X-Ray is a radiographic photograph commonly used to assist with diagnosis of musculoskeletal problems such as fractures, dislocations, and bone loss. X-Ray produces planar images and as a result often requires images to be taken in multiple planes in order to visualize a lesion’s location and size.

**How do X-rays produce images?**  X-rays have the ability to pass through matter. The degree to which an x-ray beam passes through matter depends on tissue composition and volume. Bone absorbs more x-ray than soft tissue, making bone stand out (appears white next to soft tissue). FYI: Patients with Cancer can have X-Rays taken.

**Present Applications of X-ray**
- Skeletal radiography
- Film-screen or Digital Bone Densitometry (DEXA)
- Genitourinary Imaging
- Intravenous urography
- Hysterosalpingography
- Gastrointestinal Imaging
- UGI
- Small Bowel Series
- Colon (Barium Enema)

**Arteriography:** a radiograph that visualizes injected radiopaque dye in an artery. The test can be used to identify arteriosclerosis, tumors, or blockages.

**Venography:** a radiograph that visualizes injected radiopaque dye in a vein. The test can be used to identify tumors or blockages in the venous network.

**Myelography:** an invasive test that combines fluoroscopy and radiography to evaluate the spinal subarachnoid space. The test utilizes a contrast medium that is injected into the epidural space by spinal puncture. Myelography is used to identify bone displacement, disk herniation, spinal cord compression or tumors.

**Fluoroscopy:** designed to show motion in joints through x-ray imaging. It is not commonly used due to excessive radiation exposure.

**Ultrasound**
Ultrasound can be used to determine if a lesion is solid or cystic.
**Computed Tomography (CT Scan or CAT Scan)**

- Developed in the 1970s by British engineer Godfrey Hounsfield, CT combines the sophistication of the computer technology and the absorption characteristics of x-rays to produce cross-sectional images of the body.

- A CT scanner operates by projecting a pencil-thin x-ray beam through the body from many different angles. The portion of the beam that emerges from the patient is captured by an array of x-ray detectors and converted into electrical impulses. The electrical impulses are then analyzed by an array computer in order to reconstruct a cross-sectional image.

- While film-screen radiography is superior in detailing bony anatomy and relatively minute details, CT is superior in its ability to enhance differences in soft tissue.

- CT imaging is...
  - one of the best and fastest tools for studying the chest, abdomen and pelvis because it provides detailed, cross-sectional views of all types of tissue.
  - often the preferred method for diagnosing many different cancers, including lung, liver and pancreatic cancer, since the image allows a physician to confirm the presence of a tumor and measure its size, precise location and the extent of the tumor's involvement with other nearby tissue.
  - an examination that plays a significant role in the detection, diagnosis and treatment of vascular diseases that can lead to stroke, kidney failure or even death. CT is commonly used to assess for pulmonary embolism (a blood clot in the lung vessels) as well as for abdominal aortic aneurysms (AAA).
  - invaluable in diagnosing and treating spinal problems and injuries to the hands, feet and other skeletal structures because it can clearly show even very small bones as well as surrounding tissues such as muscle and blood vessels.

**Physicians often use the CT examination to:**

- quickly identify injuries to the lungs, heart and vessels, liver, spleen, kidneys, bowel or other internal organs in cases of trauma.
- guide biopsies and other procedures such as abscess drainages and minimally invasive tumor treatments.
- plan for and assess the results of surgery, such as organ transplants or gastric bypass.
- stage, plan and properly administer radiation treatments for tumors as well as monitor response to chemotherapy.
- measure bone mineral density for the detection of osteoporosis.
Magnetic Resonance Imagine (MRI)

- MRI utilizes radio waves and strong magnetic fields to manipulate tissues at the atomic level.
- Because MRI does not use x-rays, the associated health risks are lower.
- MRI is superior to CT in enhancing subtle differences in tissue composition. This is especially useful in imaging the brain and spinal cord, but has found application in musculoskeletal imaging as well.

CT Scan vs. MRI

<table>
<thead>
<tr>
<th>CT</th>
<th>MRI</th>
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<tbody>
<tr>
<td>Less expensive</td>
<td>Expensive</td>
</tr>
<tr>
<td>CT can image bone, soft tissue and blood vessels all at the same time</td>
<td>For purposes of tumor detection and identification, MRI is unanimously superior</td>
</tr>
<tr>
<td>Less time consuming than MRI</td>
<td>Slow process</td>
</tr>
<tr>
<td>CT is less sensitive to patient movement than MRI</td>
<td>Patient must remain very still, very sensitive to patient movement</td>
</tr>
<tr>
<td>CT can be performed if you have an implanted medical device of any kind, unlike MRI.</td>
<td>Implanted medical devices are contraindications</td>
</tr>
<tr>
<td>CT imaging provides real-time imaging, making it a good tool for guiding minimally invasive procedures such as needle biopsies and needle aspirations of many areas of the body, particularly the lungs, abdomen, pelvis and bones</td>
<td>Does not provide real-time imaging</td>
</tr>
<tr>
<td>Involves radiation exposure</td>
<td>No radiation exposure</td>
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PET scan
Positron Emission Tomography (PET) is a powerful imaging technique that holds great promise in the diagnosis and treatment of many diseases, particularly cancer. PET (Positron Emission Tomography) and CT (Computed Tomography) scans are both standard imaging tools that physicians use to pinpoint disease states in the body. A PET scan demonstrates the biological function of the body before anatomical changes take place, while the CT scan provides information about the body’s anatomy such as size, shape and location. By combining these two scanning technologies, a PET/CT scan enables physicians to more accurately diagnose and identify cancer, heart disease and brain disorders.

Cancer
Can detect active, viable tumors (cancer), unlike CT or MRI.

Brain Disorders
- PET can determine if the cause is Alzheimer's disease, blood flow shortages, depression, or some other reason.
- PET can localize the brain site of seizure activity. This is especially important for children with uncontrollable seizures who are candidates for surgery as a cure.
- PET can tell if that muscle tremor is Parkinson's disease or another of the "Movement" disorders.
- PET can look at a brain tumor and reveal if it is benign or malignant. It is also widely used when recurrence is suspected to show whether structural change is tumor regrowth or merely scar tissue.
- PET can "map" the areas of the brain responsible for movement, speech and other critical functions. This is a remarkable guide for surgeons who are performing delicate operations on different areas of the brain.

Heart Disease
- Myocardial Perfusion: PET is the most accurate test to reveal whether or not a patient has coronary artery disease (CAD), also called coronary heart disease. Coronary heart disease is caused by accumulation of plaques within the walls of the arteries that supply blood to the myocardium (the muscle of the heart). Impaired blood flow to the heart muscle restricts its ability to function and pump blood to the body.

Myocardial Viability: PET is the gold standard in determining the viability of heart tissue for revascularization. Decreased or absent blood flow to the heart muscle may imply that the heart is permanently damaged. PET can determine if there is permanent damage and whether bypass surgery or a transplant would be the appropriate treatment

Contraindications/Precautions
<table>
<thead>
<tr>
<th></th>
<th>Contraindications</th>
<th>Precautions</th>
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<tbody>
<tr>
<td>X-Ray</td>
<td>Pregnancy</td>
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<tr>
<td>CT Scan</td>
<td>pregnancy</td>
<td></td>
</tr>
<tr>
<td>PET scan</td>
<td>pregnancy</td>
<td></td>
</tr>
<tr>
<td>MRI</td>
<td>electronically, magnetically, &amp; mechanically activated implants; automatic implanted defibrillators; pacemakers</td>
<td>Cochlear implants, insulin pumps, nerve stimulators, claustrophobia, pregnancy (especially the first trimester)</td>
</tr>
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**Electromyography (EMG)**

Electromyography (EMG) is the recording of electrical activity of a selected muscle or muscle groups at rest and during voluntary contraction. EMG is performed by inserting a needle electrode percutaneously into a muscle or through the use of surface electrodes. The test is commonly used to assess peripheral nerve injuries and to differentiate between various neuromuscular disorders.

**Electrocardiography (ECG)**

The recording of the electrical activity of the heart. The test identifies three distinct waveforms: P wave, QRS complex, and T wave. EEG is used to help identify conduction abnormalities, cardiac arrhythmias, and myocardial ischemia.

**Electroencephalography (EEG)**

The recording of the electrical activity of the brain. The electrical activity is collected by examining the difference between the electrical potential of two electrodes placed at different locations of the scalp. It is used to assess seizure activity, metabolic disorders, and cerebellar lesions.