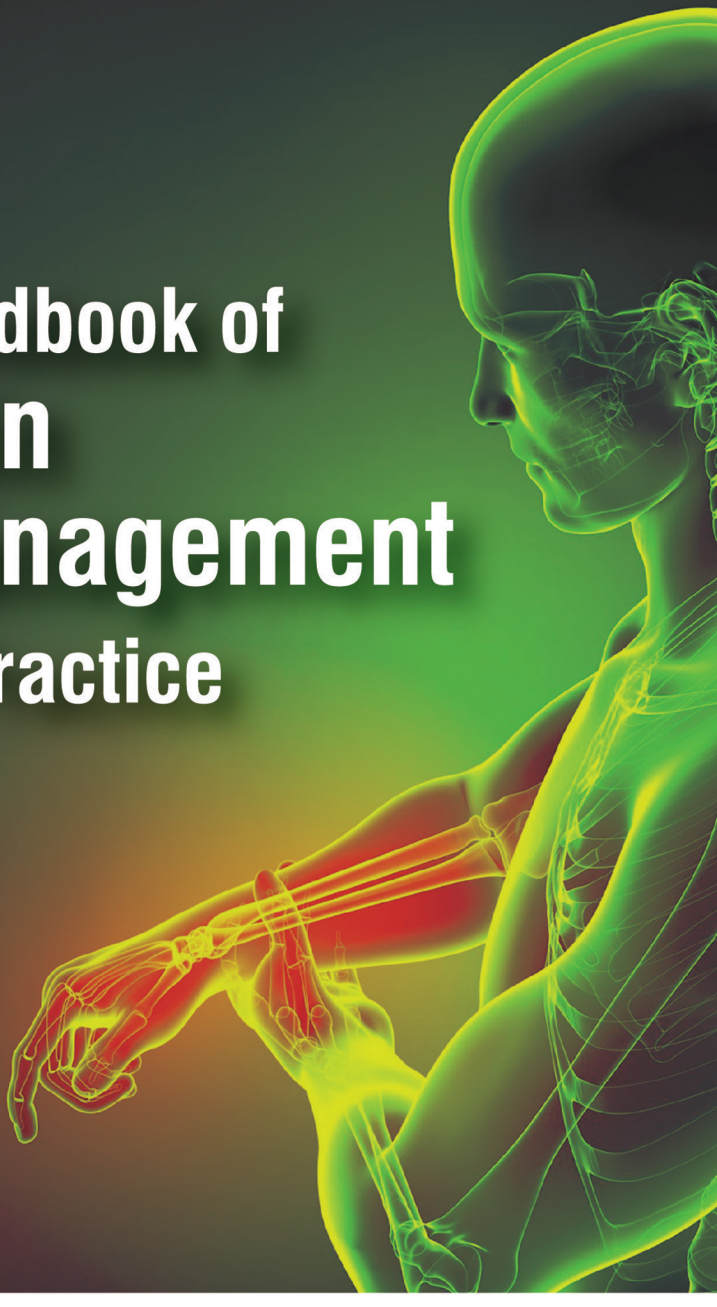
Handbook of Pain Management in Practice



Sree Ranjani S

Foreword
GK Kumar

JAYPEE

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Chapter

4

Radiological Assessment of a Patient in Pain

- X-ray/Radiograph/ Roentgenograph
- Magnetic Resonance Imaging
- Computed Tomography
- Ultrasound Scan
- Upper Limb
- Lower Limb

Musculoskeletal radiology, which deals with imaging of bone, joint and soft tissue abnormalities, forms a very important tool in the diagnosis of chronic pain. Conventional radiographs (X-rays) have been the mainstay of diagnosis in this field. Advanced imaging techniques include computed tomography (CT), magnetic resonance imaging (MRI) and ultrasound (US). Other higher investigations include myelography/CT, discography/CT and radioisotope bone scans, but are not considered in routine clinical practice. Spinal angiography is used in the evaluation of selected patients with suspected treatable causes of vascular myelopathy.

X-RAY/RADIOGRAPH/ROENTGENOGRAPH

Radiograph or roentgenograph, discovered by Wilhelm Conrad Röntgen is produced by transmitting X-rays through a patient and capturing it on a silver-impregnated film. X-ray is usually the first line of investigation, since it is quick, easily available and economical.

Physics of Radiation

Radiation is the transfer of energy in the form of particles or waves. X-rays are electromagnetic radiation, which are carried by waves of photons.

Ionizing radiation: X-ray radiation has sufficient energy to cause ionizations, which is a process whereby the radiation removes an outer shell electron from an atom. Ionization process is

clearly able to cause chemical changes in biologically important molecules, i.e. deoxyribonucleic acid (DNA).

Non-ionizing radiation: It does not contain sufficient energy to cause ionizations. For example, US, ultraviolet, infrared, radio waves, microwaves or radar.

X-ray Production

By the application of a high voltage to the X-ray tube, an electrically heated filament (cathode) within the tube generates electrons that are accelerated from the filament. X-rays are produced when high velocity electrons are decelerated by tungsten target (anode) in an X-ray tube. The energy gained by the electron is equal to the potential difference (voltage) between the anode and cathode. This electron energy is typically expressed in kilovolts (kV).

X-rays are a form of light with a wavelength in the range of 0.1–10 nm. It is extremely small wavelength, which indicates that the X-rays have a much higher energy than visible light. Doubling the distance from a radiation source, decreases the radiation level by a factor of four. Conversely, halving the distance increases the radiation level by a factor of four.

Bones are clearly seen on X-ray images, but soft tissues do not show up well. Moreover, since three-dimensional body parts are projected onto two-dimensional film, a lot of important information is lost. This problem is circumvented in MRI and CT scans.

MAGNETIC RESONANCE IMAGING

The MRI helps in diagnosis of bone and soft tissue conditions and gives highly accurate and detailed depiction of anatomy. In chronic pain, MRI is ordered either at least 6 weeks after conservative treatment to include physical therapy or immediately, if any major pathology is suspected. The intravenous (IV) contrast is given to differentiate inflammatory change from fluid and viable from non-viable tumor. The magnetic resonance arthrography (MRA), i.e. intra-articular contrast is used for large joints to assess cartilage and ligaments.

Physics of Magnetic Resonance Imaging

The body is composed of water molecules, which contain two hydrogen nuclei or protons. When a person goes inside the

powerful magnetic field of the MRI scanner, these protons align with the direction of the field. A radio frequency electromagnetic field when briefly turned on, causes the protons to alter their alignment relative to the field. When this field is turned off, the protons return to the original magnetization alignment. These changes in alignment create a signal, which is detected by the scanner. By changing the parameters on the scanner contrast between different types of body tissues is created. Turning gradient coils on and off creates the knocking sounds heard during an MRI scan.

Unlike CT, MRI uses no ionizing radiation and is generally a very safe procedure. The MRI is useful to detect neurological conditions, tumors, muscles and joints pathology, and practically any condition.

Absolute Contraindications for MRI[1]

- Electronically, magnetically and mechanically activated implants
- Ferromagnetic or electronically operated active devices, i.e. automatic cardioverter defibrillators
- Cardiac pacemakers
- Metallic splinters in the eye
- Ferromagnetic hemostatic clips in the central nervous system.

Relative Contraindications for MRI

- Insulin pumps and nerve stimulators
- Other pacemakers, e.g. for the carotid sinus
- Cochlear and non-ferromagnetic stapedial implants
- Prosthetic heart valves
- Lead wires
- Hemostatic clips.

Basic MRI scans are T1 weighted MRI and T2 weighted MRI. T1 weighted scans in particular differentiate fat from water—with water darker and fat brighter and thus highlight fat deposition. In T2 weighted scans, fat is differentiated from water —but in this case fat shows darker and water lighter. T2 scans are therefore particularly well suited to imaging edema.

The contrast agents[2] used in MRI are of IV type based on chelates of Gadolinium. Anaphylactoid reactions are rare and there is a lower incidence of nephrotoxicity compared with iodinated agents used for CT or X-ray radiography and this has made contrast-enhanced MRI scanning an option for patients with renal impairment.

COMPUTED TOMOGRAPHY

The CT gives a highly detailed picture of the anatomy of bone and the resulting changes due to pathologic conditions such as injury, infection or tumor. It consists of an X-ray tube and detectors that rotate around the patient. The scanner records the X-ray absorption by the patient's body in every direction. A computer then computes these recordings and an image is constructed.

The contrast media used for CT is iodinated media. The types of iodinated contrast media[2] are ionic and non-ionic media. Non-ionic agents are associated with less discomfort and have a lower incidence of adverse effects. Patients with increased overall risk for adverse effects from contrasts include the history of previous adverse effect from intravascular iodinated contrast media, asthma, allergic reactions, known cardiac dysfunction, renal insufficiency, sickle cell disease, pheochromocytoma, myasthenia gravis or generalized severe debilitation.

ULTRASOUND SCAN

The US helps to study the anatomy and function of the soft tissue, surrounding bones and joints.

Physics of Ultrasound

The audible range for human is frequency of 20 Hz to 20 kHz. The sound waves used diagnostically in US scan have a frequency of more than 1MHz.

The US waves are generated by piezoelectric crystals. Piezoelectric means 'pressure electric' effect. When an electrical current is applied to a quartz crystal, its shape changes with polarity. This causes expansion and contraction that in turn leads to the production of US waves.

These US generated in a transducer, passes through the tissues and are reflected at the boundaries and interfaces, this depending on the type of tissue. The reflected beams are received by the receiver and processed by a computer to generate the images.

Advantages of using US for musculoskeletal imaging include ready accessibility, portability, quick scan time, real time guidance, no radiation exposure and better patient tolerability. But the disadvantages are that it is highly operator-dependent, and experience and proper training is required for high quality studies.

As cost constraints continue to influence patient management decisions, musculoskeletal US may become the preferred method for imaging evaluation over more expensive studies.[3]

UPPER LIMB

Chronic Shoulder Pain

Shoulder Pathologies

- Fractures
- Dislocations
- Arthritic changes in acromioclavicular joint, glenohumeral joint
- Tendinitis
- Rotator cuff tears
- Other soft tissue injuries and tumors.

Choice of Investigations

- Initial investigation of choice in shoulder pain is X-ray
- If radiographs are noncontributory or pain is persistent, or there is significant pain, next study is MRI shoulder without contrast
- If MRI contraindicated, CT arthrography shoulder or US shoulder.

Radiography shoulder: Useful for evaluation of fractures, dislocation, calcification and arthritis (Figs 4.1A to D).

MRI shoulder: Procedure of choice for evaluation of occult fractures and the shoulder soft tissues, including the tendons, ligaments, muscles and capsular structures. MRI with contrast is used to differentiate inflammatory change from fluid and delineate soft tissue tumors (Fig. 4.2).

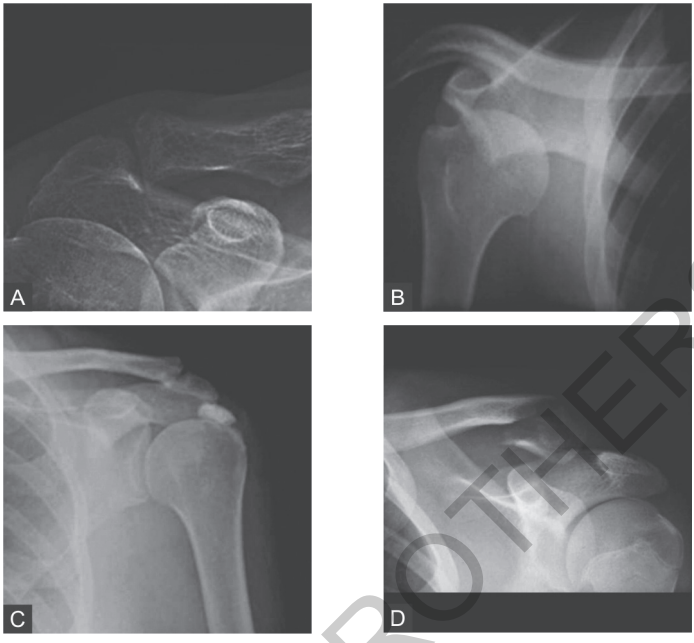
CT arthrography of shoulder: It is a good alternative in patients who have a contraindication to MRI.

Ultrasound of shoulder: As follows:

1. The US with appropriate local expertise is excellent in the depiction of rotator cuff and long head of biceps pathology in the preoperative and postoperative shoulder.
2. It is an excellent modality to guide injections and aspirations.

Computed tomography scan of shoulder: As follows:

1. The CT scan without contrast is useful for characterizing fractures, if more information is needed preoperatively; it can demonstrate fracture complexity, displacement, and angulation, especially with the use of reconstructed images.
2. The CT arthrography is useful for evaluation of the cuff, and loosening around implants.



FIGURES 4.1A to D: Radiography of shoulder. **A.** Arthritis; **B.** Anterior shoulder dislocation; **C.** Calcific tendinitis; **D.** Clavicle fracture (*Courtesy:* Seeman. Consultant Radiologist, Coimbatore, Tamil Nadu).

Chronic Elbow Pain

Causes

- Fractures
- Dislocations
- Arthritis
- Chondral and osteochondral abnormalities
- Tendinitis
- Other soft tissue injuries and tumors.

Choice of Investigations

1. Initial investigation of choice in elbow pain is X-ray (Figs 4.3A to C). This reveals fractures, dislocations and arthritic changes.

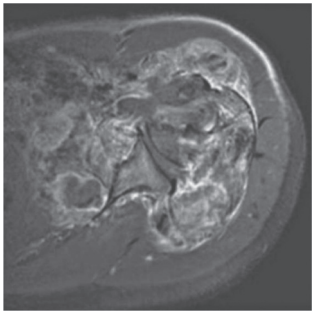


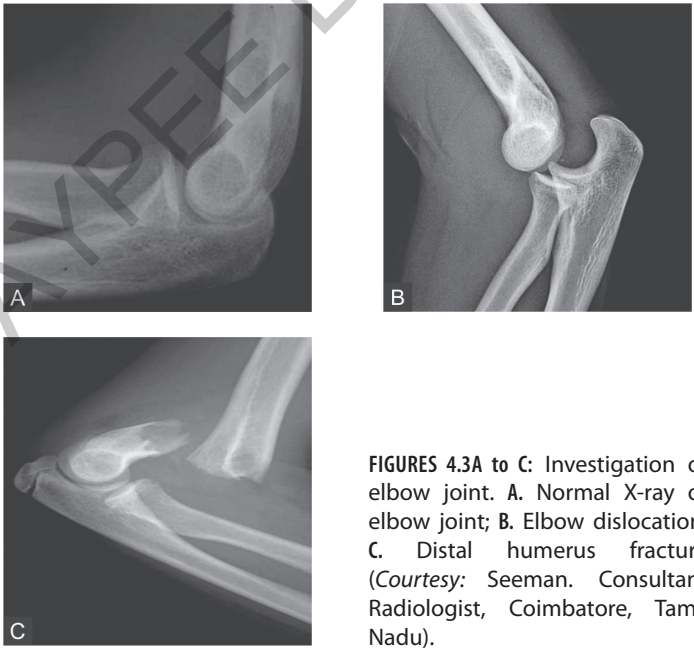
FIGURE 4.2: Magnetic resonance imaging of shoulder showing large soft tissue mass (*Courtesy:* Seeman. Consultant Radiologist, Coimbatore, Tamil Nadu).

2. If radiographs noncontributory or pain is persistent or there is significant pain, then next study is MRI without contrast. The MRI can detect radiographically occult bone abnormalities, chondral and osteochondral abnormalities and soft tissue lesions.
3. If MRI contraindicated, CT or US advised.
4. The US can detect soft tissue abnormalities.
5. The MRI or CT arthrography is helpful, especially for detecting intra-articular bodies.

Chronic Wrist Pain

Causes

- Fractures
- Dislocations
- Arthritis
- Tendinitis
- Other soft tissue injuries
- Tumors
- Carpal tunnel syndrome
- Ganglion cysts.



FIGURES 4.3A to C: Investigation of elbow joint. **A.** Normal X-ray of elbow joint; **B.** Elbow dislocation; **C.** Distal humerus fracture (*Courtesy:* Seeman. Consultant Radiologist, Coimbatore, Tamil Nadu).

Choice of Investigations

FIGURE 4.4: X-ray normal wrist (*Courtesy:* Seeman. Consultant Radiologist, Coimbatore, Tamil Nadu)

1. Initial investigation of choice in wrist pain is X-ray (Fig. 4.4).
2. If radiographs are noncontributory or pain is persistent, or there is significant pain next study is MRI without contrast; this can evaluate occult fractures, osseous and soft tissue structures of the wrist; MRI with contrast are given to differentiate inflammatory change from fluid and viable from non-viable tumor.
3. If MRI contraindicated—CT or US.
4. The CT is recommended for evaluating complex fractures and their follow-up as well as for distal radioulnar joint subluxation.
5. The US can be used to evaluate wrist ganglia, tenosynovitis and tendon rupture, but its role in the evaluation of ligamentous tears remains to be determined.
6. If carpal tunnel syndrome is suspected:
   a. X-ray wrist.
   b. The MRI wrist without contrast, if mass is suspected or symptoms recur postsurgery.
   c. Nerve conduction study.

LOWER LIMB

Chronic Hip Pain

Causes

- Fractures
- Dislocations
- Arthritis
- Other soft tissue injuries
- Tumors
- Acetabular dysplasia
- Adult hip dysplasia
- Avascular hip necrosis
- Trochanteric bursitis

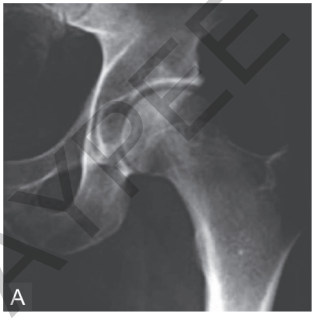
- Hamstring tear
- Synovitis
- Piriformis syndrome
- Nerve palsy—sciatic
- Osteoporosis.

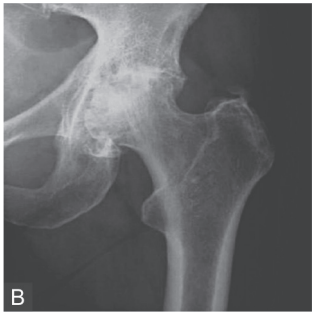
Clinical history and examination plays a very important role in patients with chronic hip pain.

Choice of Investigations

Initial evaluation for chronic hip pain is by radiography, i.e. pelvis and hip X-ray [anteroposterior (AP) and lateral views of the affected hip]. This helps in diagnosis of fractures, dislocations, arthritis, acetabular dysplasia, avascular necrosis of the hip, femoroacetabular impingement, osteoporosis and osteoid osteoma (Figs 4.5A to C).

If radiograph is negative, equivocal or nondiagnostic, then suspect osseous or surrounding soft tissue abnormality. MRI should be obtained as the next imaging study. Direct MRA should be performed, if acetabular labral tear is suspected. Contrast may be helpful in specific clinical situations such as differentiating subchondral fracture from osteonecrosis. Use of higher field MRI (3 Tesla) may obviate the need for intra-articular contrast. If MRI





FIGURES 4.5A to C: Investigation of hip joint. **A.** Normal hip joint; **B.** Avascular necrosis of hip; **C.** Osteoarthritis of hip joints (*Courtesy:* Seeman. Consultant Radiologist, Coimbatore, Tamil Nadu).

contraindicated, CT with or without contrast is asked and can evaluate complex fractures. The US imaging though not a very popular choice, can give a good picture of the pathology of the region subject to operator expertise.

Chronic Knee Pain

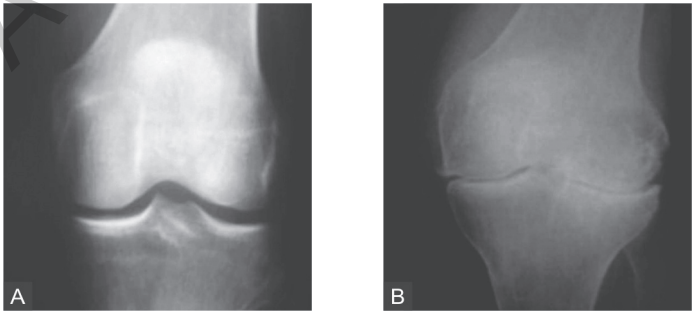
Causes

- Fractures
- Ligament tears
- Baker's cyst
- Arthritis
- Dislocation
- Cysts
- Osteonecrosis
- Tendon rupture/tendonitis
- Peroneal nerve palsy
- Popliteal artery injury
- Bursitis.

Choice of Investigations

The mandatory initial imaging examination for knee pain is AP and lateral radiography. For patients with anterior patellofemoral knee pain, an axial view should be included in the initial radiographic study. All bony abnormalities are well visualized (Figs 4.6A and B).

An MRI examination for knee pain is indicated when the pain is persistent and conventional radiographs are nondiagnostic or when additional information is necessary before instituting treatment or surgical intervention. MRI is diagnostic in meniscal



FIGURES 4.6A and B: Investigation of joint. **A.** Normal knee joint; **B.** Arthritic knee joint (*Courtesy:* Seeman. Consultant Radiologist, Coimbatore, Tamil Nadu).

and ligament tears. MRI arthrography with contrast, if internal derangement is suspected and also in cases of microfractures, osteochondritis dissecans or a loose body. If MRI cannot be done, CT arthrography is advised. The US imaging again though is not a very popular choice.

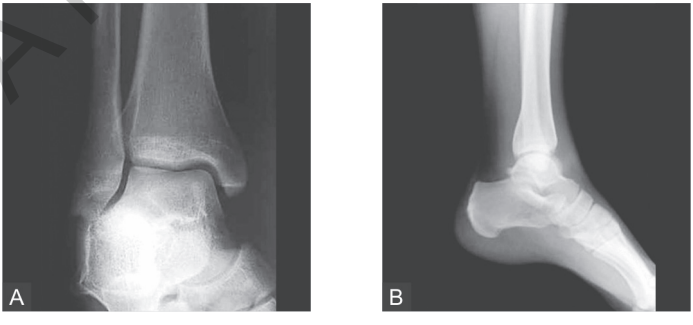
Chronic Ankle Pain

Causes

- Fractures
- Dislocations
- Arthritis
- Tendinitis
- Other soft tissue injuries
- Tumors.

Choice of Investigations

1. Initial evaluation of chronic ankle pain should begin with radiography.
2. If there is concern for focal soft-tissue abnormality, such as tendon or ligament abnormality, MRI or US may be considered; MRI is the imaging method that globally evaluates all structures of the ankle.
3. If there is concern for an intra-articular process such as osteochondral abnormality or ankle impingement; MRA may be used (Figs 4.7A and B).
4. If MRI contraindicated, CT without contrast.



FIGURES 4.7A and B: Investigation of ankle joint. **A.** Normal ankle joint; **B.** Arthritic joint (*Courtesy:* Seeman. Consultant Radiologist, Coimbatore, Tamil Nadu).

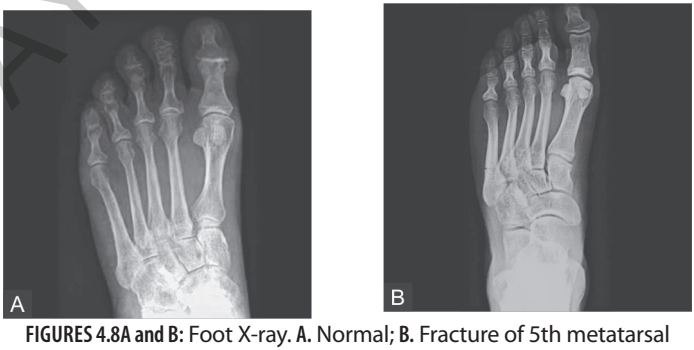
Chronic Foot Pain

Causes

- Fractures
- Arthritis
- Tendinitis
- Other soft tissue injuries and tumors
- Reflex sympathetic dystrophy
- Plantar fasciitis
- Tarsal tunnel syndrome
- Interdigital (Morton's) neuroma
- Tarsal coalition.

Choice of Investigations

1. Radiography is the initial study for imaging chronic foot pain (Figs 4.8A and B).
2. If the initial radiograph is equivocal or unremarkable and clinical concern warrants further imaging, MRI or US is indicated in evaluating for inflammatory arthropathy, plantar fasciitis, tarsal tunnel syndrome, interdigital (Morton's) neuroma, and/or tendonopathy.
3. Techmetium (Tc)-99m-labeled methylene diphosphonate (MDP) bone scan is the modality of choice for evaluating reflex sympathetic dystrophy (RSD).
4. The CT foot without contrast to rule out tarsal coalition, if X-ray is unremarkable.



FIGURES 4.8A and B: Foot X-ray. **A.** Normal; **B.** Fracture of 5th metatarsal (*Courtesy:* Seeman. Consultant Radiologist, Coimbatore, Tamil Nadu).

Spine

Causes

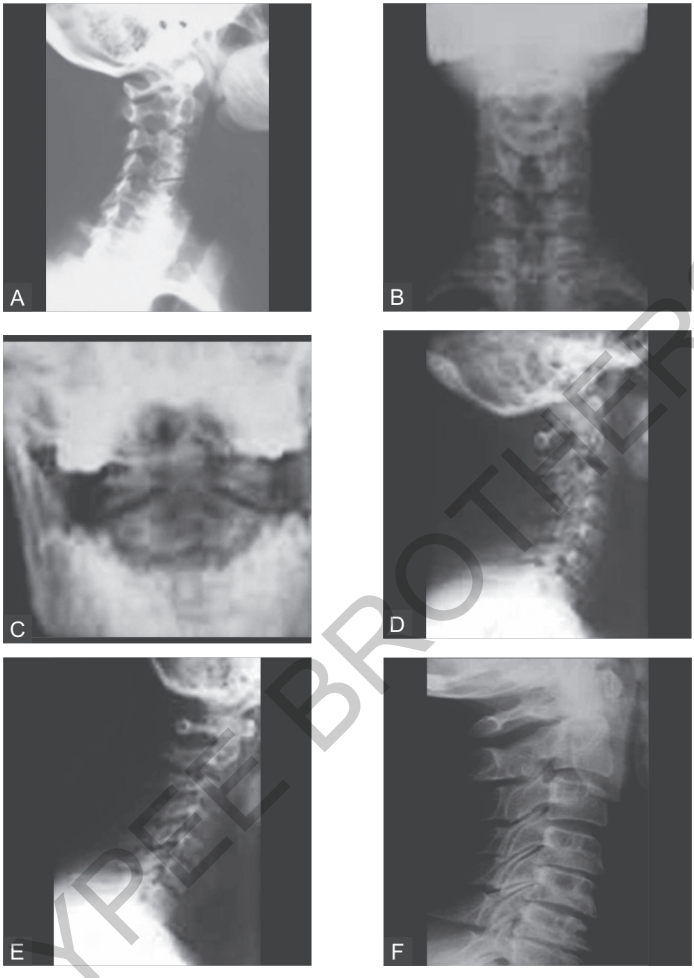
- Ankylosing spondylitis
- Fractures
- Osteoporosis
- Degenerative disk disease
- Spinal stenosis
- Paraspinal muscle spasm
- Facet dislocation
- Facet Arthritis
- Herniated disks
- Spondylosis
- Spondylolisthesis
- Coccydynia
- Tumors
- Infections
- Spinal cord injury and whiplash injury
- Syringomyelia
- Cauda equina syndrome
- Neuropraxia.

Chronic Neck Pain

Choice of Investigations (Figs 4.9A to F)

Patients of any age with chronic neck pain without or with a history of remote trauma or history of previous malignancy or history of neck surgery in the remote past should initially undergo a five view radiographic examination (AP, lateral, open mouth and both obliques). If radiographs show bone or disk margin destruction, MRI cervical spine without contrast is advised. Patients with normal radiographs and no neurologic signs or symptoms need no further imaging.

Patients with normal radiographs and neurologic signs or symptoms should undergo cervical MRI that includes the craniocervical junction (CCJ) and the upper thoracic region. If an epidural abscess is suspected, the examination should be performed with IV contrast. If there is a contraindication to the MRI examination, CT myelography with multiplanar reconstruction is recommended (Fig. 4.10).



FIGURES 4.9A to F: Investigation of neck. **A.** Normal lateral; **B.** Normal anteroposterior region; **C.** Normal open mouth view; **D.** Extension view; **E.** Flexion view; **F.** Cervical spondylosis (*Courtesy:* Seeman. Consultant Radiologist, Coimbatore, Tamil Nadu).

Low Back Pain

1. Acute uncomplicated low back pain (LBP) without red flags is a benign, self-limited condition that does not require imaging evaluation.
2. In complicated LBP, MRI is the initial imaging modality of choice. Red flags in low backache include suspected fracture (Figs 4.11A and B), muscle weakness, bowel and bladder disturbances, infections, neurologic deficits,

suspected malignancy. MRI without contrast is also indicated in low-velocity trauma, when injury is not explained by bony fracture. Other indications include osteoporosis (Figs 4.12A and B), prolonged symptom duration and age greater than 70 years.

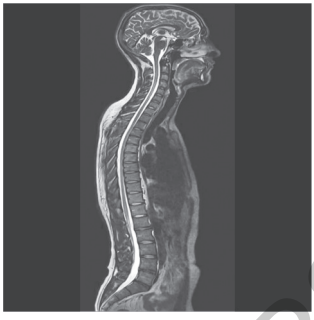
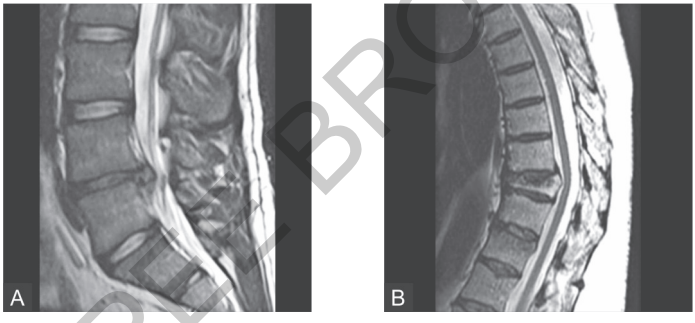
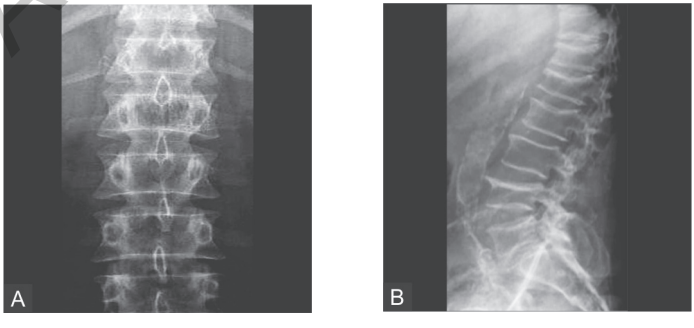


FIGURE 4.10: Whole spine (*Courtesy:* Seeman. Consultant Radiologist, Coimbatore, Tamil Nadu)

3. The MRI with contrast useful for neoplasia, infection, and post-operative evaluation preferred in oncology, infection, inflammation, and suspected vascular causes of myelopathy.



FIGURES 4.11A and B: Magnetic resonance imaging vertebral column. **A.** Disk prolapse; **B.** Vertebral compression fracture (*Courtesy:* Seeman. Consultant Radiologist, Coimbatore, Tamil Nadu).



FIGURES 4.12A and B: Lumbosacral spine. **A.** Normal; **B.** Osteoporotic (*Courtesy:* Seeman. Consultant Radiologist, Coimbatore, Tamil Nadu).

4. The CT without contrast is useful in patients with suspected spinal trauma, bony structural abnormalities postsurgery and in those patients with contraindications to MRI.
5. X-ray spine may be first test in multisystem trauma to assess stability, especially when CT is delayed.

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Handbook of
Pain Management in Practice

Salient Features

- Provides practical guidance in management of pain
- Designed to meet the requirements of general practitioners and also that of budding pain physicians
- Covers a gamut of topics related to pain
- Chapters are crisp, brief and written in simple language
- Text has a number of flowcharts and tables, making it easier to read and retain
- Emphasis is given to clinical aspects in management of pain
- Easy-to-read yet comprehensive
- For each chapter discussed, a number of references are provided
- Can be used as a textbook in pain courses.

Sree Ranjani S MBBS DA DNB (Anesthesiology) FIPM was graduated from Government Medical College, Ballari (presently, Vijayanagar Institute of Medical Sciences, Ballari, Karnataka, India). She did her Diploma in Anesthesia from MGM Medical College, Mumbai, Maharashtra, India, followed by Diplomate of National Board from Apollo Hospitals, Chennai, Tamil Nadu, India. She developed an avid interest in pain management during her tenure at Apollo Hospitals and hence took up a Fellowship in Interventional Pain Management at DARADIA: The Pain Clinic, affiliated to Aesculap Academy of Germany, under the guidance of *Dr Gautam Das—the Stalwart of Pain Management in India*. She was the batch topper. She has many academic distinctions to her credit. Her research papers presented at various conferences, national as well as zonal, have won the best paper awards and published in journals. She is also the winner of KOPS Award at the Annual National Conference of Indian Society of Anaesthesiologists, conducted at Visakhapatnam, Andhra Pradesh, India, in 2007. She has been part of the faculty, which conducted a workshop on Ultrasound Guided Nerve Blocks for the delegates of ISSPCON—23rd Annual Conference of Indian Society for Study of Pain, conducted at Vellore, Tamil Nadu, in 2008, and a workshop on Interventional Pain Management for the delegates of Neurology Update—International Neurology Conference, conducted at Chennai in 2012.

She is at present working as a Consultant in Anesthesiology and Pain Medicine, and Managing Director of Sankara Kidney Hospital in Chennai. She is also an Assistant Professor, Department of Anesthesiology at Tagore Medical College and Hospital, Chennai.

Cancer pain management and palliative care being her areas of interest, she hopes to do more for the terminally ill, in terms of reduction in pain and better quality of life. Pain relief is the basic right of every patient and she hopes to attain that by educating the primary care physicians and pain practitioners through this book.

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ISBN 978-93-5250-000-0