DNB
Master Solutions in Orthopedics
Volume - 4



Conceptual Orthopedics

The Learning Never Ends

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Paper 1

DNB Orthopedics (Dec 2018)

Question 1.

Define Growth Plate. Describe the Zones of Growth Plate with Diagram. Discuss the Clinical Significance of these Zones?

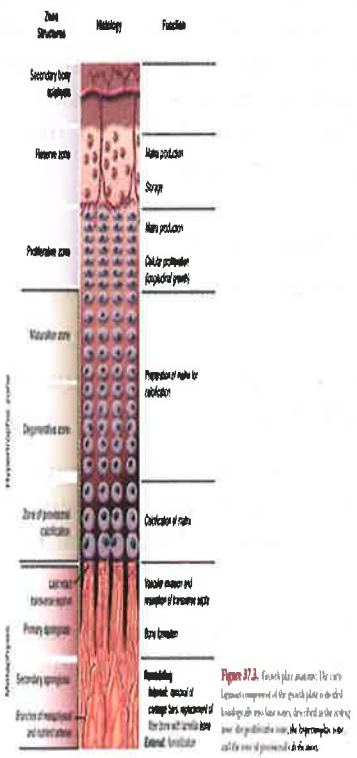
Answer 1.

Histological zone of growth plate

Physis Anatomy

- Two types of growth plates exist in pediatric long bones
  - Horizontal growth plate (the true physis)
    - Well organized into layers
    - 3 zones
      - Reserve zone
      - Proliferative zone
      - Hypertrophy zone
        - ☐ Zone of maturation
        - ☐ Zone of degeneration
        - ☐ Zone of provisional calcification
  - Spherical growth plate
    - For growth of epiphysis/apophysis
    - Less organized
- Perichondrial artery → major source of nutrition to the growth plate

Physis zones	Functions	Disorders
Reserve zone	Stores glycogen and lipids for growth Production of organic matrix	Lysosomal storage disorders Diastrophic dwarfism
Proliferative zone	Responsible for longitudinal growth Production of organic matrix	Gigantism Achondroplasia
Hypertrophy zone (Zone of maturation and degeneration)	Chondrocytes increase in size Chondrocytes mature Preparation of matrix for calcification	SCFE Mucopolysaccharidosis
Hypertrophy zone (Zone of provisional calcification)	Calcification of matrix	Rickets



Question 2.

Describe the Types of Fracture Healing. Describe the Stages of Secondary Fracture Healing. Enumerate the Factors Affecting Fracture Healing.

Answer 2.

One should know the types of bone healing- primary and secondary healing and how it happens

Endochondral ossification and intramembranous ossification

- These are the two methods of bone formation
- Endochondral ossification has a cartilaginous phase before getting converted into the osteogenic phase. This is seen in development of most of the long bones and in fractures which attempt to heal with relative stability or secondary healing. The endochondral ossification has an anabolic phase where there is increase in chondroblasts and a catabolic phase when there is increased activity of osteoclasts and osteoblasts.
- Membranous ossification does not have a cartilaginous phase and hence skips the stage of soft callus. This is seen in development of flat bones and also fractures that attempt to heal with primary healing or absolute stability. Remember that this healing occurs as result of cutting cone action by the osteoclasts and the osteoblasts lay new bone in this cone.

Fracture healing stages

When a bone fractures there is stripping of the periosteum and the vessels

This leads to bleeding at the fracture site and causes hematoma formation

If the fracture is not reduced the hematoma remains and if is immobilized the hematoma causes inflammation and this leads to exposure of the hematoma to progenitor cells.

This helps in the formation of cartilage cells in this hematoma and it is called the soft callus

So the stages of healing are

Stage of hematoma

1. Stage of inflammation
2. Stage of soft callus
3. Stage of hard callus
4. Stage of remodeling

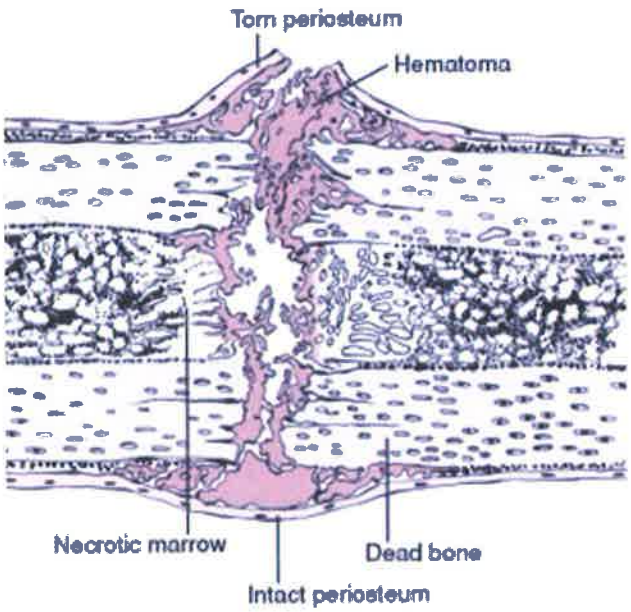
Stage of hematoma and inflammation:

At the time of fracture the following happen-

- The periosteum ruptures
- The blood vessels rupture
- The marrow close to the fracture site becomes necrotic
- The fracture site bone becomes dead
- There is hematoma below the periosteum and the fracture site
- This initiates an inflammatory response and there is increased in many mediator cells and chemicals in this fracture site.
- There is a complex interaction of inflammatory signals, modulators, and cellular components.
- Neutrophils are the earliest and most active cell populations and they remove the debris through their phagocytic mechanism.
- Inflammatory cytokines increase in concentration in early phases, including IL-1β, IL-6, IL-8, IFNγ, and TNFα
- It is always the progenitor cells that help in healing than the already existing mature cells.
- The healing of bone is different from that of any other tissue as the populations of cells that appear in the fracture site and the time at which each individual population appears is important in the final outcome of the union
- Depletion of macrophages or macrophage receptors in the fracture hematoma has deleterious effects on the healing process.
- Initially granulocytes, monocytes, hematopoietic stem cells, and lymphocytes are seen
- Once the above B cell population regress then there is activation of T- cell population in the fracture site
- The periosteum has an inner and an outer layer. The inner layer has periosteal progenitor cells are located
- This is also a source of fibroblasts, osteoblasts,

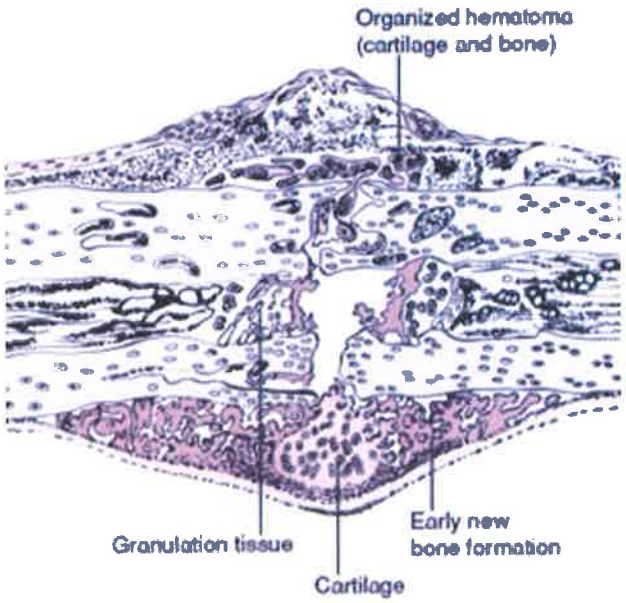
chondrocytes, and a vascular network.

- The periosteum provides an early source of osteoblasts and mesenchymal cells that can directly contribute to calcium deposition and bone formation.
- The periosteal vascular network is responsible for approximately one-third of the cortical blood supply.



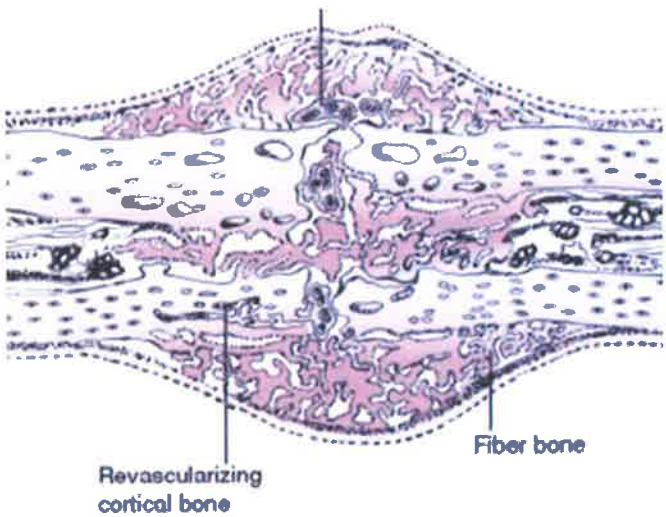
Stage of soft callus

- The mesenchymal cells are derived from the marrow, the endosteal layer of the cortex and peripheral blood.Another potential source of progenitor cells are the pericytes. And are a local cell population that resides in the perivascular space.
- The hematoma when exposed to the inflammatory cells and Sox transcription factor there is formation of chondrocytes which lay down cartilage. Remember Sox9 helps in hypertrophy of the chondrocytes and these remain beneath the periosteum and gets mobilized early once the fracture occurs.
- This chondral deposition is regulated by the TGF -beta and hedgehog signaling
- The chondrocytes get hypertrophied and later undergoes apoptosis and get converted into osteoblasts.



Stage of hard callus

- Osteoblasts lay down calcium and osteoid to transition from soft to hard callus
- These osteoblasts lay done new bone formation
- However due to the high catabolic activity there is osteoclastic activity as well which helps in remodeling



Stage of remodeling

- Osteoclasts help in the remodeling providing the normal shape of the bone
- These cells derive from the hematopoietic cell lineage found on the bone surface and form pits in the surface called Howship lacunae

- This activity is the reason why the bone tissue heals without any scarring

Factors Affecting Fracture Healing

Internal factors

1. Blood supply

- Initially the blood flow decreases with vascular disruption
- After few hours to days, the blood flow increases
- This peaks at 2 weeks and normalizes at 3-5 months
- Un-reamed nails maintain the endosteal blood supply
- Reaming compromises of the inner 50-80% of the cortex
- Looser fitting nails allow quicker reperfusion of the endosteal blood supply versus canal filling nails

2. Head injury may increase osteogenic response

Mechanical factors

- Bony soft tissue attachments
- Mechanical stability/strain
- Location of injury
- Degree of bone loss
- Pattern (segmental or fractures with butterfly fragments)
- Increased risk of nonunion likely secondary to compromise of the blood supply to the intercalary segment

External factors

1. Low Intensity Pulsed Ultrasound (LIPUS)

- Exact mechanism for enhancement of fracture healing is not clear
- Alteration of protein expression
- Elevation of vascularity
- Development of mechanical strain gradient
- Accelerates fracture healing and increases mechanical strength of callus (including torque and stiffness)
- The beneficial ultrasound signal is 30 mW/cm2 pulsed-wave
- Healing rates for delayed unions/non-unions has been reported to be close to 80% bone stimulators
- Four main delivery modes of electrical stimulation

2. Direct current

- Decrease osteoclast activity and increase osteoblast activity by reducing oxygen concentration and increasing local tissue pH
- Capacitively coupled electrical fields (alternating current, AC)
- Affect synthesis of cAMP, collagen and calcification of cartilage
- Pulsed electromagnetic fields
- Cause calcification of fibrocartilage
- Combined magnetic fields
- They lead to elevated concentrations of TGF-Beta and BMP

3. COX-2

- Promotes fracture healing by causing mesenchymal stem cells to differentiate into osteoblasts
- Radiation (high dose)
- Long term changes within the remodelling systems
- Cellularity is diminished

Patient factors

1. Diet

- Nutritional deficiencies
- Vitamin D and calcium
- Protein malnourishment decreases fracture callus strength
- Amino acid supplementation increases muscle protein content and fracture callus mineralization
- Gastric bypass patients
- Calcium absorption is affected because of duodenal bypass with Roux-en-Y procedure
- Leads to decreased Ca/Vit D levels, hyperparathyroidism (secondary) & increased Ca resorption from bone
- Treat these patients with Ca/Vit D supplementation

- Gastric banding does not lead to these abnormalities because the duodenum is not bypassed

2. Diabetes mellitus

- Affects the repair and remodelling of bone
- Decreased cellularity of the fracture callus
- Delayed enchondral ossification
- Diminished strength of the fracture callus
- Fracture healing takes 1.6 times longer in diabetic patients versus non-diabetic patients

3. SMOKING

- Decreases rate of fracture healing
- Inhibits growth of new blood vessels as bone is remodelled
- Increase risk of non-union (increases risk of pseudoarthrosis in spine fusion by 500%)
- Decreased strength of fracture callus
- Smokers can take APPROXIMATELY 70% longer to heal open tibial shaft fractures versus non-smokers

4. HIV

- Higher prevalence of fragility fractures with associated delayed healing
- Contributing factors
- Anti-retroviral medication
- Poor intraosseous circulation
- TNF-Alpha deficiency
- Poor nutritional intake

5. medications affecting healing

- Bisphosphonates are recognized as a cause of osteoporotic fractures with long term usage, recent studies demonstrated longer healing times for surgically treated wrist fractures in patients on bisphosphonates, long term usage may be associated with atypical subtrochanteric/femoral shaft fractures
- systemic corticosteroids-studies have shown a 6.5% higher rate of intertrochanteric fracture non unions
- NSAIDs- prolonged healing time because of COX enzyme inhibition
- Quinolones- toxic to chondrocytes and diminishes fracture repair

Question 3.

Describe the Investigations and their uses in Musculoskeletal System.

a) DEXA Scan

b) Bone Scan

c) Ultrasonography

Answer 3a.

Since its introduction, nuclear medicine has played ancritical role in the diagnosis and detection of soft tissue andskeletal disorders.

Nuclear imaging relevant to orthopaedics encompasses mainly following modalities

1. Bone scintigraphy/Bone Scan: Provides unique information about local and regional bone metabolism that cannot be obtained with other imaging tests. It demonstrate changes in osteoblast activity long before anatomic imaging modalities, thus complementing the anatomic studies in the diagnosis and management of neoplastic disease, osteomyelitis, acute trauma, and stressinjuries
2. Infection Imaging
3. PET Scan

Physiologic Concepts:

Scintigraphic imaging is remarkably dissimilar from radiographic imaging in that scintigraphy images physiology rather than anatomy.

Bone scintigraphy, for example, provides information about local osteoblastic activity that supplements the information demonstrated CT/MRI. This makes bone scintigraphy an extremely sensitive investigation albeit at the cost of poor specificity.

Although this poor specificity is often frustrating, the high sensitivity of the nuclear study allows us to rule out bony disease with a high degree ofconfidence when the bone scan is normal.If no abnormality is detected, the search for osseous metastases can be ruled out. Hence, bone scintigraphy is often the initial study obtained in the search for bony metastases.

Radiopharmaceuticals and their physiology:

The first tracers used were isotopes of

- phosphorus (^{32}P)
- calcium (^{45}Ca)
- strontium (^{85}Sr, ^{87m}Sr)
- gallium (^{67}Ga)
- and fluorine (^{18}F).

Most of these isotopes did not gain widespread use because of:

- long half-lives
- long clearance rates
- poorphoton energies
- high radiation dose.

These problems were solved with the introduction of a stable isotope, technetium 99m (Tc). This isotope has a half-life sufficiently long (6 hours) to allow imaging, but not so long as to expose the patient to a high radiation dose. The isotope also decays primarily by emitting a gamma photon of 140 keV, which is an ideal energy for imagingwith current gamma cameras.

Thus, technetium-labelled diphosphonates have long been the mainstay for bone imaging. Theseradiolabelled diphosphonates probably label bone by adsorption into hydroxyapatite crystal. Thus, increased osteocyte activity is seen in an area of bone injury, such as trauma or with a metastatic lesion wherein mineral phase of bone is undergoing relatively high turnover, allowing for intense focal deposition of tracer.

The amount of tracer deposited depends not only on the local osteoblast activity, but also upon the blood flow to the bone. Even if the blood flow to the bone is secondarily caused by inflammation in adjacent soft tissues, the affected bone shows relatively increased tracer deposition.

Within the first hour after intravenous injection of the tracer, approximately 50% of the tracer is associated with bone. Imaging is usually delayed until at least 3 hours following tracer administration to allow for soft tissue clearance of the remaining tracer through the urine.

Hence, patients who are not well hydrated or who have renal failure can be expected to retain significant amounts of tracer in the soft tissues, making resolution of the bony structures difficult.

It is therefore important to encourage hydration before and after the tracer is injected, or to schedule renal failure patients for dialysis between tracer injection and imaging.

Osteomyelitis is imaged using a combination of the technetium-labelled diphosphonates and ^{67}Ga citrate or white blood cells (WBC) labelled with either indium 111 (^{111}In) or ^{99m}Tc.

Gallium being an iron analogue attaches to transferrin soon after intravenous injection. The radiopharmaceutical then normally concentrates in areas of iron storage, such as the bone marrow, liver, and spleen. Concentration at sites of inflammation may occur by several mechanisms, including passage of the tracer through leaky capillaries, binding to lactoferrin at sites of WBC degranulation, and by bacterial scavenging.

Image Acquisition:

Whole-body images generally are acquired at 2 to 4 hours after injection and produce anterior and posterior static planar images of the skeleton (Fig. 1)



Fig: Normal anterior posterior whole-body bone scan images

Multiphase bone scan involves acquiring blood flow images, which are a dynamic sequence of planar images immediately after administration of the radiopharmaceutical. Blood pool images are planar images obtained immediately after the dynamic sequence (Fig. 2A and B). Blood flow and blood pool images provide an assessment of the soft tissue perfusion and may be useful in differentiating between active inflammatory processes and in the evaluation of the acuity of fractures. Delayed images typically are performed 2 to 4 hours after injection, and if necessary 24hour delayed images may be obtained (Fig. 2C).

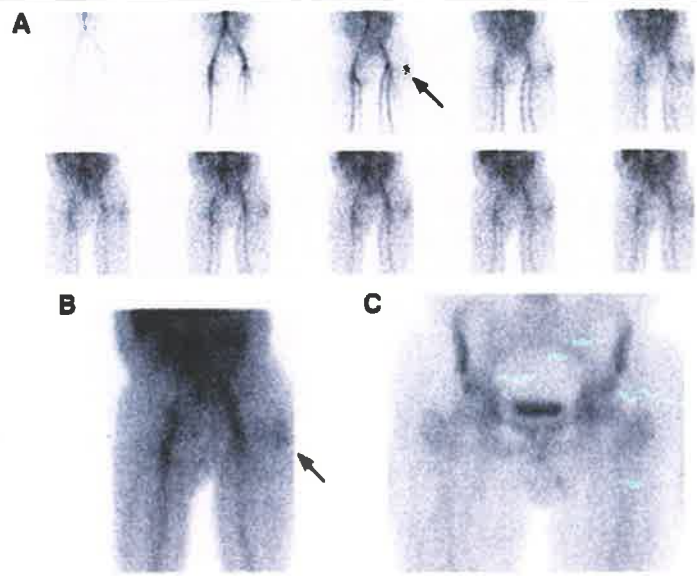


Fig. 2. (A) Anterior dynamic images acquired immediately after injection of 99mTc MDP show hyperemia lateral to the left greater trochanter (arrow). (B) Anterior static blood pool image shows soft tissue hyperemia lateral to left greatertrochanter compatible with focal cellulites. (C) Delayed anterior static image of the pelvis, which is normal.

Delayed, 24-hour imaging improves the ratio of skeletal to soft tissue uptake. Single-photon emission computed tomography (SPECT) produces a tomographic image of a portion of the skeleton by acquiring a series of static images 360 around the patient and reconstructing the data to produce tomographic images (Fig. 3).

SPECT images have improved contrast resolution compared with planar images and often can characterize the precise location and extent of disease more accurately.

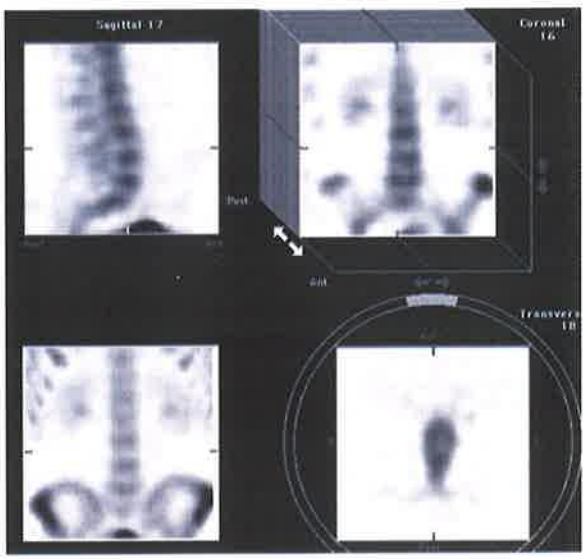


Fig. 3. Normal sagittal, coronal, transaxial, and maximum image projection images from a SPECT acquisition.

Clinical Applications of Bone Scintinography

Common indications for bone scanning include:

- Evaluation of metastatic disease
- occult fractures
- stress fractures
- osteomyelitis and
- avascular necrosis.

In a postoperative patient, bone scanning is used in the evaluation of:

- complications related to joint prosthesis surgery
- spinal fusion
- bone graft viability
- Reflex sympathetic dystrophy

Bone scintigraphy is a sensitive, but relatively nonspecific, diagnostic imaging technique. Increased activity on bone scintigraphy may be due to trauma, infections, or primary or secondarybone tumours.

It is therefore important to interpret results in light information gathered regarding current symptoms, physical findingsand history of trauma, fractures, infection, arthritis, metabolic disease, or metastatic bone disease. History of previous orthopaedic procedures or relevant non-orthopaedic surgery. previous radiotherapy, previous antibiotic therapy, and results of prior imaging investigations also would be useful information to have beforeperforming a bone scan.

Occult fractures and trauma:

- useful in detecting occult fractures and excluding bony pathology when initial radiography is normal
- Areas that often are evaluated by bone scintigraphy for occult fractures include carpal bones, proximal femurs, ribs, talar dome, pelvisand spine.
- The characteristic appearance of fractures varies as time elapses from injury, and bone scintigraphy may be useful to estimate the timing of fractures.
- The usual patterns seen on multiphase bone scan can be classified into three categories: acute, subacute, and healing. In the acute phase (1–4 weeks) of injury, there is hyperemia and hematoma formation around the area of trauma, and this is manifested as early blood flow and blood pool activity. Later, in the subacute phase (6–12 weeks), there is callus formation and a relative reduction in blood flow, and localization of activity to bone becomes more discrete along the fracture line. In the healing phase, callus is reabsorbed and replaced by normal bone, and there is gradual diminution of activity on the delayed images.
- Mildly increased activity may be appreciated on delayed images years after fracture; however, in uncomplicated fractures, bone scans typically normalize in 1 to 2 years.
- Prolonged hyperaemia or osseous remodelling activity should raise the suspicion of infection or malunion.
- The bone scan has a characteristic appearance as healing progresses, scintigraphy often is performed to date the relative age of a fracture, which may be useful in medicolegal cases or when evaluating vertebral levels for vertebroplasty.

Stress fractures:

- In contrast to acute fractures, bone scanning has a significant role in the detection and diagnosis of stress-related injuries.
- In most cases, bone scanning is the most practical modality for imaging stress fractures. The sensitivity of scintigraphy approaches 100%, whereas 80% of stress lesions are not evident on initial radiographs. Additionally, scintigraphic findings usually precede radiographic changes by 2 weeks, and early diagnosis is vital to high-performance athletes to prevent complications and facilitate a quick return to premorbid function.
- Occult pelvic fractures are often a complication of osteoporosis, although it occasionally has been observed in runners and military recruits. These fractures frequently occur along the sacrum andpubis and can resemble metastatic disease.

Infection Imaging:

- Multiphase bone scan should be the initial test of choice in suspected acute osteomyelitis. It can detect infection 2 weeks in advance of radiographic changes, and in non-violated bone.
- Bone scintigraphy shows hyperaemia and reactive osteoblastic activity, not infection in itself. In complicated bone conditions involving trauma and orthopaedic implants, in which there is another reason for increased osteoblastic activity, specificity of bone scintigraphy alone is reduced significantly to about 30%.
- In non-violated bone, the multiphase bone scan is often sufficient to make a diagnosis, but in cases in which the underlying skeleton may have sustained concurrent trauma, it can be used only to rule out infection reliably.
- In acute osteomyelitis, bone scintigraphy typically shows increased activity on all phases.
- In cases of soft tissue infection (eg, cellulitis, septic arthritis), the blood flow and blood pool phases of the study typically show hyperemia, but the delayed static images are normal or show mild increased activity.
- If doubt persists between osteomyelitis and soft tissue infection after a 2- to 4hour delayed image,

SPECT or a 24-hour image can be obtained.

- Indium 111 (111In)-labeled white blood cell scintigraphy typically is employed as an adjunct to the multiphase bone scan in the appendicular skeleton when the bone of interest has been fractured, or there is a history of recent surgery.
- Because of the localization within normal hematopoietic bone marrow, labelled white blood cell scintigraphy does not perform well in the axial skeleton.
- Gallium scintigraphy is used to investigate fever of unknown origin, neoplastic disease, and inflammatory conditions. In orthopaedics, it is chiefly useful in evaluating suspected vertebral discitis or osteomyelitis.

Spinal osteomyelitis or discitis

- Typical scintigraphic findings in discitis or vertebral osteomyelitis are increased 99mTc MDP activity within the adjacent vertebral body end plates with associated increased gallium accumulation.
- MRI has better resolution of soft tissue involvement and is helpful to detect paraspinal involvement or when an intervention is required. MRI currently is considered by many authors as the test of choice in the evaluation of patients with suspected osteomyelitis.

Prosthetic Infection

- Distinguishing between prosthetic loosening and infection is not easy by MRI and CT often due to metallic artifact.
- The clinical and laboratory picture is equivocal or incongruent, scintigraphy can often be valuable.
- Increased osseous remodelling within the prosthetic bed is sensitive to mechanical stress and infection, and consequently infectious and aseptic loosening both may show increased activity on bone scintigraphy.
- Classically, for a cemented hip prosthesis, loosening is typified by focal uptake at the tip of the femoral component, whereas diffuse periprosthetic hyperaemia and increased activity is more characteristic of infection.
- Uncomplicated, cementless prostheses can show extended activity for years after surgery. Typically, serial bone scans are required to confirm the diagnosis of loosening in patients with non-cemented prostheses.
- The absence of infection or loosening can be effectively ruled out when bone scintigraphy is clearly negative. The addition of gallium and labelled white blood cell scintigraphy can increase significantly the specificity of a bone scan in detecting periprosthetic infection, but\ evidence is accumulating to support combined white blood cell and sulfur colloid scanning as the modality of choice.

Bone Graft Viability:

- Multiphase bone scintigraphy is an effective modality to assess bone graft viability. Vascular patency to the graft is characterized by increased tracer uptake in all three phases of the scan, and tracer eventually becomes isointense to adjacent bone as it becomes incorporated.
- Nonviable grafts and grafts at risk for postoperative complications show reduced flow and do not concentrate tracer on delayed images, suggesting little to no osteoblastic function in the transplanted site

Complex regional pain syndrome type I (formerly reflex sympathetic dystrophy):

- Nuclear medicine can be useful to confirm initial clinical suspicion.
- CRPS I is a clinical diagnosis; however, scintigraphy has an adjunct role in the diagnostic confirmation and disease staging. The scintigraphic findings depend on the stage of the disease, but classically are associated with increased periarticular activity in the affected limb.

Vertebroplasty:

- Bone scintigraphy can survey easily and accurately for involved vertebral levels and differentiate acute from chronic fractures.

Pseudarthrosis:

- Pseudarthrosis or fibrous union is a frequent cause of continued pain after spinal fusion. Early recognition of this complication can help prevent surgical implant failure, loss of correction, andclinical pain.

- Conventional radiographs are generally unhelpful in more subtle or early cases of pseudarthrosis.
- Healing of the fusion mass is typically near complete at 6 months, but in some cases mild increased uptake can persist for 2 years. Scintigraphically, the presence of a focal area of increased activity within the fusion mass after 12 months is highly suspect for pseudarthrosis.

Myositis ossificans:

- Typical scintigraphic findings in myositis ossificans are hyperemia and increased soft tissue accumulation of 99mTc MDP.
- Scintinography is often positive 4 to 6 weeks before becoming evident radiographically.
- Early detection of myositis ossificans is useful because medical therapy with indomethacin or diphosphonates is available to prevent or retard this condition.
- The bone scan can determine the maturity of the lesion, which is important in timing surgical removal because removing these lesions prematurely increases the likelihood of recurrence.
- In its immature form, these lesions are positive on all three phases of the bone scan. As the lesion matures, flow and pool images normalize, and activity generally is restricted to the delayed phase.

Answer 3c.

Ultrasound in orthopaedics

- Totally safe
- Non-invasive
- No ionizing radiation emission compared to CT and X-rays
- Can be used even in patients with cardiac pacemakers and metal implants.
- Referred to as the orthopedician stethoscope.

Uses

- Diagnostic
- Interventional
- Therapeutic

Diagnostic

- Evaluation of soft tissue pathology (common).
- Detection of fluid collection anywhere in the body
- Cartilage visualization
- Bone surfaces visualization
- Tendon continuity
- Ligament integrity
- The soft tissue heating that can be caused by USG can be kept nil while performing a diagnostic USG

Interventional

- USG guided injections
- USG guided aspiration
- USG guided biopsy
- USG guided portal placement
- USG guided nerve blocks

Therapeutic

- Ultrasound massage
- Promote fracture union (low intensity pulsed therapy)
- Relief in tendinitis
- Hyperthermic, physical therapy with sonophoresis, extracorporeal shock wave therapy, low intensity pulsed therapy are the various modalities used in orthopedics treatment

Principle

- Ultrasound is not perceptible to the human ear normally and the frequencies range from 20 Hz to 20 kHz.
- Therapeutic ultrasound - 0.5 MHz
- Diagnostic ultrasound- 2 MHz and 10 MHz
- Echo sounding or sonar is the physics behind an USG. That is the varied reflection of the sound signals by varies tissues or medium is recorded as wave forms. The more reflected sound is shown as higher amplitude.
- Ultrasound examination is based on how various structures reflect and absorb frequencies
- Higher frequency is used for superficial structures whereas lower frequencies for deeper structures.
- Different structures absorb ultrasound at different rates and hence there is attenuation of the sound

waves, while the some waves are echoed back.

- Air and bone absorb sound the most, followed by fat, soft tissues and water.
- An interface between two mediums with different impedance causes reflection of the beam back towards the receiver.
- The gel used on the skin is free from acoustic impedance and helps in transmission of the sound from the probe onto the skin so that there is least echoing at the skin and also that the reflected sound from the inner tissues also reaches back the receiver.
- Absence of returning signals from within an object infers a fluid nature.
- If there is very high difference in the resistance like that in between tissue and bone then there is acoustic shadowing that is formed behind the bone.
- So USG is based on physical changes in composition. (MRIis based on the chemical composition of the tissue)
- Therapeutic ultrasound devices use either short bursts/ continuous waves/shocked or distorted waves and hence deliver effective energy to tissues.

Region wise uses of USG in Orthopedics

Neck

Diagnostic

- Early detection of calcification in soft tissue in the neck region.
- Soft tissue tumors
- Congenital muscular torticollis
- Distinguish between a tumor mass/ hematoma/ muscle rupture
- Identifying cervical rib- echogenic structure with acoustic shadowing
- Fracture of the clavicle in the newborn
- Congenital pseudoarthrosis of the clavicle
- Thoracic outlet syndrome

Interventional

- Brachial plexus block
- USG guided aspiration
- USG guided biopsy of any lesion

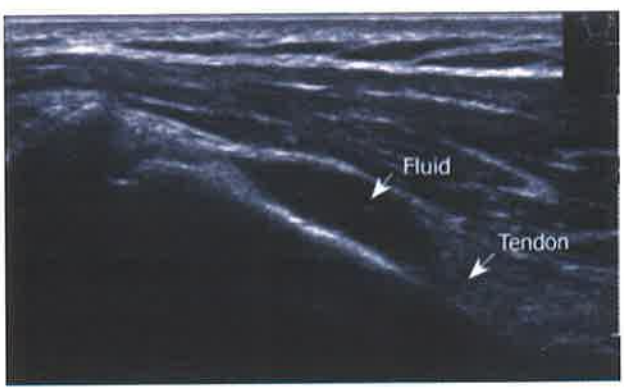
Therapeutic

- USG massage of the paraspinal muscles

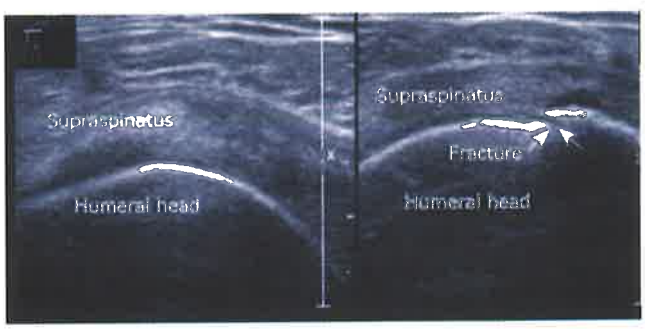
Shoulder

Diagnostic

- Early detection of calcific tendinitis
- Soft tissue tumors
- Rotator cuff pathologies are diagnosed most commonly
- Subacromial bursitis
- Adhesive capsulitis
- Biceps tendinitis
- The advantage of an USG is that all pathologies related with rotator cuff tear like subacromial bursitis, biceps tendinitis, impingement can easily be assessed and quantified in a static and dynamic study with USG



- Another use is detecting undisplaced fractures of the greater tuberosity or any lyticlesion in the proximal humerus



- Septic arthritis of the joints of the shoulder, ACJ,

sterno-clavicular joint can be quickly identified by an USG.

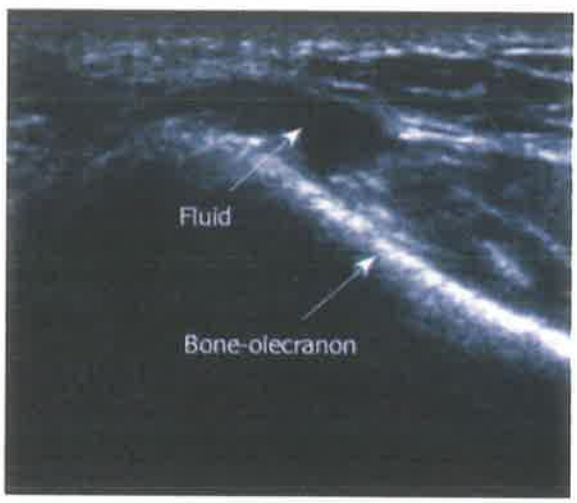
- Helps in identifying arthritis in these small joints.



- Hillsach lesion following dislocation/ identify dislocation in hemiplegic patients.
- Interventional
- USG guided aspiration
- USG guided biopsy of any lesion
- USG guided injections

Therapeutic

- USG massage
- Elbow
- Identifying tendinopathies-
- Identifying bursitis. Eg olecranon bursitis as shown here.



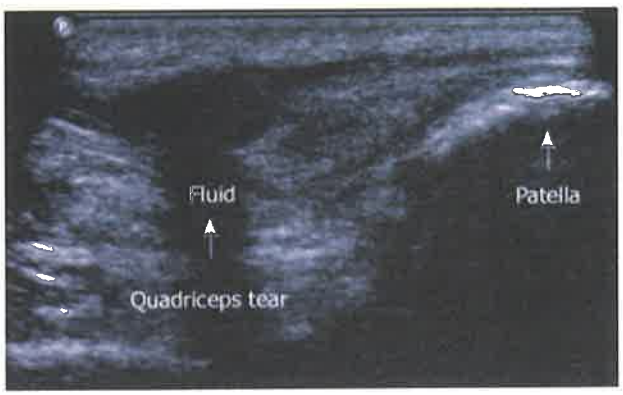
- Identifying nerve compression syndromes- Radial tunnel syndrome/ cubital tunnel syndrome
- Early detection of myositis ossificans
- Septic arthritis
- Effusion
- Synovial proliferation
- Calcification
- loose body detection
- rheumatoid nodules
- gouty tophi formation

Wrist and hand

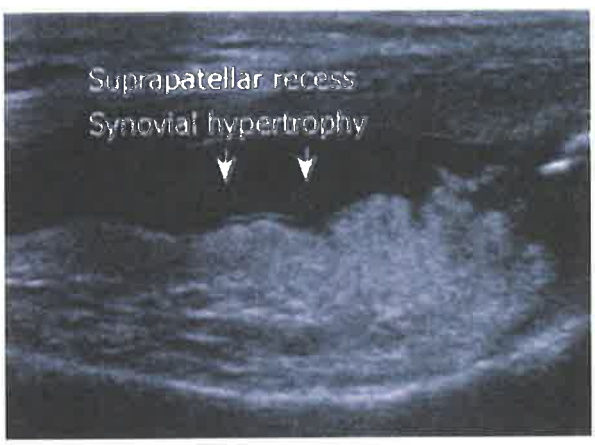
- Flexor and extensor tendons injuries/tenosynovitis
- As the proximal ends of the cut tendons tend to get retracted far proximally, identifying them using ultrasound is helpful to plan incisions, requirement of grafts etc
- Ligaments of the finger -ruptures,
- Extent of cystic or solid swelling, palpable tumors, ganglion
- Foreign bodies
- In the detection of greenstick fractures of the distal radius and ulna
- TFCC injuries
- Dequervain's tenosynovitis
- Intersection syndrome
- Nerve compression syndromes like Wartenberg syndrome/ Guyons canal syndrome/carpal tunnel syndromes
- Can be used to diagnose exact structure causing compression of the nerve.
- Mallet finger- differentiate between bony mallet and soft tissue mallet finger
- Post tendon repair to identify the continuity, strength, dynamic gliding of the tendons in the pulleys of the fingers
- Cartilage status of carpals to decide upon salvage/ fusion procedures

Knee

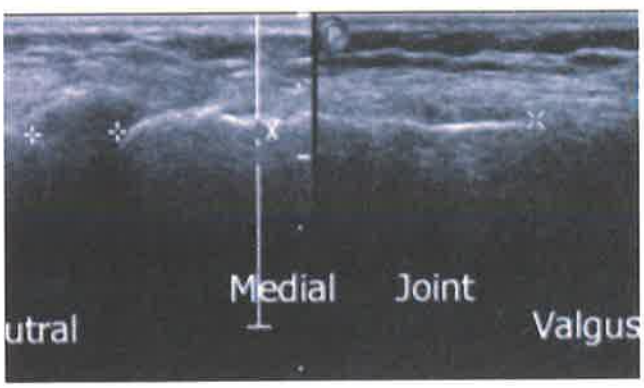
- Assessment of the extensor apparatus – Example. Quadriceps/ patella rupture. This is very important in post TKR patients where in an MRI is not feasible in the remote post operative period.



- Bursitis around the knee
- Cause of anterior knee pain
- Chondromalacia patellae
- Effusion
- Synovial hypertrophy



- PVNS
- Septic arthritis
- Dynamic study of the knee helps in assessing the amount of opening suggesting the continuity of the collaterals



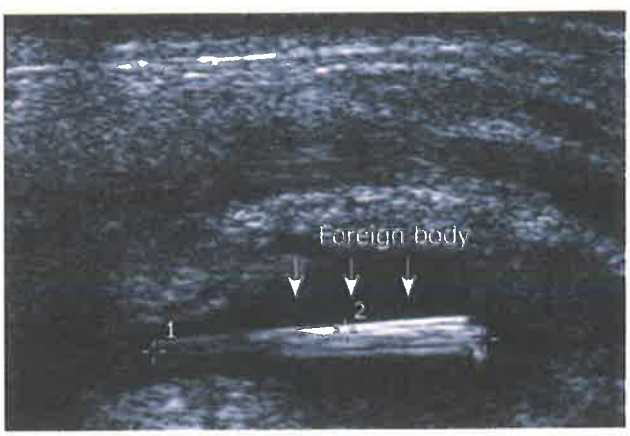
- Identify meniscus tear



- Osgood-Schlatter disease
- Bipartite patella
- Meniscal cysts and Baker cyst

Leg and foot

- Muscle tear/ tendon subluxation.
- Tendo Achilles tendonosis, tears, calcification, and inflammations
- Hagelund deformity may be related to Achilles tendon pathology.
- Ankle sprain - partial or complete tears - anterior talofibular (commonest).
- Severs disease- rough fragmentation with saw-teeth appearance - specific sign
- Tendinitis is visualized in ultrasound as hypoechogenicity of the tendon with increased interfibrillar distance.
- Retro-calcaneal bursitis and cellulitis can be seen.
- Insertion tendinopathy - hypoechoic enlargement of the tendon with fluid in the area inserted in the bone.
- Evaluating syndesmosis.
- Evaluation of foreign body which are usually not visible on plain radiographs.



- Plantar fasciitis/ tears
- Fibromatosis

- Morton neuroma
- Jones fractures
- Sesamoids fractures

Paediatricorthopaedics

- Identifying physis injuries/ developmental abnormalities
- DDH in infants
- Fragmentation of the head in Perthe's disease
- Slip in SCFE
- Septic arthritis
- Osgood Schattlers disease
- Green stick fractures
- Osteomyelitis - subperiosteal collections of fluid
- Exostosis- measure thickness of cartilage cap

Advantages

- Ultrasound is comparatively cheap, noninvasive and real time dynamic study of the musculoskeletal system.
- The radiologist has the flexibility and precision in the screening the area as one can club both clinical and radiological assessment at the same time.
- It is said that an MRI over investigates, as screening a particular area could lead to incidental findings.
- However in a USG study the radiologist can locate the local point of pain and assess and correlate with the underlying finding.
- In the incidence of any confusion then one can easily compare it with the normal contralateral limb and the normal tissue area as well.
- Helps the surgeon to identify tendon tears, smallest calcifications and foreign bodies.
- Early detection of pathologies.
- Helps in giving physiological information of vessels. To rule out DVT, arterial thrombosis prior to surgeries like flap surgeries or joint replacements.
- Can be used intraoperatively to assess any vascular injury.
- Can be used as a quick assessment tool in a poly-trauma patient to rule out chest/abdominal injuries.
- Mechanical impingement between implants and soft tissue structures can be done
- Diagnostics, therapeutic interventions and the fact that it can be repeated as many times as required makes USG one of the easiest modalities in orthopedics diagnosis.

Disadvantages

- Musculoskeletal ultrasound requires great experience and has a very long learning curve and the reports depend mainly upon the skill of the doctor performing it.
- Skin burns, scarring occurring due to high frequencies even though rare can be devastating.

Question 4.

Define allograft. Describe the types of allografts. Give salient features of each type.

Answer 4.

- A graft may be orthotopic (when it is transplanted to the exact same site in recipient that it occupied in the donor, e.g. proximal tibia to proximal tibia); heterotopic (when it is transplanted to a different site but one occupied by the same tissue as in the donor, e.g. fibula to spine); or ectopic (transplanted to a site normally occupied by a different type of tissue, e.g. fascia lata as a tendon graft).
- Allograft Supply in our country is limited due to lack of awareness and availability of minimal efficient banking facilities.
- Allografts or allogenic bone grafts are available in various forms:
  - Fresh—
    - It has High immunogenic potential
    - No known clinical use
  - Fresh-frozen—
    - It is Less immunogenic but needs an additional procedure for sterilization.
    - Advantage is that it preserves Bone morphogenic protein.
  - Freeze-dried (lyophilized):
    - Bone must be extracted from donor within

8–12 hours of death.

- Intracellular and extracellular enzymes cause enzymatic autodigestion and lead to loss of inductive factors and BMP of bone.
- The type that retains inductive factors is known as Antigen-extracted allogeneic (AAA) bone.

1. chloroform-methanol is used to extract lipids and cell membrane lipoproteins (4 hours);
2. HCl extracts acid-soluble proteins and requires 24hrs to demineralize the surface; and
3. Neutral phosphate buffer is used to remove endogenous intracellular and extracellular transplantation antigens. The bone is then frozen and freeze dried and thereafter stored at −60°C.

Demineralized bone matrix (or bone matrix gelatin):

- It is used as bone graft extender
- It is a digested source of BMP.
- DBM is available in two forms, dry or injectable.
- DBM has to be mixed with a carrier.
- Carriers (which are inert with regards to bone generation) include hyaluronic acid, glycerol, collagen, gelatin, and actual derivatives of DBM itself.
- Second generation DBM putties (where the carrier is loaded with BMP) have higher concentrations of BMP and are possibly better.

Osteochondral allografts:

- It is a bony chunk alongwith cartilage cover
- Used for large articular defects in osteochondroses of knee.

Shell allografts:

- Devascularized osteoarticular graft with a small bony component is used for
- Biologic resurfacing of articular defects.

Large composite allografts:

- Usually required for excision of large tumors or reconstruction of defects in revision arthroplasty after freeze thawing.

Indications for use of allograft:

- Reconstruction of bone defects as a result of primary joint arthroplasty osteolysis
- Reconstruction of skeletal defects following tumor resection
- Reconstruction of congenital or developmental bone and joint defects (protrusioacetabuli, dysplastic hip) and deformities.
- Repair of fresh comminuted fractures with bone loss
- Treatment of nonunion and complicated osteoporotic fractures
- Arthrodesis of large joints
- Treatment of scoliosis and spinal fusion
- Repair of massive segmental bone defects
- Repair of periodontal osseous defects.

Complications of bone grafting (autograft and allograft):

- Development of incisional hernia
- Vascular injury
- Neurological injury: posterior iliac grafting—cluneal nerves, anterior iliac grafting—lateral femoral cutaneous grafting
- Fracture of donor bone
- Hematoma and seroma formation
- Cosmetic concern and chronic pain
- Transmission of infection (allograft)
- Very rarely tumor cell transplantation.

Infections associated with bone allografts:

Allografts act as porous, acellular and avascular foreign bodies that are liable for bacterial adhesion.

After attachment bacteria become unapproachable to immune surveillance and local cellular defence mechanisms by secreting a thick glycocalyx matrix.

Varied infections have been reported form implanted allograft bone including viral [hepatitis B and C, human immunodeficiency virus (HIV)], bacterial [Clostridium species, S aureus, (group-A beta hemolytic streptococci (GABHS), Pseudomonas, Enterococcus organisms] and fungal.

Submerging the graft in antimicrobial

solutions does not eliminate the spores. In order to completely destroy the spores, gamma irradiation and treatment with ethylene oxide or a low-temperature chemical sterilization must be carried out at the time of implantation.

It has been found that Irradiation reduces bacterial transmission and may also inactivate HIV.

Advantages and Disadvantages of autograft versus allograft	
Autograft	**Allograft**
Advantages: • Readily available • Quick and reliable incorporation • No immunogenicity • No clearance hassles for authority • No risk of "transmitting" infections as with allografts • Different forms—cortical, cancellous, combined available for various use **Disadvantages:** • Increase time of surgical procedure • Limited in amount for large reconstructions and defects • Pain at operative site, morbidity and increased length of stay • Increased cost of surgery • "Second" surgery and potential risks like infection • Chronic pain may persist • Possibility of hernia and secondary complications	**Advantages:** • Quick and easy to use • Available now in various sizes and shapes for different use • Cortical vs. cancellous can be chosen • Large amount for massive reconstruction available • Shortens operative time **Disadvantages:** • Requires set-up and maintenance • Not readily available in India • Various regulatory clearances needed • Risk of infection especially the clostridial and viral infections has still not been eliminated • Weak osteogenic potential though provides good structural support (osteoconductive) • Procurement, processing and preservation need expertise and dedication

Question 5.

Pathology, Clinical Features and Management of Primary Hyperparathyroidism.

Answer 5.

Primary Hyperparathyroidism

Natural History and Incidence

- Primary hyperparathyroidism is a generalized disorder of calcium, phosphate, and bone metabolism due to an increased secretion of PTH.
- The elevation of circulating hormone usually leads to hypercalcemia and hypophosphatemia.
- There is great variation in the manifestations. Patients may present with multiple signs and symptoms, including recurrent nephrolithiasis, peptic ulcers, mental changes, and, less frequently, extensive bone resorption.
- However, with greater awareness of the disease and wider use of multiphasic screening tests, including measurements of blood calcium, the diagnosis is frequently made in patients who have no symptoms and minimal, if any, signs of the disease other than hypercalcemia and elevated levels of PTH. The manifestations may be subtle, and the disease may have a benign course for many years or a lifetime. This milder form of the disease is usually termed asymptomatic HPT.
- Rarely, hyperparathyroidism develops or worsens abruptly and causes severe complications, such as marked dehydration and coma, so-called hypercalcemic parathyroid crisis.
- The annual incidence of the disease is calculated to be as high as 0.2% in patients >60, with an estimated prevalence, including undiscovered asymptomatic patients, of 1%;
- The disease has a peak incidence between the third and fifth decades but occurs in young children and in the elderly.

Etiology

- Parathyroid tumors are most often encountered as an isolated adenomas without other endocrinopathy.
- They may also arise in hereditary syndromes, such