical reduction.

3) Non-union: This is seen in 5-30% of patients. It's incidence has increased with displaced and varus malreduction.

4) Dislocation: Higher rate is seen in Total hip Arthroplasty procedures.

5) Failure rate: High failure rate is seen in fixation group. This is about 46% in fixation and 8% in arthroplasty group.

6) Osteoarthritis: Secondary osteoarthritis of hip develops in these patients.

Prognosis: This is most expensive fracture treatment on per person basis. Preinjury mobility is most significant determinant for post operative survival.

2) STRESS FRACTURES:

A stress or fatigue fracture is one which is occurring in the normal bone of a healthy patients and traumatic incident is absent. Bending and compression stress are basically of these two types of stress. Stress produces deformations and bone responds by changes the pattern of remodelling. Compressive stresses occur on cancellous bone and with frequent repetition an impacted fracture may results. These fractures typically occurs in athletes, dancers or military personnel. These occurs due to repeated heavy loading of normal bone. This high loading creates minute deformations in bone that initiate normal process of remodelling. So according to Wolfs law there will be combination of bone resorption and new bone formation. In results of repeated and prolonged excess stress and deformation, resorption takes faster than replacement. These areas are liable to fractures at this site. Shaft of humerus (cricketer) tibial shaft (athletes), distal shaft of fibula (runner fracture) femoral neck in adults are common sites. Pain after exercise, pain during exercise and pain without exercise are the common sequence of events. Springing the bone is helpful in diagnosis. On X-rays there will be hazy transverse band of sclerosis with peripheral callous. These fractures can be seen in patients who are on chronic medication which alters the balance between bone resorption and replacement. (steroids or methotrexate) Most of these fractures require no treatment except elastic bandage and avoidance of painful activity until the lesion heals. Stress fractures of femoral neck in elderly is treated prophylactically with internal fixation.

Chapter 8

Complications of Fractures

Dr Annie Sandhu and Dr Dharminder Singh

Complications: Children with these injuries usually have malunion of these fractures. These are divided in two types usually Early and late complications.

Early:

1) Vascular Injury- Brachial artery injury is most dangerous injury usually occurring in about 5% of cases. In these cases, peripheral ischaemia may be immediate and severe in nature producing oedema and impending compartment syndrome. The child usually have undue pain which needs urgent attention of surgeon. (pain on passive extension of fingers, an absent pulse, tense and tender forearm with reduced capillary return)

2) Nerve injury-These depends upon the displacement of distal fragments. Any of the forearm nerves (radial nerve, median nerve or ulnar nerve) may be involved. Anterior interosseous branch is commonly affected. But, fortunately there is temporary loss of function and recovery is expected in 3-4 weeks. The ulnar nerve is usually injured in careless K-wiring of fragments.

Late complications:

1) Malunion: This is the most common complication of these fractures. Although remodelling of fragments occurs in children, but uncorrected sideways tilt and rotation are most important. These produces permanent varus Or valgus deformities of elbow, which does not improve with growing age. Cubitus varus is disfiguring but not functionally. Cubitus valgus causes late ulnar nerve palsy. These can be treated by various supracondylar osteotomies.

1) MYOSITIS OSSIFICANS:

Heterotopic calcification in muscles, is usually occurred after an injury. It is thought to be due to muscle damage from injury, but can be seen without injury in unconscious Or paraplegic patients. This is mainly seen in elbow region Or blow to brachialis, deltoid, or quadriceps muscles. Patients usually presents as pain with local swelling and tenderness. X-rays are usually normal. Pain usually subsides in course of nature but joint movement is limited. On late presentation, there will be fluffy calcification in soft tissues and this is palpable as bony mass and clearly defined in X-rays.

The joint should be rested in functional position of function until pain subsides. Gentle active movements should be started to avoid stiffness. Indomethacin Or radiotherapy should be given to prevent recurrence.

2) SUDECK ATROPHY (COMPLEX REGIONAL PAIN SYNDROME):

This is a condition of regional osteoporosis which sometimes occurs after fractures of the extremities. This is also called as Sundecks atrophy Or post traumatic reflex sympathetic dystrophy. Its cause is uncertain in nature and hence it is termed as Complex regional pain syndrome. This is of two types:

1) A reflex sympathetic dystrophy that develops after an injury or noxious event

2) Causalgia that develops after a nerve injury

Patients usually complains of continuous pain usually burning in nature. There may be local swelling, redness, warmth and tenderness along with moderate stiffness of joint. On examination, skin is pale and atrophic with restriction of movements. Later on on patients develops fixed deformities. On X-rays there may be patchy rarefaction of the bone. The earliest the condition is diagnosed and treatment is started, better is the prognosis. Elevation and active exercises are of utmost importance. Adequate analgesia and anti inflammatory drugs are helpful. A prolonged and

dedicated physiotherapy along with drugs like amitriptyline, carbamazepine and gabapentin is mainstay of treatment.

Chapter 9

Fixation Methods

Dr Nitish Bansal and Dr Jagdeep Singh

1) INTERNAL FIXATION:

In trauma, depending upon the fracture pattern or soft tissue condition a bone can be fixed either with external or internal fixation. The fractured bone fragments can be fixed with screws, metal plate with screws and an intramedullary rod (Nail) or circumferential bands or combination of these methods. Properly applied internal fixation securely holds the fracture fragments, so that movements can begin at once and fracture disease can be prevented. The patient can be discharged as early as when his wound has healed. The grave risk of infection has to be kept in mind while doing these procedures. The risk of infection depends upon the devitalized tissues, dirty wound and patient associated with co morbidities.

Indications:

- 1) Fractures that cannot be reduced except by operations
- 2) Fractures that are unstable and prone to re-displaced
- 3) Fractures that unite poorly and slowly like fractures neck of femur
- 4) Pathological fractures
- 5) Multiple fractures
- 6) Fractures in patients having nursing difficulties

Types of internal fixation

- 1) Interfragmentary screws: These produce a compression or lag effect between two fragments.

2) Wires: These wires hold major fractures fragments together. Trans fixation, circlage and tension band are types of fixation with wires.

3) Plates and screws: These are used for metaphyseal and diaphyseal fractures of bones. Neutralization, compression, buttresses, tension band and antilide plates are functionally classified.

4) Intramedullary nails: These are mainly used in long diaphyseal bones. Nails can be used with prior reaming of medullary canal. Interlocking screws used in these prevent the rotational forces in bones.

2) FUNCTIONAL BRACING:

This is a kind of fractures treatment which prevents joint stiffness while permitting fracture splintage and loading. These are not rigid enough, so usually applied when fractures are beginning to unite i.e. after 3-6 weeks of traction or conventional plaster. Functional bracing may be of either POP or lighter thermoplastic material. In this, POP cast is applied over the shaft of the bone, leaving the joints free. The cast segments are connected by metal or plastic hinges which allow movements in one plane only. These splints are functional because they provide joint movement. These are commonly used for fractures of shaft of femur and tibia.

Functional bracing holds the fractures through compression of the soft tissues, and small amount of movement which occurs at fracture site through using limb encourages vascular proliferation and callus formation.

Chapter 10

Inflammatory and Non-Inflammatory Arthritis

Dr Jaspreet Singh and Dr Daljinder Singh

1) Osteoarthritis :

Osteoarthritis (OA) is a progressive, whole-organ disease of synovial joints characterized by breakdown of articular cartilage, subchondral bone remodeling, osteophyte formation, and low-grade synovial inflammation.

• Etiology & Classification

- Primary (Idiopathic): Most common; driven by age-related biomechanical wear, genetic predisposition, and metabolic dysregulation (e.g., localized to nodal hand joints, hip, or knee; generalized OA).

-Secondary: Resulting from an identifiable underlying cause:

Post-traumatic

Anatomical/Congenital: DDH , SCFE

Metabolic/Endocrine

Inflammatory/Infectious sequelae

• Pathophysiology :

OA involves an imbalance between chondrocyte-mediated repair and catabolic destruction:

- Extracellular Matrix (ECM) Breakdown: Chondrocytes upregulate matrix metalloproteinases (MMP-13) and aggrecanases (ADAMTS-4 and ADAMTS-5), degrading type II collagen and proteoglycan aggrecans. Water content initially increases (loss of matrix tension), followed by cartilage fibrillation, vertical fissuring, and full-thickness chondral loss.

- Subchondral Remodeling: Loss of shock absorption triggers microfractures, vascular invasion, and dense bone formation

(eburnation). Synovial fluid forced through microcracks under pressure leads to intraosseous fibrous cystic degeneration (geodes).

- Osteophytosis: Chondro-osteogenic outgrowth stimulated at the joint margins via local overexpression of TGF- β and BMP-2.

- Synovitis: Low-grade, macrophage-driven inflammatory response triggered by cartilage breakdown products, driving secondary pain and joint effusions.

• Clinical Features

Symptoms: Insidious, activity-related “mechanical” joint pain relieved by rest; transient morning stiffness lasting < 30 minutes (“gelling” phenomenon); reduced functional mobility (stairs, rising from chairs).

Signs: Joint line tenderness, coarse crepitus, reduced range of motion, cold effusions, and characteristic hand deformities (Heberden nodes at DIPJs, Bouchard nodes at PIPJs).

Alignment: Progressive mechanical axis deviation (most commonly genu varum in knee OA due to predominant medial compartment involvement).

Radiological Evaluation & Grading

Weight-bearing, plain radiographs remain the diagnostic gold standard.

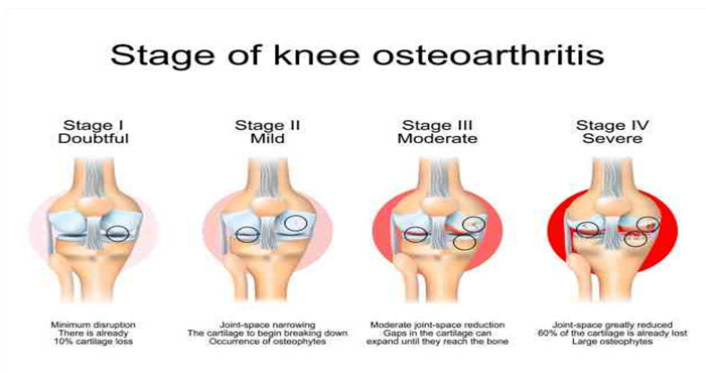
The cardinal signs on plain radiography follow the L-O-S-S mnemonic:

- L – Loss of joint space (characteristically asymmetric)

- O – Osteophytes (marginal)

- S – Subchondral sclerosis

- S – Subchondral cysts



1) Ankylosing Spondylitis (AS)

This is a generalized chronic inflammatory disease which mainly effects the spine and sacroiliac joints. These patients are characterized by pain and stiffness of the back with variable involvement of hips, and shoulders. It has prevalence of about 0.1 to 0.2 percent and males are commonly effected with ratio of 2:1 to 10:1 in age group of 15-25 years. It has strong association with HLA-B 27 marker. It has insidious onset with HLA-B 27 present in over 95% of Caucasian patients. This disease causes two main lesions like synovitis of diarthrodial joints and inflammation at the Fibro-osseous junction of syndesmotic joints and tendons.

Synovitis produces destruction of articular cartilage of sacroiliac and vertebral facets. Costovertebral joints are also frequently involved.

Inflammation of Fibro-osseous junctions affects the intervertebral discs, sacroiliac ligaments, symphysis pubis and bony insertions of ligaments. (enthesopathy) Inflammation of these causes granulation tissue formation with erosion of bone, then these lesion are replaced with fibrous tissue and ultimately produces ossification leading to ankylosis of joints.

C/F

This has insidious onset which was commonly misdiagnosed as simple mechanical back pain in young adults. Patients complain of back ache with stiffness over years before a diagnosis is made. In 10% cases it starts as an asymmetrical inflammatory arthritis. These symptoms increase in early morning and after inactivity. Sometimes symptoms of pain in buttocks and thigh can be confused with sciatica and wrongly treated as a case of intervertebral disc prolapse. These symptoms (pain and stiffness) gradually become continuous with general symptoms of fatigue, pain and swelling of joints, tenderness at insertion of Achilles tendon, and intercostal pain and tenderness. Sacroillitis is present in 10% females due to chronic pelvic inflammatory diseases.

In early cases, there will be slight flattening of lower back with restriction of extension of spine. There may be diffuse tenderness of spine and sacroiliac joints.

In late presentation, there will be loss of normal lumbar lordosis, increased thoracic kyphosis and forward thrust of neck. Spinal movements are decreased in all directions. Patients maintain standing posture with knee and hip slightly flexed. These two tests help in making the diagnosis.

Wall test: Patient is asked to stand with his back to the wall. Normally heels, buttocks, scapulae and occiput should touch to wall simultaneously. But these patients are unable to do this. Marked loss of cervical extension leads to restriction of line of vision in these patients.

Chest expansion: a normal adult is able to expand his chest more than 7cms, but in these patients, chest expansion less than 5 cms is diagnosed as ankylosis spondylitis.

Peripheral joints are involved in one third of cases. There may be tenderness at ligaments and tendon insertions. (Enthesopathy)

Investigations: The ESR and CRP are elevated in active cases. HLA-B27 is present in 95% of cases. RF is usually negative in these patients.

Radio logically:

Flattening of normal anterior concavity of vertebral body (squaring) is the earliest change. Ossification of the ligaments around intervertebral discs produce symmetrical bony spurs called syndesmophytes which looks like a bamboo spine.

Osteoporosis and erosion of peripheral joints is present in long standing cases.

Treatment:

General measures: Patients are advised to remain active. They are taught to maintain satisfactory posture and perform spinal extension exercises. Rest and immobility is contraindicated in these cases.

NSAIDS: These can be given to control pain and decrease soft tissue stiffness.

TNF inhibitors: These agents results in significant improvement in disease activity and remission.

Surgical intervention: The established cases of ankylosis spondylitis require different surgical procedures like arthroplasty or various osteotomies for deformity correction.

Chapter 11

Metabolic Diseases

Dr Arvind Kumar and Dr Ranbir Singh

1) Vitamin D deficiency:

Vitamin D deficiency occurs when systemic levels of calcidiol (25-hydroxyvitamin D) fall below the physiological threshold required for optimal calcium and phosphorus homeostasis, directly impairing bone mineralization and neuromuscular function.

• Diagnostic Benchmarks

Serum concentration of 25-hydroxyvitamin D [25(OH)D] is the standard diagnostic marker:

Deficient: < 20 ng/mL (< 50 nmol/L)

Insufficient: 21– 29 ng/mL (52.5–72.5 nmol/L)

Sufficient: 30 –50 ng/mL (75–125 nmol/L)

Toxicity risk: > 100 ng/mL (> 250 nmol/L)

• Primary Causes

Limited UVB Exposure: Modern indoor lifestyles, sunscreen usage, geographical latitude, and atmospheric pollution prevent the photochemical conversion of 7-dehydrocholesterol to pre-vitamin D₃ in the skin.

Reduced Skin Synthesis: Higher melanin concentration acts as a natural sun filter; aging skin also produces significantly less provitamin D.

Malabsorption Syndromes: Celiac disease, Crohn's disease, ulcerative colitis, and bariatric surgery impair the absorption of fat-soluble vitamins in the small intestine.

Organ Dysfunction: Chronic liver disease impairs 25-hydroxylation, while end-stage renal disease inhibits

1-alpha-hydroxylase, the enzyme responsible for creating active calcitriol ($1,25(\text{OH})_2\text{D}$).

• Symptoms and Complications

Early and Mild Cases: Frequently asymptomatic, though patients may present with nonspecific fatigue, symmetric low back pain, proximal muscle weakness, and frequent upper respiratory infections.

Pediatric Complications (Rickets): Defective growth-plate mineralization causing bowed legs, knock-knees (genu valgum), widened wrists, delayed fontanelle closure, and frontal bossing.

Adult Complications (Osteomalacia & Osteoporosis): Incomplete mineralization of bone matrix leads to dull, throbbing bone pain and severe fragility fractures. Secondary hyperparathyroidism often develops to scavenge calcium from the skeleton, accelerating bone loss.

• Treatment and Correction

Reversing a documented deficiency typically requires short-term therapeutic repletion:

High-Dose Loading: A standard clinical regimen is 50,000 IU of Vitamin D3 (Cholecalciferol) orally once per week for 6 to 8 weeks, preferred over Vitamin D2 due to superior bioavailability.

Daily Maintenance: Following normal serum recovery, ongoing supplementation of 1,000 to 2,000 IU daily maintains adequate levels.

Co-factors: Co-administration of calcium (1,000–1,200 mg daily from diet or supplements) and adequate magnesium intake is necessary for proper hormonal activation and bone remineralization.

2) OSTEOPOROSIS:

This is characterized by a combination of an abnormally low bone mass and defects in bone structure. These factors produce usually a fragile bone which has greater than

normal risk of fracture in a person of that age, sex and race. Bone depletion can be caused by either of two factors like increased bone resorption, decreased bone formation or combination of these. This reduction of bone mass causes loss of bone strength. Loss of structural connectivity between bone plates alters mechanical properties of bone leading to loss of strength out of proportion to diminution in bone mass. As a consequences of these, stress or strain fractures may be seen around the diaphyseo- metaphyseal junctions in tubular bones and in cancellous vertebral bodies. African population is consideredably less prone to these effects.

Osteoporosis can be generalized, regional, postmenopausal, involuntional, or may be secondary due to hypercortisonism, gonadal hormone insufficiency, hyperthyroidism, alcohol abuse and immobilization.

3) RICKETS:

This metabolic disease has inadequate mineralization of bone with defective calcification, producing softened bones. This may be due to defective metabolic pathway of Vitamin D. The causes may be nutritional deficiency, less sunlight exposure, intestinal malabsorption, decreased 25 hydroxylation (liver diseases and anticonvulsants) and reduced 1-alpha hydroxylation (renal diseases and enzyme deficiency). There will be defective calcification in deeper layer of physis. In proliferative zone, cells pile up irregularly instead of arranging in orderly column. This produces physeal plate thickness, poor mineralization of bone and less bone formation in zone of calcification.

The affected child is listless, failure to thrive, and flaccid. Bone changes may be in form of deformity of skull (craniotabies), thickening of knee, ankle and wrist(physeal thickness), ricketic rosary (costochondral junction enlargements) and layeral indentation of chest. (Harrison's sulcus). A child may have bowing of distal tibia and lower limb deformities.

On X-rays, a child may have thickening and widening of growth plate, cupping of metaphysis and bowing of the diaphysis.

There will be diminished levels of serum calcium and phosphate and increased levels of alkaline phosphates.

Treatment consists of treat the underlying cause. Dietary intake of Vitamin D has to be increased along with sun exposure. Treatment with Vitamin D in dose of 400-1000IU per day and calcium supplementation is effective. The use of sun blocking lotions should be discontinued.

4) OSTEMALCIA:

This is of insidious onset and patients usually complain of bone pain, back ache and muscle weakness.

It is due to dietary deficiency of Vitamin D and insufficient sun exposure in adults. It manifests as inadequate mineralization of bone producing an osteoid which is incompletely calcified leading to softened bones. The changes are AWAY from physis. There are islands of bone lined by wide defective osteoid producing unmineralized ghost trabeculae. These are not strong enough for effectively weight bearing. The bone cortices are thin than normal and new bone formation or stress fractures.

On X-rays, there may be

- # Looser zone - transverse band of rarefaction usually in long bones due to incomplete stress fractures healing with callous lacking calcium.

- # biconcave vertebrae due disc pressure

- # trefoil pelvis – lateral indentation of acetabula or

- # spontaneous fractures of ribs, pubic rami Or femoral neck

Serum calcium and phosphate levels will be decreased and increased alkaline phosphate. The calcium phosphate product is diminished in rickets and osteomalacia (< 2.4 are diagnostic).

Treatment: Dietary intake of Vitamin D has to be encouraged in adults which was common in vegetarians. Sun exposure should be sufficient and sun blocking lotions should be avoided. Vitamin D 400-1000IU per day should be taken along

with dietary recommendations. The long bone deformities should be corrected surgically.

Osteomalacia	Osteoporosis
Unwell	Well
Chronic ache	Pain after fracture
Muscles weak	Normal
Loosers zone	Not present
Alk phosphate increased	Normal
Serum phosphate decreased	Normal
$\text{Ca} \times \text{P} < 2.4 \text{ mmol/L}$	$\text{Ca} \times \text{P} > 2.4 \text{ mmol/L}$

5) RENAL OSTEODYSTROPHY:

This is a manifestation of chronic renal failure and decreased glomerular filtration. Bone changes develop due to decreased mineralization and bone formation. Patients developed a picture of secondary hyperparathyroidism.

Patients may have stunted and pasty face with marked rachitic deformities and myopathy. There will be widened and irregular epiphyseal plates. Long standing cases may have displacement of epiphysis called epiphysiolysis. Spine may have rugger Jersey appearance (alternative bands of increased and decreased bone density.)

On serology, there will be low calcium, high phosphate and elevated Alkaline phosphate. PTH levels may be increased.

Treatment consists of treating the hyperphosphataemia and secondary hyperparathyroidism by restricting intake of phosphorous and administering Vitamin D. Recently, a calcimimetic drug (Cinacalcet) has been introduced.

6) PAGETS DISEASE (OSTEITIS DEFORMANS):

Patients are usually asymptomatic and diagnosed incidentally. The pain may be dull ache, worse in bed when the patient wake up.

Pagets disease is characterized by increased bone over but internal architecture is abnormal. There is enlargement and thickening of bone. It usually seen after 50 years with prevalence of 3% in people's over the age of 40years. It is rare in Asia and Africa. The disease may be localized or whole of one bone is involved. Tibia and pelvis are commonly affected, but may be seen in femur, skull and spine.

It starts at one end of bone and progress towards diaphysis with marked increase in osteoclastic and osteoblastic activity. Serum alkaline phosphate and urinary excretion of hydroxyproline is increased when bone turn over is accelerated. In osteolytic phase, there this s resorption of bone by osteoclasts producing large excavations filled with vascular tissue. Adjoining area shows osteoblastic activities. This alternative activity produces thickened, but weekend bone. Gradually eroded areas fill with new lammelar bone producing irregularly pattern. Long standing cases Long bone deformities along mechanical stress are present. Tibia bows anteriorly while femur bows anteriolaterally. The limbs look bent and feel thick and skin is warm termed as osteitis deformans. Patient may have short neck due to flattening of skull (Platybasia). Patients looks shorter and ape like with bent bones and arms hanging in front of him.

On Xrays, there may a flame shaped lesion extending along shaft of bone or a circumscribed area of osteoporosis in skull. Occasionally, patients presents with pathological fracture.

Serum calcium and phosphate are usually normal, but serum alkaline phosphate is raised. Urinary N telopeptide is a sensitive marker of bone resorption.

Mostly patients don't have any symptoms and require no treatment. The indications for specific treatment are:-

- Persistent bone pain
- Repeated fractures
- Neurological complications

Drugs that suppress bone turnover, mainly calcitonin and bisphosphonates are effective when disease is active and bone turn over is high.

Chapter 12

Tumours

Dr Jagdeep Singh and Dr Kuldip Singh

1) OSTEOSARCOMA:

Bone tumours are basically classified as benign and malignant lesions. Benign lesions are quite common and primary malignant are rare. Most classifications of bone tumours are based on the dominant tissue involved in lesions. This may help in both diagnosis and treatment.

The metastatic tumours are the commonest bone tumours, although they are not of true bone tumours means not of mesenchymal origin.

It is a highly malignant tumour of bone arising within bone (intramedullary) and spreads outwards to periosteum and surrounding soft tissues. It may affect any bone, but long bone metaphysis are most commonly involved around knee and the proximal end of humerus. It mainly occurs in children and adolescents.

C/F

Pain which is constant and worse at night and gradually increases in severity is the usually first symptom in these patients. In early cases, patient may present with lump and pain. There will be local tenderness. In later cases, overlying tissues may be swollen and inflamed with a palpable mass.

ESR and serum alkaline phosphatase are usually raised in these patients.

Imaging:

Plane X-rays are the most useful of all imaging techniques. They shows any obvious bony abnormality like cortical thickening, a lump or a cyst, or any ill defined lesion. If boundary of a cyst is sharply defined, it is probably a benign,

and if hazy and diffuse it suggests invasive tumours. Stippled calcification in a cyst is a characteristic of cartilage tumours. Periosteal new bone formation and extension of tumour into soft tissues are suggestive of its malignant nature.

In osteosarcoma, there are alternate hazy osteolytic and dense osteoblastic areas. Usually cortex is breached with poorly defined endosteal margins and tumour extends into surrounding soft tissues. This extension into soft tissues with streak of new bone formation radiating from cortex to outwards- is called as "Sunburst appearance". A reactive new bone formation at angles of periosteal elevation is called as "Codman's triangle". Both are typical for osteosarcoma. Diagnosis is made with certainty on typical X-rays appearance. However, other imaging studies are essential for staging purposes to define a probable prognosis. CT and MRI shows the extent of tumour. Chest X-ray, preferably Pulmonary CT should be done to detect metastasis. A biopsy is indicated before starting a treatment in these patients.

Pathology: This tumour located in metaphysis of long bones. It destroys and replaces the normal bone. Tumour extends intramedullary and across the physeal plate. There is alternate bone loss and abnormal new bone formation. Tumour extends into soft tissues with ossification at periosteal margins. There are streaks of new bone extending to extraosseous tissues producing sunburst appearance.

Histologically, there are characteristic spindle cells with pink staining osteoid matrix. In some they contain cartilage cells or fibroblastic tissues with little or no osteoid.

Principles of Treatment:

Once clinical and radiological diagnosis is made, a multidisciplinary approach is of paramount importance.

- 1) **Benign but asymptomatic:** These lesions never required treatment, if diagnosis is beyond doubt. However, if appearance is non pathognomic, the biopsy is indicated.
- 2) **Benign but Symptomatic or Enlarging:** These lesions require biopsy to confirm the diagnosis. These can be removed by local (marginal) excision or by curettage.

3) **Suspected Malignant tumours:** If lesion is of primarily malignant, then a thorough detailed diagnostic evaluation is required. A surgical staging is established. The various treatment options can be discussed with patients and after all pros and cons, a choice is to be made between amputation, limb sparing operations and adjuvant therapy.

Surgical staging: Bone sarcomas are broadly divided into following stages :

* **Stage -1** All low grade sarcomas

* **Stage -2** Histologically high grade

* **Stage-3** Sarcomas with metastasis

Enneking has described surgical staging to know prognosis of these tumours: a) how the tumour behaves and b) how far it has spread.

Methods of Treatment:

1) **Excision:** Tumour excision depends upon its aggressiveness and local spread.

a) Intracapsular excision and curettage are incomplete procedures. These are indicated in benign lesions with very low risk of recurrences. Bone cementing after curettage decreases the risk of local recurrence.

b) Marginal excision: It is just only beyond the tumour margins. It is suitable for benign lesions.

c) Wide excision: In this lesion excised is carried through normal tissues. This can be done in conjunction with chemotherapy for grade II A lesions.

d) Radical excision: In this entire compartment in which tumour lies is removed En bloc without exposing the lesion.

2) LIMB SALVAGE:

The dreadful prognosis that was formerly considered in these patients, has been markedly improved as result of better diagnostic and staging procedures. These methods have made limb salvage as the treatment of choice for many

patients. Advanced surgical procedures like endoprosthetic replacement or bone grafting are available these days. In these cases, the first step is wide excision of tumour while preserving neurovascular bundles. The small defect produced during this is filled with vascularized or non vascularized bone graft. The longer defect may require custom made implants. In growing children, extensible implants have been used to avoid repeated procedures.

These are associated with various complications.

2) AMPUTATION:

Amputation may be curative in cases which are resistant to chemotherapy and radiation therapy.

3) MULTI AGENT CHEMOTHERAPY

Neoadjuvant and adjuvant are now considered as preferred for malignant bone and soft tissue tumours. Modern chemotherapy regimens effectively decrease the size of primary tumour, prevent metastatic seedings and increased survival ship.

Doxorubicin, methotrexate, cyclophosphamide, vincristine and cis-platinum are commonly used agents in chemotherapy. Treatment is started 8-120 weeks preoperatively. Chemotherapy is considered as successful, if 90% of resected tumour tissues shows necrosis.

4) RADIOTHERAPY

It gives an alternative to amputation in radiosensitive tumours. Adjuvant treatment is used in inoperable lesions, in high grade tumours, inaccessible sites, proximity to vessels and for marrow cell tumours.

Post-irradiation spindle cell carcinoma and pathological fractures are the main complications associated with radiotherapy.

2) CHONDROSARCOMA:

These are slow growing and one of the commonest malignant tumours of bone. These are seen in fourth and fifth decades

having male dominance. Patients complain of dull aching pain or a gradually enlarging lump mostly in lower limbs. Pelvis and ribs are next common sites.

Chondrosarcomas fall into basically two categories: a) centrally tumours occupying medullary cavity of bone, and b) peripheral tumours growing from cortex. Juxtacortical chondrosarcoma, clear cell chondrosarcoma, and mesenchymal chondrosarcoma are least common varieties.

1) **Central chondrosarcoma:** These involves medullary cavity of tubular or flat bones, most commonly at the proximal end of femur. There may be expanded radiolucent area on bone with flecks of increased density. These lesions may have scalloped appearance or destruction of cortex.

2) **Peripheral chondrosarcoma:** These arises in cartilage cap of an exostosis, (osteochondroma) which are present since childhood. X rays shows bony exostosis, surmounted by patchy calcifications. A tumour which is very large and have fluffy calcifications with poorly outlined are suspicious features. MRI is the best investigation to detect it's size and internal features of cartilage cap.

3) **Juxta cortical chondrosarcoma:** It arises from outermost layer of the cortex of bone, usually femur. X- rays shows flecks of calcification, sunray streaks and new bone formation at the margins of the stripped periosteum.

These are slow growing tumours and metastasize late, so these are ideal case for wide excision and prosthetic replacement.

Prognosis is determined largely by the cellular grade and resection margins.

1) **OSTEOCHONDROMA (EXOTOSIS):**

This is one of the commonest benign tumour of bone characterized as lump, mostly on the fast growing ends of long bones and crest of iliac bones. It starts as a small overgrowth of cartilage at the edge of physal plate and develops by endochondral ossification into bony protuberance covered by cartilage cap. Patient is usually teenager or a young adult

having pain due to an overlying bursa or impingement of soft tissues. It stops growing after the arrest of normal adult growth. Any change or enlargement after the end of normal growth period suggests malignant transformation of lesion. On X-rays, there will be a well defined exostosis emerging from metaphysis with base on parent bone. It looks smaller than it feels, because the cartilage cap is invisible on X-rays.

Multiple lesions may develop in a hereditary disorder called hereditary multiple exostosis.

Pathologically, a cartilage cap is surmounted on a narrow base or pedicle of bone. The cartilage cap consists of simple hyaline cartilage. Larger lesions may have cauliflower appearance, with degeneration and calcification in centre of cartilage cap.

Complications: Malignant transformation is difficult to assess in these cases. However, 1) enlargement of cartilage cap 2) a bulky cartilage cap (more than 1cm in thickness) 3) irregular scattered flecks calcifications and spread into surrounding tissues are suggestive of malignant change. MRI can be done in these patients to rule out malignant changes.

Treatment: All symptomatic lesions should be excised.

2) GIANT CELL TUMOUR (GCT):

This tumour of uncertain origin usually appears in mature bones. Distal femur, proximal tibia, proximal humerus, distal radius are most commonest sites involved. It doesn't appear before the closure of epiphysis and it is characterized by its extend up to subarticular bone plate. Clinically, a young patient usually complains of pain at the end of long bones. A history of trauma is not uncommon. Pathological fracture is seen in 10-15% of these patients. These patients may have "egg shell crackling" on examination.

On X-rays, there will be an eccentrically situated radiolucent area at the end of long bones and bounded by subchondral bone plate. The cortex is thin and ballooned producing "soap bubble appearance" of lesion. It has to be differentiated from brown tumour of hyperparathyroidism. MRI and CT scans tell us about extent of tumour. Biopsy is essential to rule out malignant change.

The tumour has a reddish, fleshy gross appearance. Histologically, there are abundance of multinucleated giant cells on back ground of stromal cells with little or no visible intercellular tissues.

Treatment:

It consists of thorough curettage and striping of cavity with burr and gouges, followed by swanning with hydrogen peroxide or application of liquid nitrogen and packing of cavity with bone chips. This tumour has the potential to transform into osteosarcoma.

3) OSTEIOD OSTEOMA:

This is a tiny bone tumour having less than 1 cm in diameter and occurs usually under 30years of age with male dominance. All bones are involved except skull. The patient complains of persistent well localized pain and typically relieved by salicylates. Small radiolucent area called nidus is typical feature on X-rays. Long bone diaphysis shows dense sclerosis and cortical thickening. It has to be differentiated from Brodie's abscess.

It appears dark brown or reddish nucleus surrounded by dense bone with central area having unorganized sheets of osteoid tissue and bone cells.

Treatment:

Complete removal or destruction by radio ablation is only effective treatment.

4) SIMPLE BONE CYST:

This benign tumour is also called a solitary cyst or unicameral bone cyst. It is seen in childhood, typically in metaphysis of long bones most commonly in proximal humerus or femur. It heals spontaneously and seldomly seen in adults. On X-rays, there will be a well demarcated radiolucent area in the metaphysis. It extends upto physeal plate, cortex may be thinned with bone expanded.

Asymptomatic lesions in older children can be left alone. Active cysts should be treated with aspiration of fluid and injection of 80-160 mg of Methylprednisolone or autogenous bone marrow.

5) ANEURYSMAL BONE CYST:

This benign expansile tumour occurs in any age and in any bone is involved. But commonly seen in young adults in long bone metaphysis areas. It is a expanding lesion and patient complains of pain and swelling on affected part. X-rays shows a well defined radiolucent cyst which is often trabeculated and eccentrically placed in bone. It doesn't extend up to the articular margin. It has soap bubble appearance on X-rays.

It contains clotted blood on opening it. Histologically, it consists of fibrous tissue with vascular spaces, deposits of hemosiderin and multinucleated giant cells. Malignant transformation doesn't occur.

Treatment consists of thorough curettage and bone grafting. Packing with bone cement (methylmethacrylate) can be done.

Chapter 13

General Examination of Orthopaedic Patients

Dr Daljinder Singh and Dr Anshul Dahuja

Examination of an Orthopaedic Patient:

1. General Principles

The examination of an orthopaedic patient is a systematic process used to identify the site, nature, severity and functional consequences of a musculoskeletal disorder. A good examination should always be performed after taking an appropriate history and should compare the affected side with the normal side whenever possible.

Before beginning the examination: Introduce yourself and explain the procedure; obtain consent; ensure adequate exposure while maintaining privacy and dignity; position the patient appropriately and comfortably; examine the patient in a systematic manner; compare the affected limb or joint with the opposite side; and examine the patient both at rest and during movement.

Classical sequence: Look → Feel → Move → Measure → Special tests → Neurovascular examination → Functional assessment.

2. General Examination

The patient should first be assessed as a whole rather than concentrating immediately on the affected limb.

Observe: general appearance and nutritional status; pallor, icterus, cyanosis and lymphadenopathy; fever or other signs of systemic illness; body habitus and height; gait and posture; obvious deformity or abnormal limb position; and evidence of previous surgery, trauma or immobilisation.

In children, particular attention should be paid to growth, limb length, developmental abnormalities and nutritional status.

3. Local Examination

Local examination is usually divided into three major components: inspection, palpation and movement.

A. Inspection

Expose the affected area adequately and inspect it from different directions.

Look for:

- Swelling – site, size, shape, extent and skin changes over the swelling.
- Deformity – abnormal angulation, rotation, shortening, dislocation or subluxation, and abnormal posture. Describe deformity in relation to the distal segment, for example varus, valgus, flexion or extension deformity.
- Skin changes – redness, scars, sinuses, ulcers, discharging wounds, bruising, pigmentation and dilated veins.
- Muscle wasting – compare the bulk of muscles on both sides.
- Abnormal movements – abnormal movement at a joint or fracture site.
- Limb position and attitude – the position adopted by the patient may provide important diagnostic clues.

B. Palpation

Palpation should be gentle and systematic. Compare the affected and normal sides.

Temperature: Feel the affected area with the dorsum of the hand. Increased temperature may suggest inflammation or infection, while reduced temperature may occur with vascular compromise.

Tenderness: Identify the site of maximum tenderness and its extent, and determine whether it is superficial or deep.

Swelling: Determine local temperature, consistency, mobility, fluctuation, compressibility, pulsatility and relation to underlying structures.

Bony tenderness: Palpate relevant bony landmarks systematically.

Crepitus: May be felt in fractures and degenerative joint disease. It should not be deliberately elicited forcefully, particularly when a fracture is suspected.

Pulses: Peripheral pulses should be examined whenever there is trauma, suspected vascular injury, acute limb pain or swelling, dislocation, or fracture around major vessels.

4. Examination of Movements

Movement should be assessed systematically.

Active movement: Ask the patient to move the joint independently. Assess range of movement, pain, restriction, quality of movement and muscle power.

Passive movement: The examiner moves the joint while the patient relaxes. Compare passive and active ranges. Restriction of both active and passive movement may suggest a joint or mechanical problem, whereas restriction predominantly of active movement may point toward muscle, tendon or neurological pathology.

Record range of movement using a goniometer when appropriate.

5. Measurement

Measurement is particularly important in orthopaedic examination.

Limb length: Measure and compare true and apparent limb length using standard anatomical landmarks.

Limb circumference: Measure muscle bulk at identical levels on both sides to identify muscle wasting, hypertrophy or swelling.

Deformity: Angular deformities can be measured clinically and, when necessary, confirmed radiologically.

6. Joint-Specific Examination

Shoulder: Assess contour and wasting, tenderness, active and passive movements, rotator cuff function, instability and neurovascular status.

Elbow: Look for carrying-angle abnormalities, swelling, deformity and tenderness; assess range of movement, stability and ulnar nerve function.

Wrist and Hand: Examine swelling and deformity, finger alignment, tendon function, grip, individual joint movements, sensory and motor function, and radial and ulnar pulses.

Hip: Assess attitude of the limb, apparent and true shortening, range of movements, fixed deformity, gait, Trendelenburg test and neurovascular status.

Knee: Examine alignment, swelling, quadriceps wasting, tenderness, range of movement, effusion, ligament stability, meniscal signs and patellar movement.

Ankle and Foot: Assess alignment, swelling, deformity, tenderness, range of movement, foot arches, gait, tendon function and neurovascular status.

7. Examination of the Spine

Inspection: Look for abnormal posture, kyphosis, lordosis, scoliosis, muscle wasting, scars or sinuses.

Palpation: Assess midline tenderness, paraspinal tenderness, muscle spasm and step deformity.

Movements: Assess flexion, extension, lateral flexion and rotation.

Neurological examination: Assess motor power, sensory function, reflexes, gait and signs of nerve-root involvement. Assess bowel and bladder function when clinically indicated.

8. Neurovascular Examination

Every significant limb injury, particularly fractures and dislocations, should include a documented neurovascular examination.

Vascular assessment: Check peripheral pulses, capillary refill, skin colour, temperature and distal perfusion.

Neurological assessment: Assess sensory and motor function of the relevant peripheral nerves.

Findings should be documented before and after manipulation, reduction or application of a splint or cast.

9. Examination of Gait

Gait provides valuable information about lower-limb and neurological disorders.

Observe the patient walking normally, turning, walking on toes and heels when appropriate, rising from a chair and climbing stairs when appropriate.

Look for limp, antalgic gait, Trendelenburg gait, high-stepping gait, foot drop, abnormal limb rotation and leg-length discrepancy.

10. Functional Assessment

Orthopaedics is concerned not only with anatomical abnormalities but also with function.

Depending on the condition, assess the patient's ability to walk, climb stairs, sit and stand, squat, run, dress independently, perform activities of daily living, use the affected upper limb, and grip or manipulate objects.

Functional assessment helps correlate clinical findings with the patient's actual disability.

11. Examination of the Opposite Limb

The opposite side should be examined whenever possible. It serves as an important internal control for range of movement, limb length, muscle bulk, deformity, joint stability and

neurological findings. However, the opposite side should not automatically be assumed to be normal.

12. Regional Examination

An important principle in orthopaedics is: Examine the joint above and the joint below the suspected site of pathology.

For example, in a patient with a suspected femoral shaft fracture, the hip and knee should also be examined. Similarly, in a patient with knee pain, examination should include the hip and lumbar spine because pain may be referred.

13. Systemic Examination

Certain orthopaedic conditions are manifestations of systemic disease. Appropriate systemic examination may include the cardiovascular system, respiratory system, abdomen, neurological system and skin, particularly in suspected infection, inflammatory arthritis, malignancy, metabolic bone disease or neurological disorders.

14. Summary of Orthopaedic Examination

1. General examination
2. Gait and posture
3. Local inspection
4. Palpation
5. Active movements
6. Passive movements
7. Measurements
8. Joint-specific and special tests
9. Neurovascular examination
10. Functional assessment
11. Examine adjacent joints and opposite side
12. Systemic examination where indicated

Chapter 14

Miscellaneous – Bone Infections and Others

Dr Arvind Kumar and Dr Jaspreet Singh

1) Osteomyelitis:

Introduction

Osteomyelitis is an infection of bone and bone marrow, usually caused by bacteria. It may occur following haematogenous spread, direct inoculation of organisms into bone, or spread from an adjacent soft-tissue infection. Osteomyelitis can affect individuals of any age, but its presentation and common causes vary with age and underlying conditions.

Etiology and Risk Factors

The most common causative organism is *Staphylococcus aureus*. Other organisms include *Streptococci*, Gram-negative bacilli, and, in certain clinical situations, *Pseudomonas*. Risk factors include diabetes mellitus, peripheral vascular disease, open fractures, orthopaedic implants, recent surgery, pressure sores, immunosuppression and intravenous drug use.

Classification

Osteomyelitis may be classified according to its duration and route of infection:

- Acute osteomyelitis – usually develops over days to weeks and may result from haematogenous spread or direct infection.
- Chronic osteomyelitis – persists for a prolonged period and is often associated with necrotic bone, sinus formation and recurrent infection.
- Haematogenous osteomyelitis – more common in children and commonly involves the metaphysis of long bones.

- Contiguous-focus osteomyelitis – commonly occurs following trauma, surgery, open fractures or spread from adjacent infected tissue.

Clinical Features

The clinical presentation depends on the age of the patient, site and duration of infection. Acute osteomyelitis commonly presents with fever, malaise, localized pain, tenderness, swelling and restriction of movement. In children, the child may refuse to use the affected limb.

Chronic osteomyelitis may present more subtly with persistent pain, swelling, recurrent discharge or a discharging sinus. A sinus may communicate with the infected bone and is an important clinical feature of chronic disease.

Investigations

Laboratory investigations may show leukocytosis and raised inflammatory markers, particularly C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR). Blood cultures should be obtained when haematogenous infection is suspected.

Plain radiographs are useful but may be normal during the early stages of acute infection. Later findings may include bone destruction, sclerosis, periosteal reaction and sequestrum. MRI is highly sensitive for detecting early bone marrow involvement and is particularly useful when the diagnosis is uncertain. CT can demonstrate cortical destruction and sequestra.

Whenever possible, deep tissue or bone samples should be obtained for microbiological culture and sensitivity before starting antibiotics, provided that doing so does not compromise the patient's condition.

Treatment

Treatment depends on the type, severity and organism responsible. Antibiotic therapy is the mainstay of treatment and should initially cover the likely organisms before being modified according to culture and sensitivity results.

Surgical treatment may be required when there is abscess formation, necrotic bone, sequestrum, infected implants, chronic sinus formation or failure of medical treatment. Procedures may include drainage of abscesses, debridement of infected tissue and removal of non-viable bone. Appropriate soft-tissue coverage and management of associated conditions, such as diabetes or vascular insufficiency, are important for successful healing.

Complications

Untreated or inadequately treated osteomyelitis can lead to chronic infection, pathological fracture, deformity, growth disturbance in children, joint involvement and systemic sepsis. Long-standing chronic osteomyelitis may rarely be complicated by malignant transformation in a chronic sinus.

2) Pott's Spine:

Introduction

Pott's spine is tuberculosis of the vertebral column caused by *Mycobacterium tuberculosis*. It is the most common form of skeletal tuberculosis and commonly affects the lower thoracic and thoracolumbar spine. Infection usually reaches the vertebra through the bloodstream or lymphatic system from another focus of tuberculosis.

Pathology

The infection initially involves the vertebral body, usually near the end plate. It may spread to the adjacent vertebral body through the intervertebral disc. Progressive destruction of the vertebral bodies can result in vertebral collapse, kyphotic deformity and neurological compression. A characteristic cold abscess may develop in the paravertebral or psoas region.

Clinical Features

The presentation is usually insidious. Common symptoms include:

- Persistent back pain
- Localized tenderness and stiffness

- Low-grade fever, weight loss and loss of appetite
- Constitutional symptoms may be absent
- Progressive kyphosis or gibbus deformity
- Neurological symptoms such as weakness, sensory disturbance or bladder/bowel involvement in advanced disease

In children, spinal tuberculosis may produce significant deformity because of ongoing vertebral growth.

Investigations

Blood tests may show raised ESR and CRP, although they can be normal.

X-ray spine may show:

- Narrowing of the intervertebral disc space
- Destruction of adjacent vertebral bodies
- Vertebral collapse and kyphosis
- Paravertebral soft-tissue shadow

MRI is the investigation of choice for assessing the extent of spinal infection, epidural or paravertebral abscess, neural compression and cord involvement.

Microbiological confirmation should be attempted whenever feasible. Samples from an abscess or affected tissue can be sent for AFB testing, culture and molecular tests such as CBNAAT/Xpert, along with histopathological examination.

Treatment

Treatment consists primarily of anti-tubercular therapy (ATT) according to current tuberculosis treatment guidelines. Treatment should be appropriately supervised and modified when drug resistance is identified.

Most patients without significant neurological deficit or mechanical instability can be treated conservatively with ATT, analgesia and appropriate spinal support when required.

Indications for Surgery

Surgery may be considered in selected patients with:

- Progressive or significant neurological deficit
- Spinal cord compression
- Severe or progressive deformity
- Mechanical instability
- Large abscess causing compression or failing to resolve with medical treatment
- Diagnostic uncertainty
- Failure of appropriate medical treatment

Surgical procedures may include decompression, abscess drainage, debridement and spinal stabilization/fusion depending on the pathology.

Complications

Important complications include vertebral collapse, kyphotic deformity, spinal cord compression, paraplegia, radiculopathy, instability and residual deformity.

3) CTEV:

Definition

Congenital Talipes EquinoVarus (clubfoot) is a congenital 3-D deformity with four components: CAVE – Cavus, Adductus, Varus and Equinus.

Assessment

Assess flexibility, calf wasting, skin creases and associated hip/spine/neurological abnormalities. Grade severity with Pirani (0–6) or Dimeglio score.

Pirani score

Six signs, each scored 0, 0.5 or 1. Midfoot: curved lateral border, medial crease, lateral head of talus. Hindfoot: posterior crease, rigid equinus, empty heel. Total = 0–6.

Ponseti treatment

Weekly gentle manipulation and above-knee serial casts. Sequence: correct cavus → adductus/varus by abduction around the talar head → equinus last. Residual equinus usually requires percutaneous Achilles tenotomy. Final cast is generally maintained for 3 weeks, followed by a foot-abduction brace.

Brace

Brace is worn full-time initially and then during sleep/naps for several years to reduce relapse.

Relapse

Repeat casting for early relapse; tibialis anterior tendon transfer for persistent dynamic supination; resistant/neglected feet may require soft-tissue or bony procedures.

CTEV – PONSETI SERIAL CASTING



Clinical sequence of serial Ponseti casting; casts are typically changed weekly.

**Key sequence: Cavus → Adductus/Varus → Equinus →
Achilles tenotomy if required → brace.**

1) AMPUTATION:

Definition

Surgical removal of a limb or part of a limb through bone or a joint, removing non-viable/diseased tissue while preserving maximum useful length and function.

Indications

Irreversible ischemia/gangrene • uncontrolled infection/sepsis • non-reconstructable trauma • malignant tumour • painful, useless limb.

Levels

Toe/digital → transmetatarsal → Lisfranc/Chopart → Syme → BKA → knee disarticulation → AKA → hip disarticulation.

What is cut/preserved

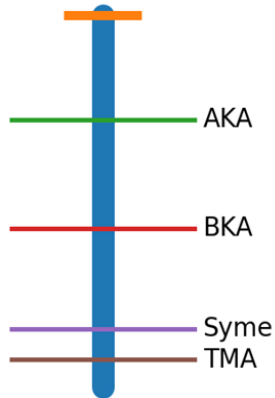
Structure	Action	Exam point
Skin/subcutis	Planned flap	Viable, tension-free cover
Muscle	Transect at planned level	Balanced myodesis/myoplasty
Vessels	Identify and ligate	Secure haemostasis
Nerve	Gentle traction → sharp division	Proximal retraction; reduce neuroma
Bone	Cut, smooth/bevel	Adequate soft-tissue coverage

Infective vs Ischaemic amputation

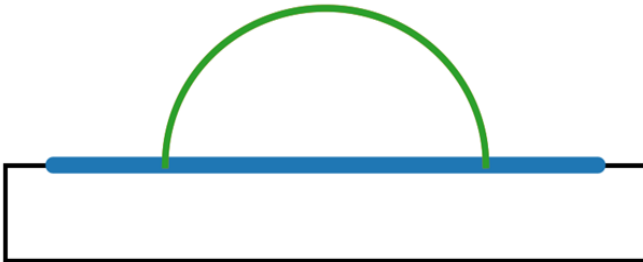
Feature	Infective	Ischaemic
Tissue	Wet, oedematous, purulent/malodorous	Dry, mummified, demarcated
Systemic features	Fever/SIRS/sepsis may occur	Usually no sepsis unless infected
Approach	Urgent source control; staged/guillotine may be needed	Assess revascularization; choose level that will heal
Level	Proximal to all infection/non-viable tissue	Most distal level with adequate perfusion

AMPUTATION – LEVELS & FLAPS

Common Lower-Limb Amputation Levels



Flap concept



Bone cut • smooth edges • tension-free soft-tissue cover

Goal: painless, durable, sensate and prosthesis-ready stump.

Chapter 15

Orthopedic Instruments

Dr Jagdeep Singh and Dr Mahesh Goel

Instruments:

1. Periosteal elevator : A rigid instrument featuring a flat, semi-sharp blade curved slightly at the working edge. Uses: Peels and strips the periosteum (the fibrous outer sheath of bone) and attached muscle away from the bone shaft without fracturing the cortical wall.



2. Bone curette : A slender handle terminating in a small, sharp-rimmed, spoon- or cup-shaped tip. Uses: Scrapes away necrotic bone, fibrous tissue, and infected material from non-unions or osteomyelitis sites, and harvests soft cancellous bone for grafting.



3. **Osteotome** : A heavy, chisel-like blade beveled on both sides, equipped with a flat metallic impact plate at the handle base. Uses: Cuts, scores, or divides bone along precise anatomical planes during reconstructive osteotomies and joint realignment.



4. **Bone Mallet** : A weighted surgical hammer constructed from solid stainless steel, brass, or fitted with dense Teflon-capped striking faces. Uses: Delivers controlled mechanical impact to osteotomes, chisels, gouges, and prosthetic impactors.



5. **Bone nibbler** : Heavy, spring-loaded plier forceps with sharp, concave, cup-shaped biting jaws, available in single- or double-action hinges. Uses: Bites away ("nibbles") sharp bone spikes, excess callus, and cartilage to contour edges and decompress nerve roots or joints.



6. Bone Holding Forceps: Heavy clamping forceps with curved, serrated, or pronged jaws, secured with a ratchet or threaded spin-lock. Uses: Clamps bone fragments firmly into anatomic reduction and holds metal osteosynthesis plates flush against the bone shaft during screw insertion.



7. Hohmann Retractor : A lever-style handheld retractor with a narrow beak that hooks directly over bone and a wide, curved blade. Uses: Levers bulky muscle groups and soft tissue away from the surgical corridor, providing clear exposure of joints and fractures.



8. Orthopaedic Depth Gauge : A thin sliding probe with a tiny right-angled hook at the distal tip and a calibrated millimeter scale on the sleeve. Uses: Hooks onto the far cortex of a pre-drilled pilot hole to measure the exact screw length required for rigid fixation.



