RADIOLOGY &
Diagnostic Principles

Prepared by

PROF. AHMED FARID YOUSIF

Professor of Radiology

Benha Faculty of Medicine

Dr. Shaimaa Fathy

MD of Radiodiagnosis

Second Year

2018/2019

Acknowledgments

This two-year curriculum was developed through a participatory and collaborative approach between the Academic faculty staff affiliated to Egyptian Universities as Alexandria University, Ain Shams University, Cairo University , Mansoura University, Al-Azhar University, Tanta University, Beni Souef University , Port Said University, Suez Canal University and MTI University and the Ministry of Health and Population(General Directorate of Technical Health Education (THE). The design of this course draws on rich discussions through workshops. The outcome of the workshop was course specification with Indented learning outcomes and the course contents, which served as a guide to the initial design.

We would like to thank **Prof.Sabah Al- Sharkawi** the General Coordinator of General Directorate of Technical Health Education, **Dr. Azza Dosoky** the Head of Central Administration of HR Development, **Dr. Seada Farghly** the General Director of THE and all share persons working at General Administration of the THE for their time and critical feedback during the development of this course.

Special thanks to the **Minister of Health and Population Dr. Hala Zayed and Former Minister of Health Prof. Ahmed Emad Eldeen Rady** for their decision to recognize and professionalize health education by issuing a decree to develop and strengthen the technical health education curriculum for pre-service training within the technical health institutes.

توصيف المقرر

1- بيانات المقرر		
الرمز الكودى :	اسم المقرر :الاشعة و مبادئ التشخيص **Radiology and diagnostic principles**	الفرقة /المستوى :الثانية
التخصص :	عدد الوحدات الدراسية : نظرى 2 عملى 2	

2- Overall Aim of Course: 2 هدف المقرر:	- Recognize the role of different images modalities in the diagnosis of musculoskeletal disease - Learn how to select the proper image modalities for each musculoskeletal lesion
3- Intended learning outcomes of the course (ILOs): 3-المستهدف من تدريس المقرر	
1. Knowledge and Understanding: ا. المعلومات والمفاهيم :	**Upon successful completion of this course the students will be able to:** a1- Define the history of radiology & its course of development. a2- Recognize the role of photographer a3- Describe the principle of x ray. a4- Describe the Principle of ultrasound a5- Describe the principle of computed tomography a6- Identify the principle of fluoroscopy a7- Identify the principle of magnetic resonance images a8- Identify the different image modalities used on the diagnosis of musculoskeletal disease
2. Intellectual Skills: ب- المهارات الذهنية :	b1- Differentiate between the principle of different image modalities. - B2- Select the proper image modalities for each musculoskeletal lesion
3. Professional Skills:	c1- Use how to deal with different image modalities according to its principle and importance on the diagnosis

ج- المهارات المهنية الخاصة بالمقرر:	of musculoskeletal disease
4. General and Transferable Skills: د- المهارات العامة :	D.1- Communicate effectively with colleagues, staff members and helping personnel. D.2- Demonstrate appropriate professional attitude and behavior in different situations. D.3-Practice independent learning by using information technology tools. D.4-Evaluate information from various standard sources to improve professional skills.
4- Course content 4- محتوى المقرر:	1. History of radiology 2. Principle of different image modalities including: **i.** X ray **ii.** Fluoroscopy **iii.** Computed tomography **iv.** Ultrasound **v.** Magnetic resonance images
5- Teaching and Learning Methods: 5- أساليب التعليم والتعلم	1. Lectures. 2. Group discussions. 3. Problem solving and case presentation 4. Practical sessions.
6- Teaching and learning methods for students with limited abilities 6- أساليب التعليم والتعلم للطلاب ذوى القدرات المحدودة	
7- Student Assessment: 7- تقويم الطلاب :	
a- Assessment methods: أ- الأساليب المستخدمة	a. Class work: 1. Quiz 2. Practical exam 3. Assignments 4. Clinical Participation

	b. Final exam: Theoretical and practical.
b- Assessment schedule: ب- التوقيت	a. Class work: 1. Quiz (5th week) 2. Midterm (7th week) b. Final exam Practical exam (13th week) written exam (15th week)
C-Weight of Assessments: ج- توزيع الدرجات	Quiz : 3 mark Midterm: 5 marks Attendance 2 marks Clinical: 10 marks Final written theoretical exam 80 marks. **Total percentage 100 mark**
7- List of References: 8- قائمة الكتب الدراسية والمراجع :	
a- **Course notes:** أ- مذكرات	Lectures history of radiology
b- **Essential books (text books)** ب- كتب ملزمة	The History of Radiology(Adrian M. K. Thomas and Arpan K. Banerjee) Oxford Medical Histories 2014
c- **Recommended books** ج- كتب مقترحة	Radiology: An Illustrated History

CONTENT

Course description
Chapter 1:
Radiology &Diagnostic image technique:

Chapter 2:
Musculoskeletal images
Role of:

Course description

The course include what the student should know about radiology history, basic principle of radiology modalities, the role of different images modalities on the diagnosis of musculoskeletal disease and finally the radiological principle on musculoskeletal diseases.

Core knowledge

By the end of this course the student will be able to:

- Define the history of radiology & its course of development.
- Recognize the role of photographer
- Describe the principle of x ray.
- Describe the Principle of ultrasound
- Describe the principle of computed tomography
- Describe the principle of fluoroscopy
- Describe the principle of magnetic resonance images
- Recognize the role of different imge modalities on the diagnosis of musculoskeletal diseases

Core skills

By the end of this course the student will be able to:

- Differentiated the images modalities according to its physical principle.
- Select the proper modalities for diagnosis of different entities of musculoskeletal disease.

Course Overview

Topics	Interactive lecture	Clinical skills
Radiology history & Role of radiographer	2 hours	2 hours
Principle of x ray	2 hours	2 hours
Principle of ultrasound	2 hours	2 hours
Revision and quiz	2 hours	2 hours
Principle of fluoroscopy & Principle of computed tomography	2 hours	2 hours
Principle of magnetic resonance images & Bone & whole body scintigraphy	2 hours	2 hours
Revision & quiz	2 hours	2 hours
Role of x ray & CT on musculoskeletal disease	2 hours	2 hours
Role of MRI and ultrasound on musculoskeletal disease	2 hours	2 hours
Bone scientigraphy	2 hours	2 hours
Musculoskeletal trauma& tumor by radiology	2 hours	2 hours
Arthritis and metabolic bone disease by radiology	2 hours	2 hours
Revision	2 hours	2 hours
Total hours	26 hours	26 hours

Chapter 1

Objectives:

- Recognize the history of radiology
- Defined the basic principle of x ray
- Describe the Principle of ultrasound
- Describe the principle of computed tomography
- Describe the principle of fluoroscopy
- Describe the principle of magnetic resonance images

Radiology

Radiology is a branch of medicine that uses medical imaging techniques. When the science began to be limited to the use of X - ray devices
Interventional Radiology is a new branch of this science, and the Army is concerned with some medical interventions

History of Radiology

Radiology began with the discovery of the German scientist Wilhelm Röntgen for X rays, in 1895, and the world was awarded the Nobel Prize in physics in 1905.
In the early decades of radiation detection, I did not realize the risk of radiation exposure to technicians and doctors. Many of the early radiologists were diagnosed with various cancers of the skin, bone and thyroid, as well as cataract and leukemia. At present, all workers are monitored continuously and monthly.

Radiologist

The radiologist works on diagnostic or therapeutic radiology devices, through which he contributes to the diagnosis of various diseases, and is used in the treatment of some types, such as tumors and cancers.
The radiologist works on the following devices:
X-ray machine
CT scan computed tomography
Magnetic Resonance System M.R.I
Cobalt device 60

Gamma Camera Device
Ultrasonic device

Diagnostic imaging techniques

Axial tomography (X-ray)

X-ray or X-ray is an electromagnetic ray of wavelength (between 10 and 0.01 nm), that is, its energy is between 120 and 120 thousand electron volts. It is widely used in radiography and in many technical and scientific fields.

X-ray discovery

William Roentgen, an X-ray discoverer, has shed an electronic beam inside a glass tube with high electrical tension between the ends. This tube was discharged from the air and electrons from a negative electrode went into a positive electrode. This tube is surrounded by light colored paper to protect the user from the emitted electromagnetic field. A phosphoric screen was placed at the end of the tube. When the electronic beam collided with it, this screen began to glow. When Richard Roentgen accidentally put his hand between the tube and the phosphoric screen, he saw a picture of his hand on the screen, this was the first X- ray picture.

Radiography (originally called radentgen), which is named after Wilhelm Conrad Röntgen, the X-ray detector, is produced by x-ray transmission across the patient. X-rays are projected across the body on the detector. An image is formed based on which rays pass through (and are detected) versus those that are absorbed or dispersed in the patient (and thus are not detected). Roentgen discovered X-rays on November 8, 1895, and received his first Nobel Prize in Physics for discovery in 1901.

In the radiography of the screen, the X-ray tube generates an x-ray beam that targets the patient. X-rays that pass through the patient are filtered through a device called the network or X-ray filter; to reduce dispersion, and to infect an unfinished film, which is firmly attached to a screen of phosphorus that emits light in a light cassette.

The film is then chemically developed, the movie. Radiography is replaced with phosphorylation but recently by digital radiography (DR) and EOS imaging.

In the newer systems X-ray sensors that convert generated signals into digital information are transferred and converted to a picture displayed on the computer screen.

In digital radiography, the sensors form a plate, but in the EOS system, a scanning system for the opening, a linear sensor scans the patient vertically.

Normal radiography (x-ray) was the only imaging technique available during the first 50 years of radiation. Because of their availability, speed and low cost compared to other methods, radiography is often the first line test for choice in radiological diagnosis.

Also despite the vast amount of data in CT, magnetic resonance imaging and other digital imaging, there are many pathological entities in which the classical diagnosis is obtained by regular x-rays. Examples include different types of arthritis, pneumonia, bone tumors (especially benign bone tumors), fractures, congenital structural abnormalities, etc.

Mammography and DXA are applications of low-energy radiography, used to assess breast cancer and osteoporosis.

Indication

Radiology in medicine to detect teeth and bones and fractures and locate the objects such as solid fragments or bullets in the body, as well as the detection of tumors in the body, possibility to see the fractures of bone with high accuracy, where these rays penetrate the soft bodies such as the skin but cannot Traffic through the bones, leading to the emergence of a recent image.

The most important characteristic is the lack of collateral damage

Doctors also use these rays to treat and eliminate malignant tumors. X-rays kill cancer cells, and healthy body cells regain their vitality after a short period of time and return healthy

X-rays were also used in industry to detect the cracks in the metal molds and wood used in the craft industry. The study of the absorption spectra of the radiation in the material helped to make X-rays a way to detect and analyze the elements involved in the composition of different materials. In this case, x-rays that characterize each chemical element are used. It has been possible to measure the thickness of the solids and the survey of industrial parts in search of defects that cannot be observed by the naked eye by

In the field of security, X-rays are used to monitor travelers' baggage at airports for weapons or bombs

In the study of solid objects, that using X-ray diffraction showed that there is a certain symmetry in some types of solids (crystals) and this was the beginning of a huge breakthrough in the study of properties of solid and crystalline structure, and knowledge of the atomic structure of the elements

In the field of art, it was used to identify painterly methods and to distinguish between real paintings and counterfeit paintings, because the colors used in the old paintings contain many metal compounds that absorb X-rays. The colors used in modern paintings are organic compounds that absorb X-rays less

.

X-ray disadvantage:

X-rays belong to ionizing radiation. Which caused the ionization of the medium through which the separation of some electrons in the atoms and molecules. They can cause changes in living cells that may lead to cancer. Therefore, governments shall establish instructions and regulations concerning the use of X-rays, whether in medicine or in industry, and shall observe the instructions and punish those who violate the instructions in accordance with the laws established in this regard

X-rays are also used to fight cancer in the way X-rays are focused on cancer cells. DNA is a highly deoxyribonucleic acid in living organisms that is highly sensitive to x-rays, and is increasingly damaged by increased absorption of radiation. That is to say, exposure to a small dose of radiation, however small, is the possibility of turning one of the living cells into a cancer cell. The risk of cancer is therefore taken into account when X-rays are used in diagnosis or treatment

In general, women should not be exposed to X-rays on the body, and must be very careful to use on children, and may cause infertility in men and women if exposed to reproductive organs.

Fluoroscopy (Fluoroscopy)

X-ray radiography and vascular imaging are special X-ray applications where the fluorescent and image magnification are connected to a closed circuit television system. This allows for real-time imaging of moving structures or increased radioactivity. Radioactive radiation agents are usually given by swallowing or injecting into the patient's body to diagnose the dissection of the blood vessels, reproductive system or gastrointestinal tract.

There are now two radio signal devices in common use. Barium Sulphate ($BaSO_4$) is given orally or in a straight line to assess the digestive system. Iodine, in multiple forms of ownership, is given by mouth, rectum, vagina or intra-arterial or intravenous routes.

These radiation factors strongly tolerate or dispersion of x-rays, and in conjunction with real-time imaging, allows for the presentation of dynamic processes, such as peristalsis in the gastrointestinal tract or blood flow in the arteries and veins.

The variation in iodine may also be concentrated in abnormal areas more or less than the normal tissues and more pronounced deformities (tumors, abscesses, inflammation) occur.

In addition, under certain conditions air can be used as a contrast agent for the digestive system and carbon dioxide can be used as a contrast agent in the venous system. In these cases, the contrast factor reduces X-ray less than the surrounding tissue.

Computed Tomography

X-ray tomography is used with computing algorithms to photograph the body.
In a CT scan, the x-ray tube opposite the x-ray detector (or detectors) flows into a ring-shaped device around the patient, resulting in a computer-generated tomography (tomogram).

CT scans are obtained in the axial plane, with coronal and soft images produced by the computer reconstruction.

Radiation factors are often used with computed tomography (CT) for improved autopsy. Although radiographs provide higher spatial resolution, CT scans can detect more subtle variations in x-ray attenuation (higher contrast resolution).
CT scans expose the patient to much more ionized radiation than radiography.

The multidetectors spiral CT use 16, 32, 64, up to 320 or more detectors during continuous motion of the patient through the beam of radiation to obtain accurate images in a short time for testing.
With the rapid management of venous contrast during CT, these detailed images can be reconstructed in three-dimensional (three-dimensional) images of the carotid, cerebral, coronary or other arteries.

The introduction of CT in the early 1970s led to a revolution in diagnostic radiology by providing doctors with real anatomical 3D images. CT has become a test in the selection of some urgent and emergency cases, such as cerebral hemorrhage, pulmonary embolism (pulmonary embolism), aortic dissection (appendicitis), appendicitis, spleen, kidney blockage stones.

Continuous improvements in CT technology, including scanning speed and improved accuracy, have increased the accuracy and usefulness of the CT scan, which may partially explain the increased use of medical diagnostics.

Characterization of CT

There are many characteristics that make this method of scanning better than other methods of medical scanning.

First, CT can show a clear picture of a member being photographed without showing the members around him. For example, when the lungs are photographed, the heart or viscera does not appear in the picture.

Second, the chromatic contrast between the tissues in the picture helps doctors know the difference in mass density. In addition, this mechanism can produce high-quality images without producing a large amount of radiation. What distinguishes this mechanism is the need not to put any gas or device directly within the body as in the catheter

How long does this examination take

The modern CT cameras allow us to get the pictures in a matter of minutes. If intravenous injection of colored material is required, this will require an additional time of not more than a few minutes and usually the duration of the test is between 15-20 minutes

Usage

The use of CT has increased over the past two decades. In 1980, only 3 million CT scans were performed on patients. In 2007, approximately 70 million CT scans were performed in the United States. Approximately 6% of the imaging operations were performed on children.

This great turnout is not only in America, but in most countries of the world. The main reason is that most physicians prefer to have a CT scan of patients who are admitted to the hospital to assess their health status accurately. One of the main reasons why photography is so common is its ease and speed. The process of photography alone takes a few minutes.

How photography works

The X-ray device circulates around the section to be photographed, and sensors or receptors receive radiation at the opposite end of the circuit. These receptors contained Xeon gas but were later replaced by more efficient receptors.

The old imaging equipment would move the object, which is slightly photographed after the X-ray device is in full cycle, and the new devices allow the body to move while the source of the source of radiation around it. CT is used in medicine as a diagnostic tool especially before surgery. Images taken must be processed before obtaining high-resolution cross-sectional images of the photographed person

How to print the image

Pixel is a point of a certain color in the two-dimensional image resulting from CT. Foxel is like a pixel but in a 3D image. Color pixels or pixels depend on X-ray permeability across the tissues being photographed.

One transmittance is the Honsfield unit. The more permeable tissue is given the value of 3070 units of Honsfield, the least permeable-1024 Honsfield unit.

When images are printed, tissues with more than 80 Honsfield permeability are shown in white, tissue with a permeability of less than 0 Honsfield is shown in black, and tissues with a range of between 0 and 80 Honsfield units appear in gray, the range of grayscale is related to permeability . Also, when printing the picture appears upside down, the left part of the image represents the right part of the patient, and vice versa

Pre-imaging preparations

Before starting the imaging process there are many procedures to take. First, the patient should tell the doctor if he is allergic to certain substances because he will be injected with a contrasting substance.

Second, the patient should tell the doctor if he or she has previous heart disorders, asthma or other illnesses because these diseases may increase the side effects of x-rays.

Third, the patient should stop eating several hours before the examination. It is preferable to wear comfortable and wide clothing prior to CT.

Finally, the patient is required to take off jewelry, ornaments, shoes and pins as they may adversely affect the examination.

How to do CT scan

The patient will be asked to lie down on a solid, moving table. Then, by moving the mobile table, the part of the body is placed in a donut-like device.

The patient will be asked to stay still as less movement may affect image quality. The imaging technician may ask him to lock himself up to preserve the image quality.

Throughout the examination, the imaging technician monitors the patient through a small window. There is also an internal communication device that allows the patient to communicate with the photographer. At the end of the examination, the patient can return immediately to follow up his normal work

.

Sometimes a CT specialist may decide to give the patient a venereal injection of dye to illustrate what is seen in the pictures. The imaging technician then puts a venous needle to inject the dye. When injected, the patient may feel a general feeling of warmth and a metallic taste in his mouth. In some cases of gastrointestinal (gastrointestinal) imaging, another type of dye may be requested by drinking to obtain a more accurate diagnosis as appropriate. This dye is drunk before the examination for an hour to four hours according to its type

Cross-sectional images

The two-dimensional images are often collected and processed by special software to obtain 3D images. For example, when photographing the spine, the two-dimensional picture shows only one vertebra of the spine. The three-dimensional image shows the position of the paragraph relative to the surrounding vertebrae, as well as the cartilages that link the paragraphs to each other. After processing the resulting image, the colors are added to it to make it easier to distinguish between different members. The aim of these images is to help doctors when performing surgeries. Members close to the viewer are usually semi-transparent until they are done After processing the resulting image, the colors are added to it to make it easier to distinguish between different members. The aim of these images is to help doctors when performing surgeries. Members close to the viewer are usually semi-transparent so they can see the other half of the image.

Negative effects of computed tomography

The radiographs used in tomography damage cells in the body and nucleic acids, which causes various cancers. The CT scan used to diagnose cancer tumors may cause cancer. The amount of radiation produced by these devices exceeds the amount of x-ray produced more than 1,000 times.

Too many patients are subject to imaging too much, which increases their risk of cancer. Scientists estimate that about 5% of cancers in the future will be caused by medical imaging of all kinds. The risk of cancer varies according to the age of the person. The amount of radiation produced can be reduced when children are photographed to protect them as children are more likely to develop cancer than adults. Although CT has side effects, it cannot be dispensed with or replaced by other imaging methods

Generations Scanning System

Cross-sectional scanning devices are classified into several generations according to the evolution of the scanning mechanism, its speed and the time it takes to form the image:

First generation

The first generation of CT scanners uses a beam of pencil thickness directed to the body and is monitored by only one or two detectors. The images are collected through a rotary and transitional scan where the source of the X-ray and the detector are installed in a device called the gantry and rotate to each other so that the human body in the axis of rotation for them, and the duration of the image is about 4 minutes where the Gantry has a full 360 degree The gantry then moves to clear another part of the human body, and the use of this generation requires immersion of the patient's body in a water basin to reduce its exposure to X-rays

Second generation

The scanning device was developed so that the number of reagents increased and the x-ray beam became more extensive to cover the corresponding reagents. The scanning method is still similar to the scanning method used in the first generation. It is by circular and transient scanning around the human body, increasing the number of reagents, the scanning cycle for each section of the body covers 180 degrees by moving 30 degrees instead of one degree as in the first generation, thus reducing the scanning time

Third generation

There has been a marked improvement in the third generation in terms of speed in obtaining the image, by canceling the transition movement and make the movement circular only, making the survey time only one second. To eliminate transient movement during third-generation scanning, reagents that monitor X-rays from the human body are designed in the form of an arch, maintaining a fixed distance between the X-ray source and the reagents during rotation. Patient and X-ray barriers were added between the patient and the reagents to ensure a thin beam of X-ray that is carried out to the human body, thereby reducing its exposure to radiation

The fourth generation

Is similar to the third generation in terms of scanning with circular motion only, and the addition of the detectors that were installed on the entire perimeter of the Gantry, which has 1000 detectors, making the movement limited to the source of X-ray only with the stability of reagents because it surrounds the entire Gantry. This design make scanning a full section of the body does not take more than one second, and in this way the device has been photographed using X-ray each region.

Ultrasound

Medical ultrasound imaging uses ultrasound (high frequency sound waves) to visualize soft tissue structures in the body in real time. The ultrasonic imaging technique is based on the projection of a sound package and the reflection of the reflector from the organ, forming an image ranging from black to white due to the difference of acoustic resistance between the tissues of the body, so that the tissue shows high resistance white and non-resistant tissues black.

There is no ionizing radiation, but the quality of the images obtained by ultrasound depends largely on the person's skill (ultrasound) that performs the examination and the size of the patient's body.

Larger patients with extra weight may be low in image quality because subcutaneous fat absorbs more sound waves. This results in fewer sound waves that penetrate the devices and return to the power adapter, resulting in loss of information and a lower quality image.

Ultrasound is also limited because it cannot take pictures through the air pockets (lungs, bowel rings) or bones. Its use in medical imaging has evolved in the past 30 years.

Ultrasonic device components

Ultrasonic Imaging System
SIP
Display Screen
Control Panel
CD player
Storage unit
Printer

Definition of the probe (US-Transducer)

The sensor is a device used to convert the electrical energy of the sound energy to send it in the form of pulse PW or continuous pulse PW, and on the contrary receives this sound energy reflected from the tissues of the body in the form of waves to convert the electrical energy and sends to the camera in the form of electrical pulses to be processed and analyzed There are different types and shapes vary depending on the use and there are multi-frequency types. Based on the above, we find that the sensor is the most important part of the ultrasound

Types of probe

Linear probe

The probe uses several different shapes and features to suit the imaging of many parts of the body, including: # Linear probe: uses a high frequency sound 7 MHz Hertz, produces parallel linear sound waves to photograph the surface parts of the body such as thyroid

Curved probe:

Frequency of sound waves used from 2 - 5 MHz to be able to enter deeper areas of the body as members of the abdominal region of liver and kidney

The probe used for three-dimensional imaging: -

The wave frequency is between 1-3 MHz, which shoots in two different directions at high quality at the same time, or stereoscopic images of the body or fetal organs at the same The first ultrasound images were fixed and 2D, but with modern ultrasound, real-time 3D reconstruction can be seen as "4D" effectively.

Since ultrasound techniques do not use ionizing radiation to create images (other than radiography and tomography), they are generally considered safer and are therefore more common in photodetector imaging.

The progress of the load can be accurately assessed with less concern about the damage caused by the techniques used, allowing the detection and diagnosis of many fetal anomalies.

Growth can be assessed over time, which is important in patients with chronic disease or pregnancy-related illnesses, and in multiple pregnancies (twins, triplets, etc.).

The Doppler ultrasound measures the flow of color from the severity of peripheral vascular disease and is used by cardiologists to dynamically evaluate the heart, heart valves and major vessels. Stenosis, for example, of carotid arteries may be a warning sign for impending stroke. A submerged clot can be found in one of the inner veins of the legs via ultrasound before it is excreted and travels to the lungs, leading to possible pulmonary embolism.

Ultrasound is useful as a guide to the performance of biopsies to minimize damage to surrounding tissues and to discharges such as thrombosis. Small and portable ultrasound devices replace the peritoneal membrane in the trauma wards through a non-surgical evaluation of internal bleeding and any internal organ damage. Comprehensive internal bleeding or injury in the main organs may require surgery and repair.

Principle of ultrasound work

When connecting the ultrasonic device with electricity will pass the electric current to the crystals of the component of the probe, which leads to vibration, creating a so-called "piezoelectric" electrode, depending on the pressure. Ultrasonic waves are produced as a result of the pressure that leads to the expansion and contraction of the crystals after the passage of electricity at a frequency between 2-15 MHz and pass through the body and pass one of these interactions with the body's internal tissues:

Mitigation: Reduce the intensity of waves

Refraction: Change in direction and speed of waves

Magnetic Resonance images

Magnetic resonance imaging (MRI) uses strong magnetic fields to align atomic nuclei (usually hydrogen protons) within the tissues of the body, then uses a radio signal to disturb the spin axis of these nuclei and notes the RF signal from the nucleus's return to baseline states.

Radio signals are collected by small antennas called coils, placed near the area of interest. The MRI feature is its ability to produce images in axial, ellipsoid, sagittal, and many oblique planes with equal ease.

Magnetic resonance imaging (MRI) gives the best contrast to soft tissue between all imaging modalities. With advances in scanning speed and spatial space, improvements in computer algorithms and 3D devices, MRI has become an important radiology tool in diagnosis of soft tissue lesions.

One disadvantage is that the patient must remain steadfast for long periods of time in a tight, noisy place during imaging. Indoor fear (claustrophobia) has been reported to be severe enough to terminate the MRI scan in up to 5% of patients.

Recent improvements in magnet design including stronger magnetic fields (9 teslas), shortening test times, shorter and shorter magnet arcs and more open magnetic designs, have led to some comfort for patients suffering from indoor fear. However, for magnets with equivalent field strength, there is often a tradeoff between image quality and open design.

Magnetic resonance imaging (MRI) has great utility in imaging the brain, spine and musculoskeletal system.

Magnetic resonance imaging (MRI) is not currently used for patients with pacemakers, industrial cochlea implantation, some sedative pumps; certain types of cerebral vasodilation, metal fragments in the eye and some metal devices due to strong magnetic fields and strong, open.

Areas of potential advancement include functional imaging, magnetic resonance imaging, cardiovascular and magnetic resonance imaging

Magnetic Resonance System

There are many different types today with many ideas for MRI, in general there are three main types of MRI:

- Permanent

- Resistant
- And resistance

The MRI device generally contains a part that gives a strong magnetic field & part emits the radio waves to stimulate the protons and picks up the signals coming from them & the stratified system part

The survey used in medical fields costs one million dollars per Tesla and several hundred thousand dollars are spent annually in maintenance.

Computers are used primarily in MRI tests and advanced programs that effectively help to give the best results.

Uses of Magnetic Resonance

Use of magnetic resonance imaging is for diagnostic purposes such as imaging of veins and arteries, or imaging of neurological changes in the brain, and MRI is considered the best imaging in clarifying tissues and body fluids, as well as used to plan treatment plans based on radiation therapy. Before magnetic resonance imaging, the history of the disease should be reviewed and the complete absence of previous surgery or accidents leading to the presence of minerals in the body such as shrapnel is confirmed. This is confirmed by routine general radiography and passage of the patient through a metal detector. The patient usually gives a special dye injected into the body to increase contrast and clarify the close parts.

Chapter 2

Objective:

Diagnostic image modalities used in musculoskeletal system including:

- Routine radiograph
- Computed tomography
- Ultrasound
- Computed tomography
- Magnetic resonance images
- Bone scan

Defined the radiological criteria of

- Bone trauma
- Bone tumor
- Arthritis
- Metabolic bone disease

Diagnostic Imaging Modality in Musculoskeletal Diagnosis

Routine radiographs are the first imaging modality of nearly all musculoskeletal disorders.
Magnetic resonance imaging (MRI) is highly sensitive to fractures and soft tissue injuries.
Computed tomography is superior to MRI for fracture characterization, particularly involving bones of the hand or the hook of the hamate in the wrist.
Magnetic resonance arthrogram is recommended for intra-articular disorders such as an injury to the triangular fibrocartilage complex in the wrist, the glenoid labrum in the shoulder, or the acetabular labrum of the hip.

Routine Radiographs

Routine radiographs should almost always be performed as the initial imaging modality for musculoskeletal injuries.
The resolution of osseous anatomy is superior to that of soft tissues.

Radiographs often yield a diagnosis or aid in appropriate selection and interpretation of advanced imaging, particularly with magnetic resonance imaging (MRI).

A minimum of 2 radiography projections taken at right angles to each other of the body part of interest are necessary for evaluation.

A 3-view radiographic evaluation is recommended for distal extremities in the setting of trauma, because prior studies have shown that up to 6.7% of fractures are only detected on the oblique view and would otherwise have been missed.

Certain joints require specific views to depict abnormalities on radiographs In addition, fluoroscopic positioned spot views can be used to avoid bony overlap in certain cases.

The sensitivity of routine radiographs varies depending on the mineralization of the bone involved, the specific disorders, and the chronicity of the disorders.

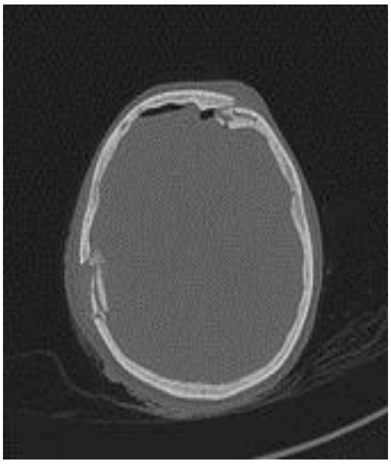
Computed Tomography

Computed tomography (CT) uses a rotating x-ray source that is reformatted to a cross- sectional image using a computer processor.

CT is superior to routine radiographs for evaluating the complex structures of the axial skeleton, the osseous structures of the foot, ankle, pelvis, shoulder, wrist, and hand.

CT is superior to radiography in showing subtle cortical bone injury. Specific CT reformatting techniques are often performed for surgical planning

Indications of CT is to detect Fracture, cortical bone injury



Magnetic resonance images (MRI)

MRI uses a fixed or superconducting magnet that creates a strong magnetic field.

The field strength is typically between 1.5 T and 3 T, but may be lower in an open MRI scanner.

MRI is optimal to evaluate soft tissue, occult fractures, articular cartilage, masses, marrow abnormalities, synovitis, and infectious processes.

MRI is the most sensitive modality for detecting fractures and is recommended if there is clinical suspicion for fracture and radiographs are negative.

MRI indication is to Soft tissue mass, vascular disease, ligament/tendon injuries, fracture, osteonecrosis, articular disorders, abnormal cartilage, effusion, foreign bodies, guidance for injection

Ultrasound

Ultrasound uses high-frequency sound waves directed into musculoskeletal structures.

Each tissue comprising the musculoskeletal system varies in density and its ability to transmit and reflect sound waves. The reflected sound waves are converted into an image.

Similar to MRI, the image quality depends on the frequency and type of the transducer.

In addition, clinical expertise with ultrasound varies and can affect the sensitivity and specificity of ultrasound for evaluation of various injuries.

Ultrasound may be used to evaluate masses in soft tissues, vasculature, ligaments, tendons, bone, cartilage, effusions, and foreign bodies

Bone Scan (Scientigraphy)

Bone scans detect changes in the skeleton's level of bone formation by using an intravenously administered radiopharmaceutical that binds to the hydroxyapatite crystals in the bone matrix proportionately to local blood flow and osteoblastic activity, thus highlighting areas of increased bone turnover and bone perfusion.

Therefore, bone scans can detect abnormalities in bone, such as fractures, stress fractures, osteomyelitis, and osteoblastic metastases, before anatomic changes can be detected on radiograph.

In addition, bone scans have a higher sensitivity for stress reactions than CT.

Although bone scans are highly sensitive for any bone injury that results in bone formation, the specificity is limited.

Single-photon emission CT (SPECT) is used in conjunction with planar bone imaging based on the clinical indication or radionuclide uptake pattern to provide a three-dimensional image and improve specificity and sensitivity.

Bone scan with SPECT can increase the sensitivity for detecting vertebral bone lesions and distinguish between aggressive and nonaggressive lesions.

In addition to osseous disorders, a 3-phase bone scan can detect abnormal sympathetic activity in an extremity, which is often associated with complex regional pain syndrome.

A characteristic finding on the planar 3-phase bone scan is diffuse generalized increased uptake of bone agent throughout all the bones of 1 extremity in all 3 phases, which is caused by increased generalized blood flow.

Indications:

Stress fracture, differentiation of osteomyelitis from cellulitis, avascular necrosis or bone infarction, reflex sympathetic dystrophy, peripheral vascular disease, subtle lumbar lesions such as pars defect

Musculoskeletal truma

How to describing a fracture radiologically?

Is a basic requirement when making an assessment of a plain radiograph. There are many ways to approach the assessment of the radiograph.

Type of fracture

When describing a fracture, the first thing to mention is what type of fracture it is. Broadly, these can be split into:

- complete: all the way through the bone
- transverse: straight across the bone
- oblique: oblique line across the bone
- spiral: looks like a cork-screw
- comminuted: more than 2 parts to the fracture
- incomplete: the whole cortex is not broken
- bowing: the long bone has been bent
- buckle: the fracture is of the concave surface
- greenstick: the fracture is on the convex surface
- Salter-Harris: fractures that involve the growth plate

The fracture site

The next thing to describe is the bone that is involved and what part of the bone is affected:

- diaphysis: the shaft of the bone
- metaphysis: the widening portion adjacent to the growth plate
- epiphysis: the end of the bone adjacent to the joint

In some cases, you will use the anatomical name for a part of the bone, e.g. the metacarpals have a base, shaft, neck, and head.

Displacement

Once you have an idea of where it is and what type of fracture it is, you need to be able to describe what it looks like.

Fracture displacement describes what has happened to the bone during the fracture. In general, when describing a fracture, the body is assumed to be in the anatomic position and the injury is then described in terms of the distal component displacement in relation to the proximal component.

Displacement can include one or more of:

- angulation
- translation
- rotation
- distraction or impaction

Joint involvement

It is really important to determine whether the joint surface is involved by the fracture. If the fracture does extend to the joint, the patient will probably need to have a different treatment, and it is much more likely that they will need a surgical procedure.

Another fracture?

Always finish off by checking for other fractures. Also, check that you have imaged enough of the patient. If they have pain in the joint above or below a fracture, it may well be worth getting an x-ray of that joint too.

Fracture complications

Immediate

• Hemorrhage, shock
• Fat embolism
• Acute ischemia (5 P's: pulselessness, pain, pallor, paresthesia, paralysis)
• Spinal cord injury, epidural hematoma

Delayed

- Nonunion
- Osteoporosis due to disuse
- Secondary osteoarthritis
- Myositis ossificans
- Osteomyelitis
- Osteonecrosis
- Sudeck atrophy
- Volkmann ischemic contracture

Specific Fractures

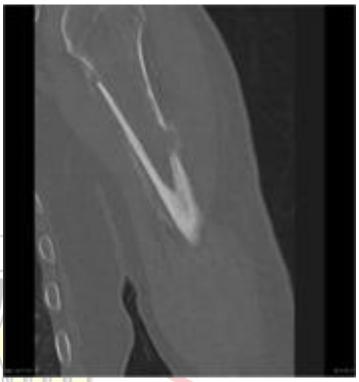
• Stress fractures:

Fatigue fracture: abnormal muscular stress applied to normal bone (e.g., march fracture).

Insufficiency fracture: normal muscular stress applied to abnormal bone (e.g., osteoporotic vertebral fracture).

• **Pathologic fracture:** fracture superimposed on underlying bone disease





• **Intraarticular fracture**: fracture line extends into joint

• **Salter-Harris fracture**: fractures involving growth plate

• **Pseudo fracture**: fissure like defects in osteomalacia (Looser's zones)

• **Occult fracture**: suspected but non-visualized fracture on plain film; demonstrated by99mTc MDP scintigraphy or magnetic resonance imaging (MRI)

• **Hairline fracture**: non displaced fracture with minimal separation

• **Avulsion fracture**: fragment pulled away from bone at tendinous and ligament insertion (commonly at tuberosity)



• **Apophyseal fracture**: at growth centers such as ischial tuberosity and medial epicondyle; commonly avulsion fractures

Bone tumors

Approach to bone tumors:

It is important to realize that the plain radiograph is the most useful examination for differentiating these lesions.
CT and MRI are only helpful in selected cases.

- Once we must decide whether a bone lesion is sclerotic or osteolytic and whether it has a well-defined or ill-defined margins,
- Then we look for the transitional zone which is the area between the lesion margin and the normal bone.
- The next question should be: how old is the patient? Age is the most important clinical clue.
- Finally other clues need to be considered, such as a lesion's localization within the skeleton and within the bone, any periosteal reaction, cortical destruction, matrix calcifications, etc.

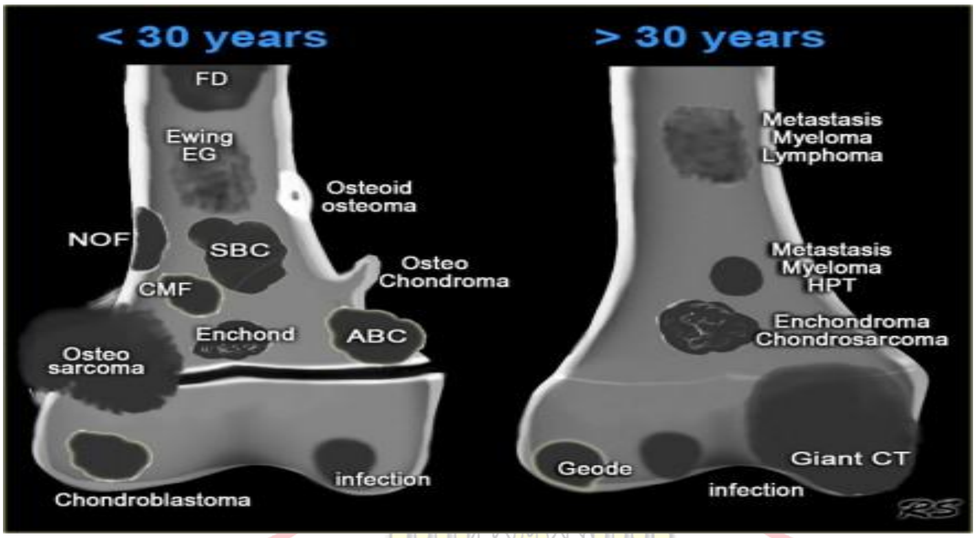
The most important determinators in the analysis of a potential bone tumor are:

The morphology of the bone lesion on a plain radiograph

- Well-defined osteolytic
- ill-defined osteolytic
- Sclerotic

The age of the patient

- Age is the most important clinical clue in differentiating possible bone tumors.
  There are many ways of splitting age groups, as can be seen in the following table.
- Some prefer to divide patients into two age groups: 30 years.
- Most primary bone tumors are seen in patients > 30 years we must always include metastases and myeloma in the differential diagnosis.



Zone of transition

- In order to classify osteolytic lesions as well-defined or ill-defined, we need to look at the zone of transition *between the lesion and the adjacent normal bone*.
  The zone of transition is the most reliable indicator in determining whether an osteolytic lesion is benign or malignant.
  The zone of transition only applies to osteolytic lesions since sclerotic lesions usually have a narrow transition zone.

1- Small zone of transition:

A small zone of transition results in a sharp, well-defined border and is a sign of slow growth.
A sclerotic border especially indicates poor biological activity.
In patients > 30years, and particularly over 40 years, despite benign radiographic features, metastasis or plasmacytoma also have to be considered

- Notice that in all three patients, the growth plates have not yet closed
  Narrow zone of transition: NOF, SBC and ABC

2- Wide zone of transition:

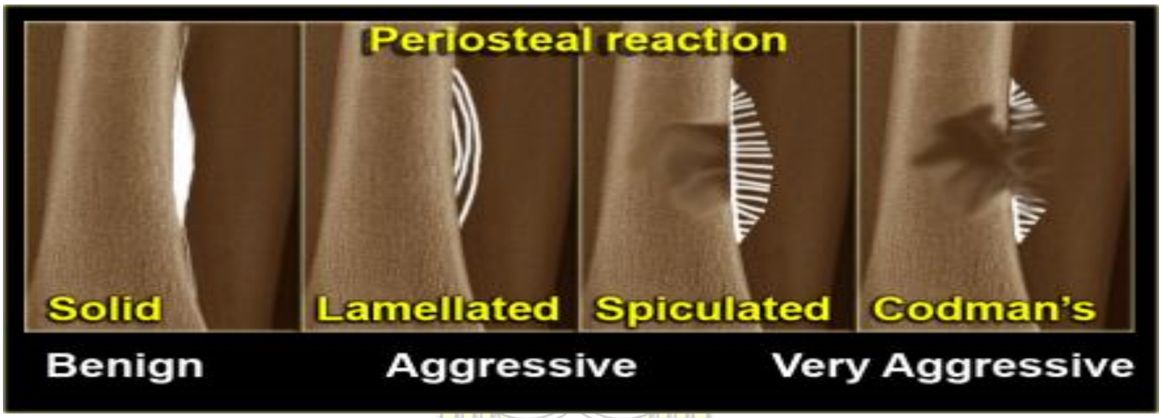
An ill-defined border with a broad zone of transition is a sign of aggressive growth.
It is a feature of malignant bone tumors.
There are two tumor-like lesions which may mimic a malignancy and have to be included in the differential diagnosis.
These are infections and eosinophilic granuloma.
Both of these entities may have an aggressive growth pattern.
Wide zone of transition indicated malignancy or infection or esinophylic granuloma

- Infections and eosinophilic granuloma are exceptional because they are benign lesions which may seem malignant due to their aggressive biologic behavior.
- These lesions may have ill-defined margins, but cortical destruction and an aggressive type of periosteal reaction may also be seen.
- EG almost always occurs in patients Infections have to be included in the differential diagnosis of any bone lesion at any age.

Periosteal reaction:

- A periosteal reaction is a non-specific reaction and will occur whenever the periosteum is irritated by a malignant tumor, benign tumor, infection or trauma.
- There are two patterns of periosteal reaction: a benign and an aggressive type.
- The benign type is seen in benign lesions such as benign tumors and following trauma.

An aggressive type is seen in malignant tumors, but also in benign lesions with aggressive behavior, such as infections and eosinophilic granuloma



Benign periosteal reaction:

- Detecting a benign periosteal reaction may be very helpful, since malignant lesions never cause a benign periosteal reaction.
- A benign type of periosteal reaction is a thick, wavy and uniform callus formation resulting from chronic irritation.
- In the case of benign, slowly growing lesions, the periosteum has time to lay down thick new bone and remodel it into a more normal-appearing cortex.

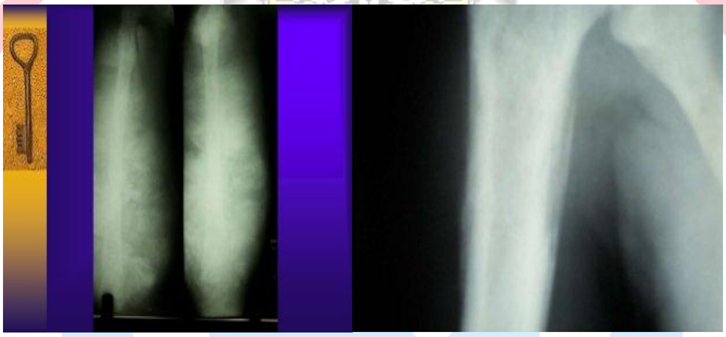
Benign periosteal reaction on ostoid osteoma

Aggressive periosteal reaction:

- This type of periostitis is multilayered, lamellate or demonstrates bone formation perpendicular to the cortical bone.
- It may be speculated and interrupted - sometimes there is
- A Codman's triangle.
- A Codman's triangle refers to an elevation of the periosteum away from the cortex, forming an angle where the elevated periosteum and bone come together.
- In aggressive periostitis the periosteum does not have time to consolidate.

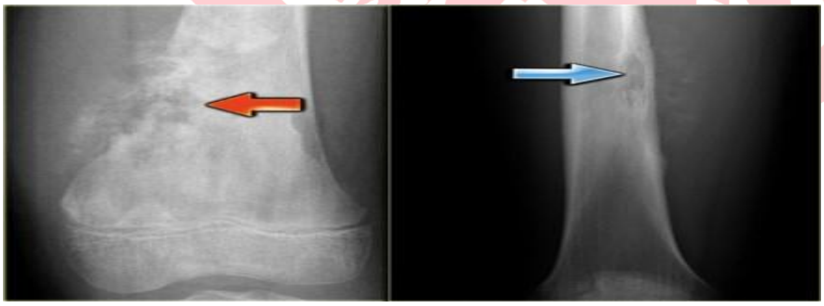
Osteosarcoma **Ewing sarcoma** **infection**

- Fibrous dysplasia, Enchondroma, NOF and SBC are common bone lesions.
- They will not present with a periosteal reaction unless there is a fracture.
If no fracture is present, these bone tumors can be excluded



Cortical destruction:

Cortical destruction is a common finding, and not very useful in distinguishing between malignant and benign lesions.
Complete destruction may be seen in high-grade malignant lesions, but also in locally aggressive benign lesions like EG and osteomyelitis.
More uniform cortical bone destruction can be found in benign and low-grade malignant lesions.
Endosteal scalloping of the cortical bone can be seen in benign lesions like FD and low-grade chondrosarcoma.



(The images show irregular cortical destruction in an osteosarcoma (left) and cortical destruction with aggressive periosteal reaction in Ewing's sarcoma)

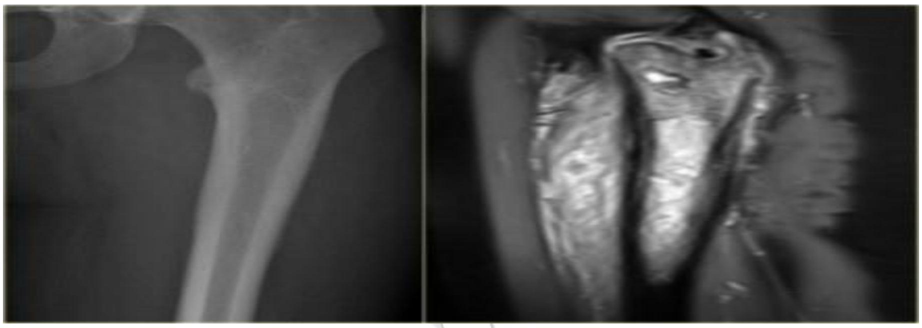
- Ballooning is a special type of cortical destruction.
- In ballooning the destruction of endosteal cortical bone and the addition of new bone on the outside occur at the same rate, resulting in expansion. This 'neocortex' can be smooth and uninterrupted, but may also be focally interrupted in more aggressive lesions like GCT

(*Left*: Chondromyxoid fibroma : A benign, well-defined, expansile lesion with regular destruction of cortical bone and a peripheral layer of new bone. *Right*: Giant cell tumor)

A locally aggressive lesion with cortical destruction, expansion and a thin, interrupted peripheral layer of new bone. Notice the wide zone of transition towards the marrow cavity, which is a sign of aggressive behavior.

- In the group of malignant small round cell tumors which include Ewing's sarcoma, bone lymphoma and small cell osteosarcoma, the cortex may appear almost normal radiographically, while there is permeative growth throughout the Haversian channels.

- These tumors may be accompanied by a large soft tissue mass while there is almost no visible bone destruction.



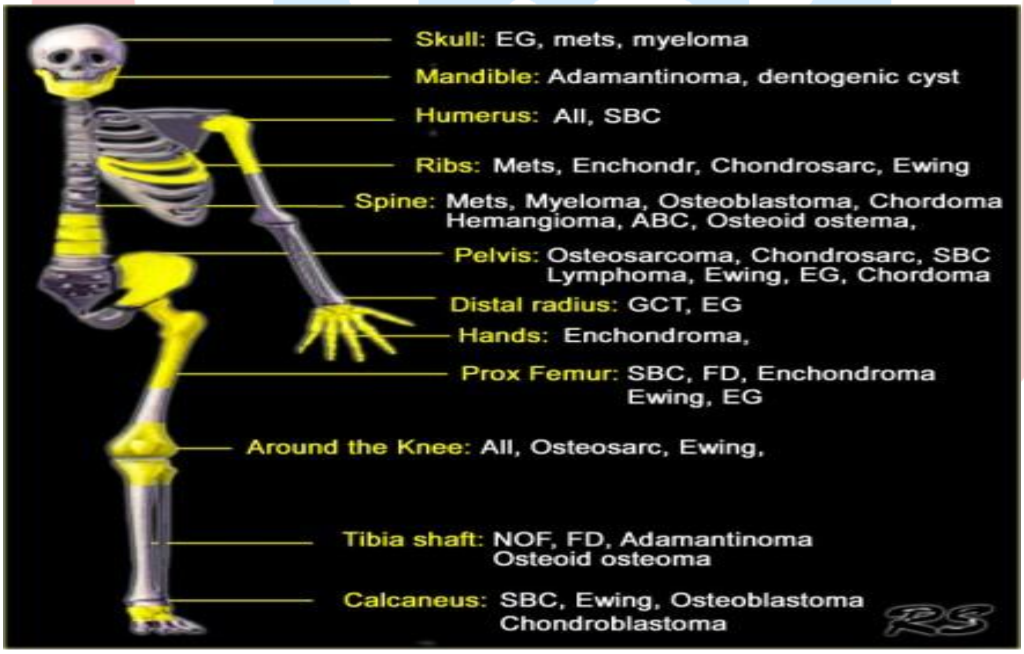
(The image shows an Ewing's sarcoma with permeative growth through the Haversian channels accompanied by a large soft tissue mass.
The radiograph does not shown any signs of cortical destruction.)

Location within the skeleton

The location of a bone lesion within the skeleton can be a clue in the differential diagnosis.

The following illustration shows the preferred locations of the most common bone tumors.

In some locations, such as in the humerus or around the knee, almost all bone tumors may be found



Location: epiphysis - metaphysis - diaphysis

- **Epiphysis**
  only a few lesions are located in the epiphysis, so this could be an

important finding.
In young patients it is likely to be either a chondroblastoma or an infection.
In patients over 20, a giant cell tumor has to be included in the differential diagnosis.

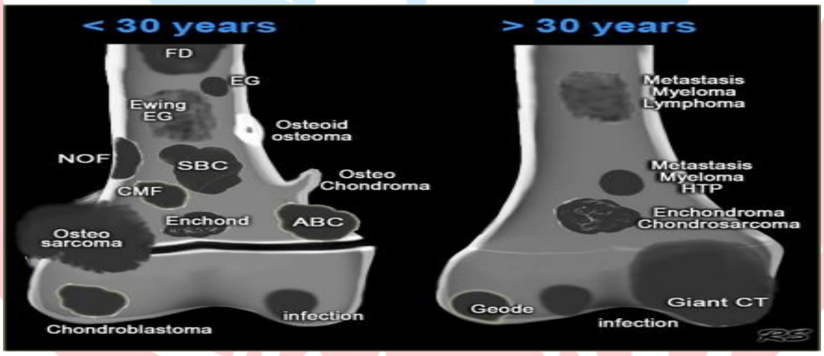
- In older patients a geode, i.e. degenerative subchondral bone cyst must be added to the differential diagnosis.
Look carefully for any signs of arthrosis.

- **Metaphysis**

NOF, SBC, CMF, Osteosarcoma, Chondrosarcoma, Enchondroma and infections.

- **Diaphysis**

Ewing's sarcoma, SBC, ABC, Enchondroma, Fibrous dysplasia and Osteoblastoma.
Differentiating between a diaphyseal and a metaphyseal location is not always possible.
Many lesions can be located in both or move from the metaphysis to the diaphysis during growth.
Large lesions tend to expand into both area



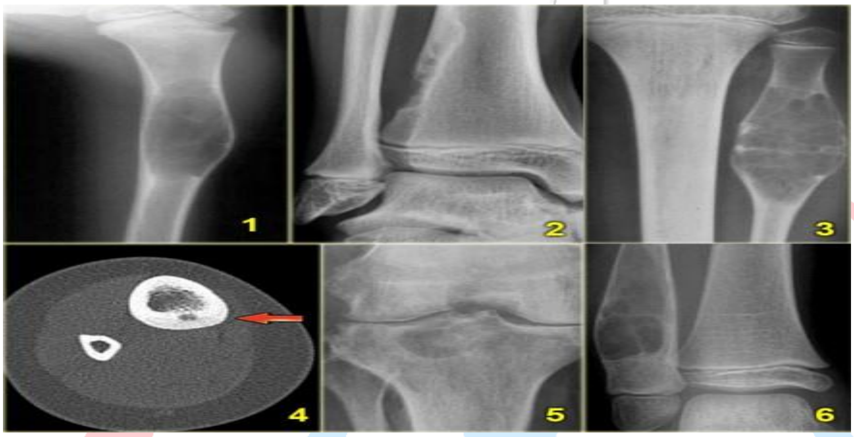
Location: centric - eccentric – juxtacortical

- **Centric in long bone**
SBC, eosinophilic granuloma, fibrous dysplasia, ABC and enchondroma are lesions that are located centrally within long bones.

- **Eccentric in long bone**
Osteosarcoma, NOF, chondroblastoma, chondromyxoid fibroma, GCT and osteoblastoma are located eccentrically in long bones.

- **Cortical**
  Osteoid osteoma is located within the cortex and needs to be differentiated from osteomyelitis.

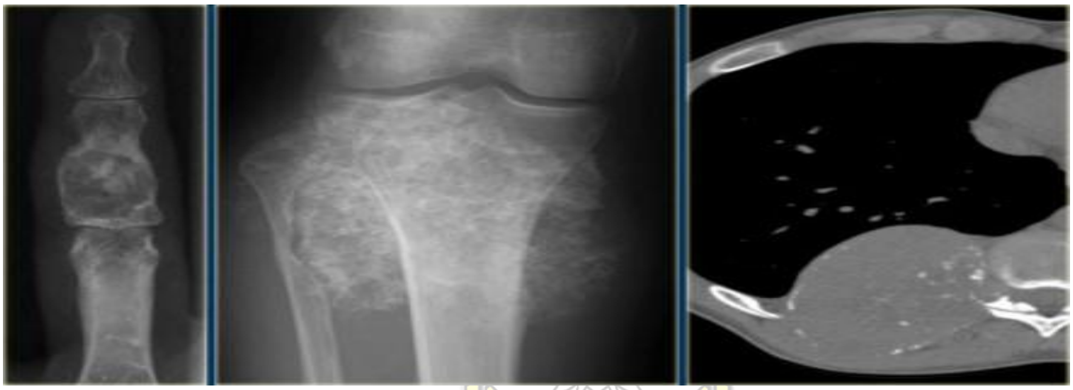
- **Juxtacortical**
  Osteochondroma. The cortex must extend into the stalk of the lesion. Parosteal osteosarcoma arises from the periosteum.



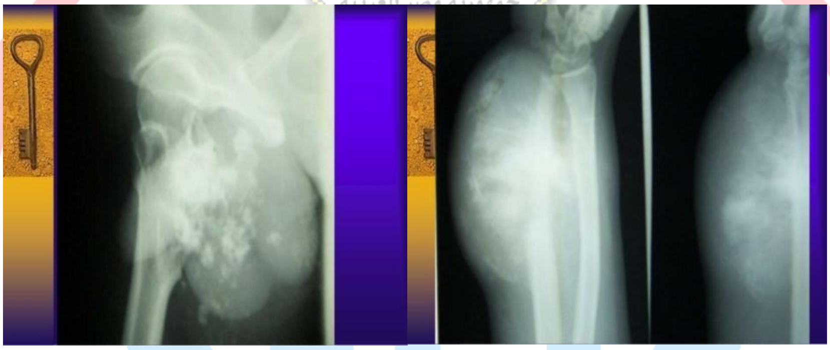
1. SBC: central diaphyseal
2. NOF: eccentric metaphyseal
3. SBC: central diaphyseal
4. Osteoid osteoma: cortical
5. Degenerative subchondral cyst: epiphyseal
6. ABC: centric diaphyseal

Matrix

Calcifications or mineralization within a bone lesion may be an important clue in the differential diagnosis.
There are two kinds of mineralization: a chondroid matrix in cartilaginous tumors like enchondromas and chondrosarcoma and an osteoid matrix in osseous tumors like osteoid osteoma and osteosarcomas.
Chondroid matrix
Calcifications in chondroid tumors have many descriptions: rings-and-arcs, popcorn, focal stippled or flocculent.



(Chondroid matrix left: Enchondroma, the most commonly encountered lesion of the phalanges.
Middle: middle: Peripheral chondrosarcoma, arising from an osteochondroma (exostosis).
Right: Chondrosarcoma of the rib)



Ostoid matrix

Mineralization in osteoid tumors can be described as a trabecular ossification pattern in benign bone-forming lesions and as a cloud-like or ill-defined amorphous pattern in osteosarcomas.
Sclerosis can also be reactive, e.g. in Ewing's sarcoma or lymphoma

Polyostotic or multiple lesions

- Most bone tumors are solitary lesions.
  If there are multiple or polyostotic lesions, the differential diagnosis must be adjusted.

- **Polyostotic lesions**
  NOF, fibrous dysplasia, multifocal osteomyelitis, enchondromas, osteochondoma, leukemia and metastatic Ewing' s sarcoma.
  Multiple enchondromas are seen in Morbus Ollier.
  Multiple enchondromas and hemangiomas are seen in Maffucci's syndrome.

- **Polyostotic lesions > 30 years**
  Common: Metastases, multiple myeloma, multiple enchondromas.
  Less common: Fibrous dysplasia, Brown tumors of hyperparathyroidism, bone infarcts.

- Mnemonic for multiple oseolytic lesions: FEEMHI:
  Fibrous dysplasia, enchondromas, EG, Mets and myeloma, Hyperparathyroidism, Infection.

Fibrous dysplasia of the femur

Arthritis

General Approach

Types of Arthritis

There are three types of arthritis (which often can be distinguished radiologically):

Degenerative joint disease

Characterized by:

- Osteophytes
- Subchondral sclerosis
- Uneven loss of articular space

Inflammatory arthritis

- Erosions
- Periarticular osteoporosis common
- Soft tissue swelling
- Uniform loss of articular space

Metabolic arthritis

- Lumpy bumpy soft tissue swelling
- Marginated bony erosions with overhanging edges

ABC Approach to Differential Diagnosis of Arthritis

Alignment:

Subluxation, dislocation: common in RA and SLE

Bone:

Osteoporosis versus Normal mineralization: all arthritides except RA

Juxta-articular osteopenia: any arthropathy; subtle findings have no differential diagnosis value

Diffuse osteoporosis: only in RA

Erosions: Aggressive erosion (no sclerotic borders, no reparative bone): RA, psoriasis
Nonaggressive erosion (fine sclerotic border): gout

Location: inflammatory erosions occur at margins (mouse ear), erosions in erosive OA occur in the central portion of the joint (seagull)

Bone production
Periosteal new bone formation: psoriasis, Reiter syndrome (this is a feature that distinguishes RA from spondyloarthropathies due to tenosynovitis)

Ankylosis (bony bridging of a joint): inflammatory arthropathies

Overhanging edges of cortex: typical of gout (tophus)

Subchondral bone (reparative bone beneath cortex): typical of OA

Osteophytes (occur where adjacent cartilage has undergone degeneration and loss): typical of OA

Cartilage

Joint space
Maintenance of joint space: any early arthropathy; only gout and PVNS maintain normal joint space in progressive disease

Uniform narrowing: all arthritis except OA

Eccentric narrowing: typical of OA

Wide joint space: early inflammatory process

Distribution:

- Monoarticular or polyarticular
- Monarticular: infection, crystal deposition, or posttraumatic
- Proximal/distal Proximal joints: RA, CPPD, AS
- Distal joints: Reiter, psoriatic
- Symmetrical: RA, multicentric reticulohistiocytosis

SOFT TISSUES

Swelling Symmetrical around joint:
Seen in all inflammatory arthropathies but most commonly in RA

Asymmetrical:
most commonly due to asymmetrical osteophytes rather than true soft tissue swelling; most common in OA

Lumpy, bumpy soft tissue swelling:
gout (tophus)

Swelling of entire digit:
psoriasis, Reiter (sausage digit)

Calcification Soft tissue:
gout (calcified tophus)

Cartilage:
CPPD (calcium pyrophosphate dehydrate).

Subcutaneous tissue:
scleroderma (typical)
(AS, ankylosing spondylitis; CPPD, calcium pyrophosphate dihydrate; OA, osteoarthritis; RA, rheumatoid arthritis.)

Scleroderma

Metabolic Bone Disease

General

Bone tissue consists of:

Extracellular substance

- Osteoid: collagen, mucopolysaccharide
- Crystalline component: calcium phosphate, hydroxyapatite

Cells

- Osteoblasts
- Osteoclasts

Bone is constantly absorbed and replaced with new bone. Disturbances in this equilibrium result in either too much bone (increased radiodensity, osteosclerosis) or too little bone (decreased density = osteopenia).

Osteopenia

Osteopenia is a nonspecific radiographic finding that indicates increased radiolucency of bone. Bone density may be difficult to assess because of technical factors (kVp, mA) that influence the radiographic appearance.

Types

- Osteoporosis: decreased amount of normal bone
- Osteomalacia: decreased bone mineralization
- Marrow replacement: bone replaced by tumor, marrow hyperplasia, or metabolic products
- Hyperparathyroidism: increased bone resorption

Osteoporosis

Classification

Primary osteoporosis (most common): unassociated with an underlying illness

- Type I osteoporosis: postmenopausal
- Type II osteoporosis: senile
- Idiopathic juvenile osteoporosis

Secondary osteoporosis (less common)

- Endocrine disorders

Hypogonadism | Hyperthyroidism
Cushing disease | Acromegaly

- Nutritional

Malabsorption syndromes
Alcoholism | Scurvy

- Hereditary metabolic or collagen disorder

Osteogenesis imperfect | Marfan syndrome
Ehlers-Danlos syndrome | Homocystinuria
Hypophosphatasia | Wilson disease
Alkaptonuria | Menkes syndrome

• Drugs

Heparin Exogenous steroids

Radiographic Features

• Osteopenia: 30%-50% of bone has to be lost to be detectable by plain film
• Diminution of cortical thickness: width of both MCP cortices should be less than half the shaft diameter
• Decrease in number and thickness of trabeculae in bone
• Vertebral bodies show earliest changes: resorption of horizontal trabeculae
• Empty box vertebra: apparent increased density of vertebral endplates due to resorption of spongy bone
• Vertebral body compression fractures: wedge, biconcave codfish bodies, true compression
• Pathologic fractures
• Qualitative assessment: Singh index is based on trabecular pattern of proximal femur.

Patterns:

- Mild: loss of secondary trabeculae
- Intermediate: loss of tensile trabeculae
- Severe: loss of principal compressive trabeculae

Osteomalacia

Abnormal mineralization of bone is termed *osteomalacia* in adults and *rickets* in children. In the past, the most common cause was deficient intake of vitamin D.

Today, absorption abnormalities and renal disorders are more common causes:

Nutritional deficiency of:

• Vitamin D
• Calcium
• Phosphorus

Absorption abnormalities

- GI surgery
- Malabsorption
- Biliary disease

Renal

- Chronic renal failure
- Renal tubular acidosis
- Proximal tubular lesions
- Dialysis induced

Abnormal vitamin D metabolism

- **Liver disease**
- Hereditary metabolic disorders

Drugs

- Phenytoin (Dilantin)
- Phenobarbital

Radiographic Features

- Generalized osteopenia
- Looser's zones (pseudofractures):

cortical stress fractures filled with poorly mineralized osteoid tissue.

- Milkman's syndrome: osteomalacia with many Looser's zones
- Typical location of Looser's zones (often symmetrical)
    - Axillary margin of scapula
    - Inner margin of femoral neck
    - Rib
    - Pubic, ischial rami
- Osteomalacia may be indistinguishable from osteoporosis; however, Looser's zones are a reliable differentiating feature.

Basics of MR on musculoskeletal disease

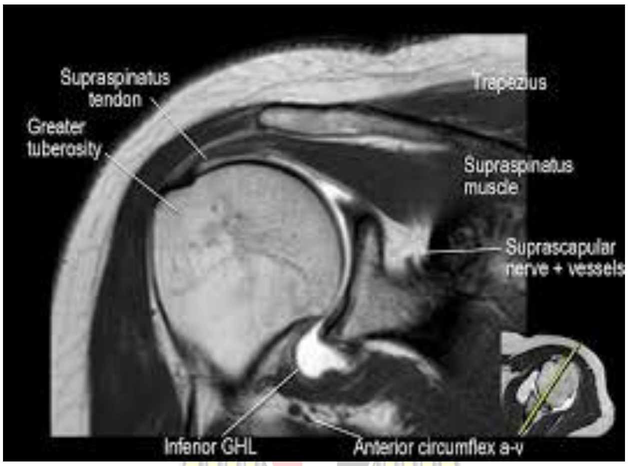
Tendons

Best image MRI sequence for tendon and ligaments is T2 sequence

Best images sequence for meniscus is proton density (PD) & Dixon sequences

Best images sequence for bone marrow disease is T2 STAIR

- A normal tendon is dark on all MRI sequences.



Tenosynovitis

Is inflammation surrounding a tendon. Tenosynovitis may be secondary to repetitive motion, inflammatory arthritis, or infection.

• On MRI, fluid completely surrounds the tendon circumferentially.

• A variant form, called stenosing tenosynovitis, features several loculated collections of fluid in the tendon sheath.

Myxoid degeneration (tendinosis)

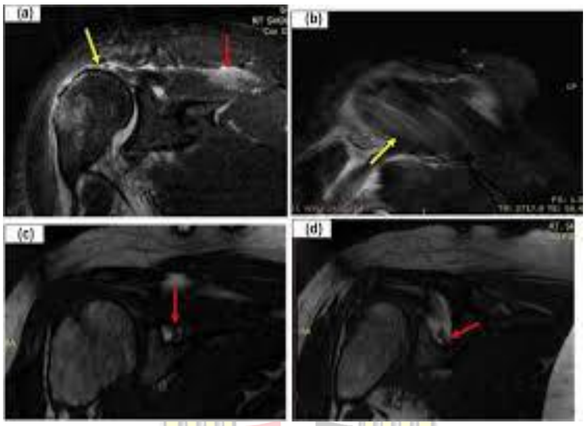
• Aging or overuse often leads to myxoid degeneration, which is synonymous with tendinosis.

The word tendinitis should not be used as myxoid degeneration is not due to inflammation.

• MRI of myxoid degeneration/tendinosis will show intermediate intra-substance (within the tendon) signal. The tendon may be either normal in size or enlarged. If fluid intensity signal is seen within a tendon, concern should be raised for a partial tear, although MR cannot always reliably differentiate between tendinosis and partial tear.

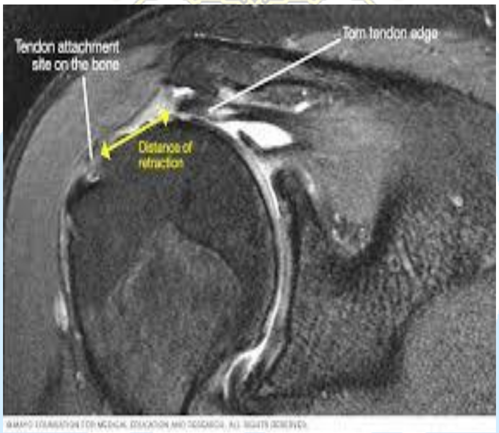
Partial tear

• A partial tendon tear represents incomplete disruption of the fibers and can have a varied MRI appearance. The tendon may be thickened, thinned, or contain intrasubstance fluid.



Complete tear

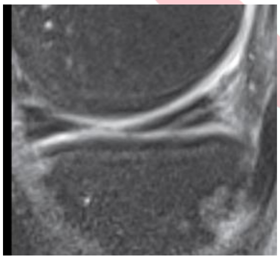
• A complete disruption of the tendon will appear as complete discontinuity of the tendon. There is often retraction of the tendon remnants.



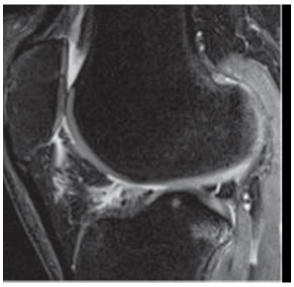
MRI can evaluate the meniscal tear

- **Typers of meniscal tear:**

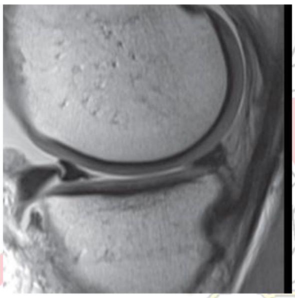
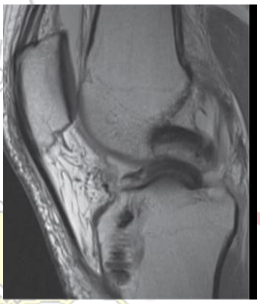
The best MRI sequance to detect menscial tear is the proton density (PD).
Oblique or horizontal tear: posterior horn of medial meniscus is more common



Vertical or horizontal tear: curved tear that follow the contour of the meniscus



Bucket handle tear:

A bucket-handle tear is the result of an extensive vertical tear, occurring when the free inner edge of the meniscus (medial meniscus most commonly) gets displaced or flipped over.

• The most sensitive imaging finding of a bucket-handle tear is the *absent bow tie* sign, seen when there are fewer than two "bow ties" on adjacent 4 mm-thick sagittal slices.

• The most common location of the displaced meniscal fragment is the intercondylar notch, but the meniscal fragment may also displace anteriorly or posteriorly.

• Anterior displacement produces the *double delta* sign on sagittal MRI (either meniscus).

• Posterior displacement produces the *double PCL* sign on sagittal MRI (medial meniscus only).

Radial-transverse tear: is a vertically oriented tear that is perpendicular to the arc of the meniscus. More common with lateral discoid meniscus