Radiography (X-ray)

Procedure: Xray
Bodypart: Head
Patient Group: Female Male Child

Summary

Other terms: X-ray, Plain radiography, Film, Projection radiography, Radiographs, Roentgen rays

Diagnostic X-rays is often a first test ordered by a doctor. It can visualize many different parts of the body, allowing more accurate testing and diagnosis. Basic X-rays use a small amount of radiation to view the chest, abdomen, spine, skull, arms or legs. More specialized X-rays use a contrast material, which is swallowed or injected into a vein in the arm, to better define the spine, kidneys, stomach, colon or bladder.

X-rays are a form of radiation similar to light rays, except that they are more energetic than light rays and are invisible to the human eye. They are created when an electric current is passed through a vacuum tube. X-rays were accidentally discovered in 1895 by German physicist Wilhem Roentgen (1845-1923), who was later awarded the first Nobel Prize in physics for his discovery. Roentgen was also a photographer and almost immediately realized that the shadows created when X-rays passed through the body could be permanently recorded on photographic plates. His first X-ray picture was of his wife's hand. Within a few years, X-rays became a valued diagnostic tool of physicians world-wide.

Diagnostic X-rays are some of the most powerful medical imaging tools available. Other imaging techniques that do not use X-rays include magnetic resonance imaging (MRI), ultrasonography, and radionucleotide imaging. Based on the symptoms presented by the patient, the physician can request specific x-rays (such as chest X-rays) that help diagnose many types of cancers, including sarcomas, lymphomas, and lung cancers. X-rays allow the physician to visualize certain internal body conditions with little or no invasive procedures. Conditions may be visualized on photographic film, or for more complex and detailed information, computed tomography (CT scan), fluroscopy, or angiography might be used.

Roentgen’s X-ray picture of the hand of Alfred von Kolliker, taken 23 January 1896
© Wikipedia

Technique

What it is
An X-ray is a picture of the internal structures of the relevant part of the body, produced by exposure to a controlled source of X-rays and generally recorded on a sensitive photographic film.

These days, not all X-ray images will actually be recorded on film, but may be kept in digital form, and shown on a computer screen. Despite all the newer, more sophisticated forms of scanning, a plain X-ray is still one of the most sensitive ways of detecting many problems.

X rays are electromagnetic radiation that differentially penetrates structures within the body and creates images of these structures on photographic film or a fluorescent screen. These images are called diagnostic x rays.

X rays are used in imaging and therapy.

**Diagnostic radiography**

Diagnostic radiography involves the use of both ionising radiation and non-ionising radiation to create images for medical diagnoses. The predominant test is still the X-ray (the word X-ray is often used for both the test and the actual film or digital image). X-rays are the second most commonly used medical tests, after laboratory tests. This application is known as diagnostic radiography. Since the body is made up of various substances with differing densities, X-rays can be used to reveal the internal structure of the body on film by highlighting these differences using attenuation, or the absorption of X-ray photons by the denser substances (like calcium-rich bones).

**How it works**

X rays pass easily through air and soft tissue of the body. When they encounter more dense material, such as a tumor, bone, or a metal fragment, they are stopped. Diagnostic x rays are performed by positioning the part of the body to be examined between a focused beam of x rays and a plate containing film. This process is painless. The greater the density of the material that the x rays pass through, the more rays are absorbed. Thus bone absorbs more x rays than muscle or fat, and tumors may absorb more x rays than surrounding tissue. The x rays that pass through the body strike the photographic plate and interact with silver molecules on the surface of the film.

Once the film plates have been processed, dense material such as bone shows up as white, while softer tissue shows up as shades of gray, and airspaces look black. A radiologist, who is a physician trained to interpret diagnostic x rays, examines the pictures and reports to the doctor who ordered the tests. Plain film x rays normally take only a few minutes to perform and can be done in a hospital, radiological center, clinic, doctor's or dentist's office, or at bedside with a portable x-ray machine.

Projection radiography uses X-rays in different amounts and strengths depending on what body part is being imaged:

- Hard tissues such as bone require a relatively high energy photon source, and typically a tungsten anode is used with a high voltage (50-150 kVp) on a 3-phase or high-frequency machine to generate braking radiation. Bony tissue and metals are denser than the surrounding tissue, and thus by absorbing more of the X-ray photons they prevent the film from getting exposed as much. Wherever dense tissue absorbs or stops the X-rays, the resulting X-ray film is unexposed, and appears translucent blue, whereas the black parts of the film represent lower-density tissues such as fat, skin, and internal organs, which could not stop the X-rays. This is usually used to see bony fractures, foreign objects (such as ingested coins), and used for finding bony pathology such as osteoarthritis, infection (osteomyelitis), cancer (osteosarcoma), as well as growth studies (leg length, achondroplasia, scoliosis, etc).

- Soft tissues are seen with the same machine as for hard tissues, but a "softer" or less-penetrating X-ray beam is used. Tissues commonly imaged include the lungs and heart shadow in a chest X-ray, the air pattern of the bowel in abdominal X-rays, the soft tissues of the neck, the orbits by a skull X-ray before an MRI to check for radiopaque foreign bodies (especially metal), and of course the soft tissue shadows in X-rays of bony injuries are looked at by the radiologist for signs of hidden trauma (for example, the famous "fat pad" sign on a fractured elbow).

- Dental radiography uses a small radiation dose with high penetration to view teeth, which are relatively dense. A dentist may examine a painful tooth and gum using X-ray equipment. The machines used are typically single-phase pulsating DC, the oldest and simplest sort. Dental technicians or the dentist may run these machines-- radiologic technologists are not required by law to be present.

- Mammography is an X-ray examination of breasts and other soft tissues. This has been used mostly on women to screen for breast cancer, but is also used to view male breasts, and used in conjunction with a radiologist or a surgeon to localise suspicious tissues before a biopsy or a lumpectomy. Breast implants designed to enlarge the breasts reduce the viewing ability of mammography, and require more time for imaging as more views need to be taken. This is because the material used in the implant is very dense compared to breast tissue, and looks white (clear) on the film. The radiation used for mammography tends to be softer (has a lower photon energy) than that used for the harder tissues. Often a tube with a molybdenum anode is used with about 30 000 volts (30 kV), giving a range of X-ray energies of about 15-30 keV. Many of these photons are "characteristic radiation" of a specific energy determined by the atomic structure of the target material (Mo-K radiation).

**Equipment**
An X-ray unit is the equipment used to produce X-rays. To prevent exposure to the operator and to prevent the unnecessary leakage of X-ray radiation to the rest of the facility where X-rays are performed, the x-ray unit is generally enclosed in a room that has walls made of, or reinforced with, a dense material (usually lead) that will absorb any X-rays that are scattered during the X-ray process.

Additionally, the operator of an X-ray unit generally turns the X-ray equipment on and off from behind a protective wall that is lined with lead. Lead is extremely dense to X-rays and even a one-quarter inch thickness of lead will prevent all X-rays emitted from current X-ray machines from being able to pass. A lead-impregnated smock or apron is also provided to patients while they are being X-rayed to prevent unwanted exposure of their bodies to X-rays.

**Purpose**

Diagnostic x rays are useful in detecting abnormalities within the body. They are a painless, non-invasive way to help diagnose problems such as broken bones, tumors, dental decay, and the presence of foreign bodies.

X-rays are especially useful in the detection of pathology of the skeletal system, but are also useful for detecting some disease processes in soft tissue. Some notable examples are the very common chest X-ray, which can be used to identify lung diseases such as pneumonia, lung cancer or pulmonary edema, and the abdominal X-ray, which can detect ileus (blockage of the intestine), free air (from visceral perforations) and free fluid (in ascites). In some cases, the use of X-rays is debatable, such as gallstones (which are rarely radiopaque) or kidney stones (which are often visible, but not always). Also, traditional plain X-rays pose very little use in the imaging of soft tissues such as the brain or muscle. Imaging alternatives for soft tissues are computed axial tomography (CAT or CT scanning), magnetic resonance imaging (MRI) or ultrasound.

**Target Patient Group**

- **Abdominal studies**, in which a plain film of the the abdomen, flat and upright, is used to detect stones, abnormalities, and bowel dilation. These studies also provide an indirect look at the liver, spleen, gallbladder, and kidneys.

- **GI studies**, which may cover the upper gastrointestinal (GI) tract (esophagus, stomach, and duodenum, the upper part of the small intestine) and the lower GI tract (lower small intestine, colon, and rectum), or both. These are usually done after swallowing barium, a chalky contrast medium, or having it infused through the rectum (a barium enema). Also called upper and lower GI series, these studies are done to detect polyps and other tumors, abnormal narrowing or obstructions, ulcers, and diverticula, pouches that bulge out from the intestinal walls.

- **Mammography**, in which special X-ray equipment is used to produce detailed images of the breast. Mammography is especially useful in detecting early breast cancer.

- **Renal studies**, which entail X-raying the kidneys, are usually done after injecting a contrast medium into a vein. A series of X-rays is then taken to show the renal outline and collecting system and structures of the kidneys, as well as the ureters (the tubes that carry urine from the kidneys to the bladder) and the bladder itself. Sometimes this study is combined with a CT scan.

- **Extremity exams**, which are X-rays of the joints, usually after injection of a contrast medium. These X-rays are especially useful in assessing arthritis, sports injuries, and other common joint problems. During the procedure, the doctor may manipulate the joints to take X-rays from different angles. Fluoroscopy is sometimes used to observe the joints in motion. Companion...
studies, including CT scans, MRI, or arthroscopy, may be carried out at the same time.

- **Chest X-rays**, which are done to study the lungs, heart, rib cage, and other bones of the chest, are probably the most common imaging study. Typically, the X-rays are taken from both the front and side views, and can detect such problems as pneumonia, congestive heart failure, tumors, or fluid in the lungs; an enlarged heart; and broken or abnormal bones. At one time, a routine chest X-ray was included in the annual physical exam; this is no longer done, but routine chest X-rays are still taken upon hospitalization and before any surgical procedure.

- **Dental studies**, which are usually done every two years to detect cavities and other dental problems.

- **Hysterosalpingography (HSG)** is one of several X-ray studies of the female reproductive tract. It entails taking X-rays of the uterus and fallopian tubes after injection of a contrast medium.

There are several sub-specialities:

- **Projection radiography**
  The creation of images by exposing an object to X-rays or other high-energy forms of electromagnetic radiation and capturing the resulting remnant beam (or "shadow") as a latent image is known as "projection radiography." The "shadow" may be converted to light using a fluorescent screen, which is then captured on photographic film, it may be captured by a phosphor screen to be "read" later by a laser (CR), or it may directly activate a matrix of solid-state detectors (DR--similar to a very large version of a CCD in a digital camera). Bone and some organs (such as lungs) especially lend themselves to projection radiography. It is a relatively low-cost investigation with a high diagnostic yield.

Other modalities are used in radiography when traditional projection X-ray cannot image what doctors want to see. Below are other modalities included within radiography:

- **Angiography**
- **Fluoroscopy**
- **Dual energy X-ray absorptiometry**
- **Computed tomography**

### Procedure

#### Persons

Medical diagnostic radiography is undertaken by a specially trained professional called a diagnostic radiographer in the UK, or a radiologic technologist in the USA.

Generally you will be cared for by a radiographer, but your film will be examined and reported on later by the radiologist, sometimes assisted by a radiographer.

#### Factors affecting results

It is essential to remain motionless during the x-ray, since movement causes the resulting picture to be blurry. Sometimes patients are asked to hold their breath briefly during the procedure. Children who are not old enough follow directions or who cannot stay still may need to be restrained or given medication to sedate them in order to keep them still enough to obtain useful results. Sometimes parents can stay with children during an x-ray, unless the mother is pregnant, in which case she must protect the fetus from x-ray exposure.

#### After procedure

For non-invasive diagnostic x-ray procedures, the patient is dismissed immediately after the films have been reviewed, and little or no aftercare is necessary.

#### Experience
You will not feel any pain and apart from having to remain still for a short while, you experience no discomfort.

**Process**

X-ray procedures are administered in a hospital or clinical setting. Most procedures may be conducted on an outpatient basis. The time required for the procedure may vary from a few minutes to more than an hour. There is little or no discomfort associated with diagnostic x rays.

The general procedure for diagnostic x rays include:

- proper positioning and shielding of the patient
- administering contrast dyes, if necessary
- administering radiation
- review of the films by a technician to insure proper imaging
- Scheduling a time to review the films with the radiologist. However, if fluoroscopy or angiography is used, the procedure is dynamic (in motion), and the radiologist is present during the x ray administration.
- dismissal of the patient

You will be taken into the X-ray room where you will stand against a frame or part of the machine. Although the radiographer will go behind a screen, you will be seen and heard at all times should you have a problem.

You will be asked to stay still and sometimes to take a deep breath in and hold it for a few seconds. You might hear a slight whirring noise as the machine becomes fully running, but you will be unaware of the fraction of a second when the X-ray source is active.

**Duration**

15-20 minutes, depends on procedure

**Precautions**

Before consenting to any x-ray procedure, the patient should consider the impact of existing medical conditions or medications. Sensitivities to contrast dyes may produce allergic reactions. Pregnant women or those who suspect they might be pregnant should consult a physician prior to x-ray treatments to avoid injury to the fetus. Nursing mothers may be required to store enough milk to last for 48 hours following certain procedures. Patient age should always be taken into consideration when choosing the type and intensity of x ray. Patients should be aware that some prescribed cancer medications act as radiosensitizers and amplify the effect of x rays. Any patient with a suppressed immune system or diabetes may require special x-ray procedures.

**Preparation**

No special preparation is needed for fixed plate x rays unless contrast material is used. When x rays are scheduled that involve the use of contrast material, the physician will give specific instructions for preparation. For example, in a lower GI series, the individual may have to fast and use special laxatives to cleanse the bowel before swallowing the contrast material. Parents can prepare children for x rays by explaining what will happen and that these tests are short and painless.

**Results**
The film will be examined shortly after your visit, and a report on the findings written. This may take some time to reach your referring doctor, but is normally available in less than 14 days. You could ask the radiographer or radiologist for some indication of time.

**Normal results**
Diagnostic x rays provide detailed information that the physician can use to determine the best approach to correct or control a medical problem. Normal results would indicate no existing abnormalities.

**Abnormal results**
Abnormal results would indicate irregularities such as a tumor, an enlarged lymph node, or pleural effusion. Although highly unlikely, diagnostic x-ray films can be misread and the wrong diagnosis made.

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**Consideration**

**Importance**
X-ray images of the skull, spine, joints, and extremities are performed every minute of every day in hospital emergency rooms, sports medicine centers, orthopedic clinics, and physician offices. Images of the injury can show even very fine hairline fractures or chips, while images produced after treatment ensure that a fracture has been properly aligned and stabilized for healing. Bone x-rays are an essential tool in orthopedic surgery, such as spinal repair, joint replacements, or fracture reductions. X-ray images can be used to diagnose and monitor the progression of degenerative diseases such as arthritis. They also play an important role in the detection and diagnosis of cancer, although usually computed tomography (CT) or MRI is better at defining the extent and the nature of a suspected cancer. On regular x-rays severe osteoporosis is visible, but bone density determination detects early loss of bone density. Bone density determination is usually done on special equipment.

**Benefits**
X-rays are relatively inexpensive compared to CT scans and other imaging studies; the equipment is readily available in most hospitals and many doctors’ offices. The examinations are painless and quick.

**Risks**
A general rule for x rays suggests that the beneficial effects of x rays far exceed the risks involved. As a result of certified training and strict guideline compliance, risks from technical application are essentially nonexistent. However, for any x-ray procedure, radiation exposure is always a concern, and although uncommon, the risk of infection during invasive techniques can not be discounted.

Low dose exposure to x rays creates minimal cell damage and minimal risk when x rays are performed in an accredited facility. There is an increased risk that a developing fetus will develop leukemia during childhood if exposed to x-ray radiation; pregnant
or potentially pregnant women should avoid x rays. There is also a slight risk of an allergic reaction to the contrast material or dye used in certain x rays.

**Limitations**

Plain X-rays often do not provide adequate details about internal organs, blood vessels, and other soft-tissue structures.

**FAQ**

Radiography started in 1895 with the discovery of X-rays (later also called Röntgen rays after the man who first described their properties in rigorous detail), a type of electromagnetic radiation. Soon these found various applications, from helping to find shoes that fit, to the more lasting medical uses. X-rays were put to diagnostic use very early, before the dangers of ionising radiation were discovered. Initially, many groups of staff conducted radiography in hospitals, including physicists, photographers, doctors, nurses, and engineers. The medical speciality of radiology grew up around the new technology, and this lasted many years. When new diagnostic tests involving X-rays were developed, it was natural for the radiographers to be trained and adopt this new technology. This happened first with fluoroscopy, computed tomography (1960s), and mammography. Ultrasound (1970s) and magnetic resonance imaging (1980s) was added to the list of skills used by radiographers because they are also medical imaging, but these disciplines do not use ionising radiation or X-rays. Although a nonspecialist dictionary might define radiography quite narrowly as "taking X-ray images", this has only been part of the work of an "X-ray department", radiographers, and radiologists for a very long time. X-rays are also exploited by industrial radiographers in the field of nondestructive testing, where the newer technology of ultrasound is also used.