BETTER IMAGING: THE ADVANTAGES OF DIGITAL RADIOGRAPHY

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https://doi.org/10.5281/zenodo.11398869

***Abstract**. X-ray scanners are devices used to obtain fluoroscopic images. These scanners are used in various fields: security, flaw detection, medicine etc. Sometimes X-ray scanners are called medical X-ray machines. Medical x-rays are used to generate images of tissues and structures inside the body. If x-rays traveling through the body also pass through an x-ray detector on the other side of the patient, an image will be formed that represents the "shadows" formed by the objects inside of the body. In medical applications, X-ray machines are used by radiographers to acquire x-ray images of the internal structures (e.g., bones) of living organisms, and also in sterilization. X-rays pass through objects, including internal organs, body tissue and clothing. The x-rays project a picture onto film or send a digital image to a computer. Bones appear white on x-ray images because denser objects absorb more radiation. Less dense parts of the body, such as skin and muscles, remain dark on x-ray images because the radiation passes through them. There are two types of X-Rays: Traditional and Digital X-Ray.*

***Keywords**: detectors, flat panel detectors, radiation, radiography, conventional radiography.*

INTRODUCTION:

A digital x-ray is an imaging technology that uses digital sensors to electronically capture and store x-ray images, instead of using traditional film. This technology has largely replaced the use of film in modern medical imaging because it offers a number of advantages over traditional film x-rays. In digital x-rays, the x-ray machine uses a sensor to capture the image, and the resulting image is immediately available on a computer screen. This allows the radiologist or technician to view and analyze the image more quickly and easily than with film x-rays. Digital radiography, also known as direct digital radiography, uses x-ray–sensitive plates that directly capture data during the patient examination, immediately transferring it to a computer system without the use of an intermediate cassette as is the case with CR.

Digital x-rays also offer the ability to enhance and manipulate the image digitally, allowing for more accurate diagnosis and better visualization of subtle details. Additionally, digital x-rays require lower radiation doses than film x-rays, which makes them safer for patients.

Overall, digital x-rays provide a faster, more accurate, and safer way to diagnose and treat a wide range of medical conditions. Today, digital x-ray technology is widely used in medical imaging and has largely replaced traditional film x-rays. Digital x-ray systems are faster, more accurate, and safer than traditional x-rays, and they offer the ability to manipulate images digitally, making them a valuable tool for diagnosis and treatment planning

MATERIALS AND METHODS:

History of the Digital X-Ray:

The first computed tomography (CT) scanner was invented in 1972, which allowed for three-dimensional imaging of the body's internal structures. This paved the way for further developments in digital imaging and x-ray technology.

• In the 1980s, researchers began to experiment with digital radiography, which used electronic sensors to capture x-ray images. These early digital radiography systems were large, expensive, and not widely available.

• In the 1990s, the first commercially available digital x-ray systems were introduced. These systems used flat-panel detectors to capture x-ray images and were much smaller and more portable than earlier digital radiography systems.

• In the early 2000s, digital x-ray technology continued to evolve, with the development of new sensors and image processing techniques that improved image quality and reduced radiation exposure.

The history of digital x-ray technology is one of continuous innovation and improvement, driven by the need for more accurate and efficient medical imaging techniques.

The difference between conventional and digital X-Ray:

• Compared to traditional X-rays, digital X-rays provide better and clearer images with high resolution that can be enlarged or manipulated as needed, minimizing the need for repeating the procedure.

• Since traditional X-rays are printed on a film, there is no chance of tampering with them.

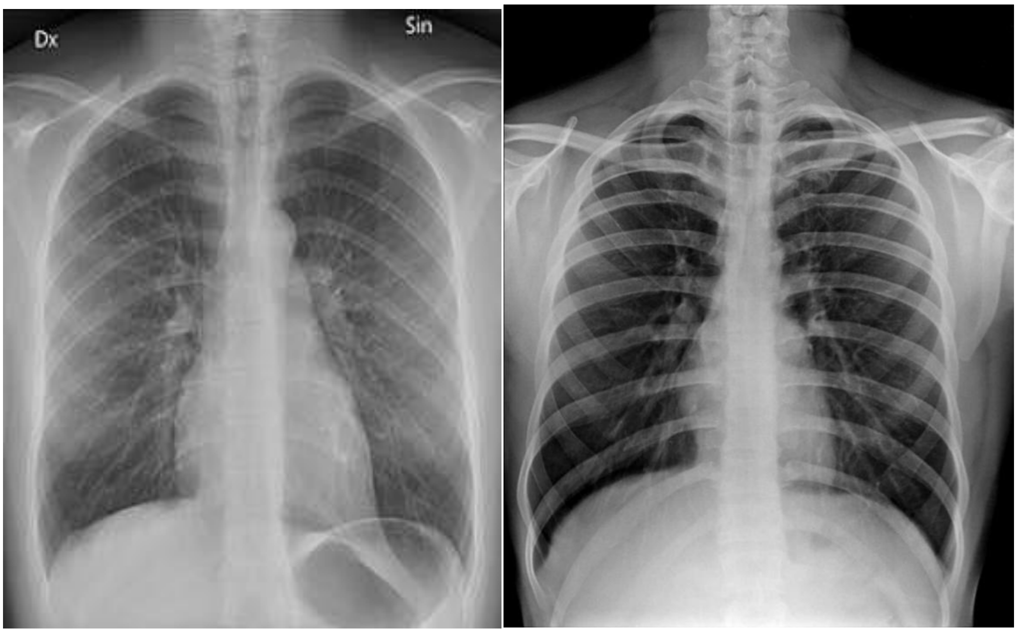

Figure 1. The picture taken by Conventional X-Ray. The picture taken by Digital X-Ray.

The advantages of Digital Radiography:

Digital X-rays provide a number of advantages over their predecessor. Digital X-rays produce images with better resolution, more clarity, and highly detailed images. Not only does improved clarity help improve diagnoses and shape your treatment plan, but the images themselves can be digitally manipulated or brightened using computer software. Digital X-rays expose you to significantly less radiation. Though traditional X-rays emit only small amounts of radiation, digital X-rays emit even less. Digital X-rays use digital rather than film technology. This allows your provider to begin developing a treatment plan faster. Additionally, you do not have to wait to find out whether the initial scan provided a clear image. Your provider knows this instantly, and a second X-ray can be taken on the spot. If an area in your X-ray is difficult to see, the contrast can be increased or decreased. This gives a better view of the area of concern and helps ensure an accurate diagnosis. Following your exam, your X-rays can be sent to your provider with the click of a button. Using secure and encrypted technology, your images reach your provider safe and sound. There is no time wasted or risk of losing the images, which can occur when handling printed X-ray images. Though traditional X-rays emit only small amounts of radiation, digital X-rays emit even less. Digital radiography was introduced to:

- Improve care for patients
- Support better outcomes for patients
- Expand capabilities of consultation
- Enhance the interaction of client

Greater Image Versatility with Digital Radiography:

The ability to manipulate, magnify, and modify digital images, thanks to DR technology, gives medical practitioners a more precise understanding of a patient's condition. The capability to adjust image contrast and brightness after image capture is one of the main advantages of DR technology. Filters that emphasize bone tissue, for instance, can be used to enhance images of bone structures, making it simpler to spot fractures and other bone-related diseases. Additionally, DR technology offers more flexibility in communication and image sharing, allowing for remote diagnosis and consultation by sharing digital images between medical practitioners working in various places. This can result in better patient outcomes in addition to time savings.

Workflow Integration with Digital Radiography:

Workflow integration is a critical advantage of DR that healthcare providers should consider. DR systems can be integrated into existing radiology operations, which can streamline the process of capturing, storing, and accessing images. This integration can result in improved patient care, as healthcare providers can more efficiently review and interpret medical images, leading to faster diagnosis and treatment.

To ensure that healthcare personnel can effectively use the new DR system, comprehensive training, and ongoing support are crucial. This includes training on how to use the new system, as well as troubleshooting any potential issues that may arise. Workflow integration is a key advantage of DR that can significantly improve healthcare provider efficiency, patient care, and resource utilization.

More Environment Friendly:

When it comes to traditional film-based radiography, a significant amount of waste is generated from the chemicals used in film processing. These chemicals can be hazardous to both human health and the environment, and they must be properly disposed of as hazardous waste.

In contrast, DR eliminates the need for film and chemicals altogether. Images are captured electronically and can be stored, viewed, and shared digitally. This way, there is no need for chemicals to develop film, and there is no physical film that needs to be stored or disposed of. By eliminating the use of chemicals and film, DR significantly reduces the amount of waste generated and helps to reduce the environmental impact of healthcare operations.

Reduced Radiation Exposure:

The ongoing effort to reduce radiation exposure for patients during x-ray exams is likely to continue, with new techniques and technologies being developed to further minimize the risk. The future of digital x-rays looks very promising, with continued advancements in technology likely to lead to more accurate diagnoses, better patient outcomes, and improved efficiency in medical care.

AI integration:

As artificial intelligence continues to develop, it will be integrated with digital x-rays to help identify potential health issues and assist doctors in making accurate diagnoses.

Enhanced Image Manipulation Capabilities:

DR offers enhanced image manipulation capabilities, which allows radiologists to manipulate and adjust the images to improve their quality and accuracy. This level of control is not possible with traditional film-based radiography, which often requires repeated exposures to obtain the desired image quality. With DR, images can be easily adjusted to compensate for over or underexposure or to highlight specific areas of interest.

Moreover, DR provides advanced image processing tools that enable radiologists to enhance images for diagnostic purposes. For example, with DR, the contrast, brightness, and sharpness of an image can be adjusted to reveal details that may not be visible in a traditional film-based image. This allows radiologists to make more diagnoses that are accurate and improve patient outcomes.

Summing Up:

DR technology has revolutionized the field of radiology, offering faster, more accurate, and more efficient imaging capabilities than ever before. With continued advancements in technology, it is likely that DR will become even more widely used in the years to come.

Compared to conventional radiography using film, DR has a number of benefits. The equipment is adaptable, cost-effective, and produces high-quality diagnostic images that are simple to edit and share. By investing in this advanced imaging equipment, healthcare facilities may enhance patient care and outcomes, thanks to the various advantages of DR technology.

Cost and Space Savings with Digital Radiography:

DR technology eliminates the need for physical X-ray films, which saves a significant amount of storage space. It helps healthcare establishments with limited space by reducing the cost of storage facilities. The cost of X-ray imaging is greatly decreased by DR technology's ability to do away with the requirement for expensive film processing chemicals. Using DR technology, digital images are taken and electronically preserved, doing away with the requirement for physical X-ray film storage.

Cost reduction is also a result of less frequent equipment maintenance and repair requirements. In the case of conventional radiography, poor image quality brought on by patient movement or wrong exposure settings may need further radiation exposure as well as rising expenditures for the patient. The use of retakes is decreased, thanks to the ability to view photos immediately on a computer screen and make tweaks to improve image quality. Current range - 10-800 mill amperes; Voltage range - 40 ~ 150 kilovolt.

Faster and More Efficient:

Digital radiography has revolutionized the speed and efficiency of the radiology process. With traditional radiography, the process of capturing an image is much more time-consuming. The technician had to use X-ray film, which then needed to be developed in a darkroom before the image could be viewed. This process could take anywhere from several minutes to several hours, depending on the type of film used and the conditions in the darkroom.

In contrast, DR systems allow for almost instantaneous image capture and display. The X-ray image is captured and transmitted to a computer screen in real-time, making the entire process much faster and more efficient. The digital radiography pictures produced can be easily viewed, manipulated, and transmitted to other healthcare providers, improving the speed and accuracy of the diagnosis.

This increased efficiency has a positive impact on patient care. Faster image processing and transmission allow doctors and specialists to make quicker and more accurate diagnoses, which can lead to faster treatment and improved outcomes. It also means that patients spend less time waiting for results and can receive prompt care.

Digital X-Ray machine parts:

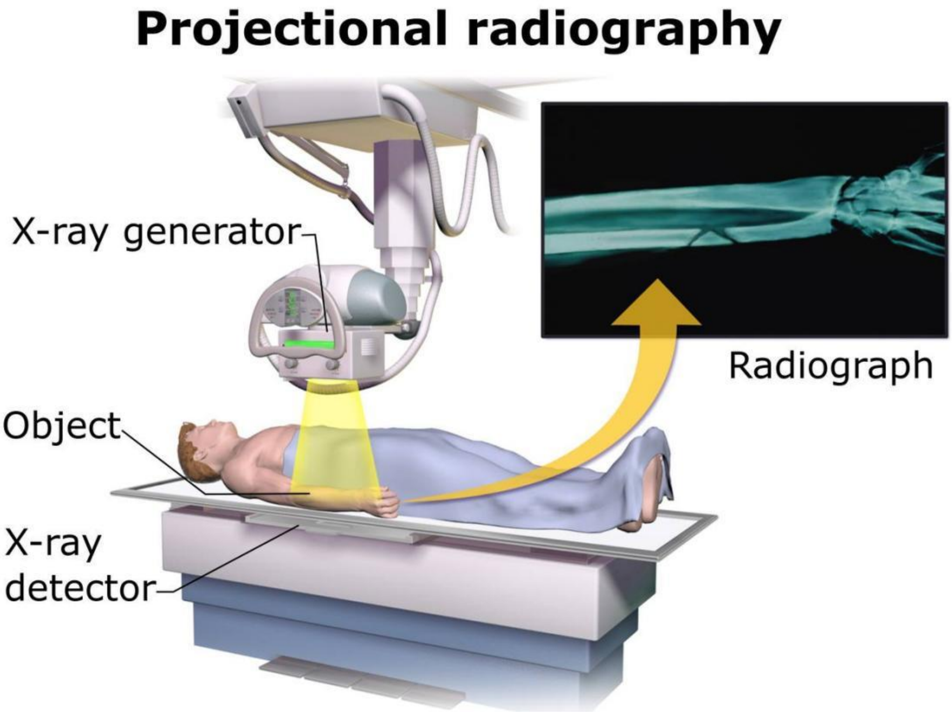

Figure 2. They have two main parts that allow them to operate: the X-ray generator and the image detection system (and object).

The X-ray generator is made up of four components that work together to generate the X-ray. This includes the X-ray tube, the high-voltage generator, the control console, and the cooling system. The X-ray tube contains a tube cathode or filament that creates a current of electrons. The high-voltage generator is between the cathode and the anode of the X-ray tube and creates a high-voltage potential. The control console contains adjustable controls that regulate the tube amperage, voltage, and exposure time. Likewise, the cooling system uses a water or oil recirculation system responsible for cooling the anode. The image detection system captures the image generated by the X-ray generator. The X-ray generator produces X-rays when an electrical current is applied to it. The X-ray generator is a device that acts as the primary control mechanism for the entire fluoroscope. It is through the X-ray generator that current is allowed to flow into the X-ray tube. The basic function of adjusting the voltage differential and current of the X-ray tube are controlled automatically to maintain optimal contrast and brightness. Generator types used in fluoroscopy include single phase, three phase, constant potential, and high frequency. High-frequency generators provide superior exposure reproducibility along with the most compact size, lowest purchase price, and lowest repair costs. As a result, high-frequency generators are commonly used in new radiographic equipment.

X-ray detectors are devices used to measure the flux, spatial distribution, spectrum, and/or other properties of X-rays. Detectors can be divided into two major categories: imaging detectors (such as photographic plates and X-ray film (photographic film), now mostly replaced by various digitizing devices like image plates or flat panel detectors) and dose measurement devices (such as ionization chambers, Geiger counters, and dosimeters used to measure the local radiation exposure, dose, and/or dose rate, for example, for verifying that radiation protection equipment and procedures are effective on an ongoing basis.

Flat-panel detectors are a class of solid-state x-ray digital radiography devices similar in principle to the image sensors used in digital photography and video. Flat panel detector (FPD) is the most common detector type used in direct digital radiography (DR). They are used in both projectional radiography and as an alternative to x-ray image intensifiers (Ils) in fluoroscopy equipment. The x-rays are converted to electrical charges, either directly or indirectly (x-rays first converted to visible light, then to charges). The charges are then read out using a thin film transistor (TFT) array. Flat-panel detectors are more sensitive and faster than film. Their sensitivity allows a lower dose of radiation for a given picture quality than film. The efficiency of X-ray detector systems is characterized by how well they receive photons and how much noise is added to the detected signal. This is measured by quantum efficiency or DQE. 100% DQE means that every X-ray photon is detected and there is no noise at all. Currently, the commonly used detectors are mainly amorphous silicon (A-Si) flat panel detectors. Its image sensors consist of photodiode arrays with two-dimensional pixelization, each pixel containing a thin film transistor (TFT) and a photodiode.

TYPES:

Indirect flat panel detector

Construction of an indirect flat panel detector:

- Scintillator layer made of cesium iodide (CsI)
- Photodiode made of amorphous silicon (a-Si)
- TFT readout array

X-ray photons encounter a cesium iodide (CsI) scintillator and are converted to visible light. The needle-like CsI structure acts to minimize scatter at this step. The light then reaches a low-noise amorphous silicon (a-Si) photodiode array where it is converted into an electrical charge. Each photodiode represents a single pixel, and each produces an electrical charge that is read out digitally by the TFT array layer underneath before finally being sent to the image processor.

Direct flat panel detector

Construction of a direct flat panel detector:

- High voltage electrode
- Photoconductor layer made of amorphous selenium (a-Se)
- TFT readout array

This technique employs a semiconductor material which produces electron-hole pairs in proportion to the incident x-ray intensity. The most commonly used semiconductor is amorphous selenium (a-Se).

A digital radiography (DR) system mainly includes an X-ray generating device, a flat panel detector, a system controller, an image display, an image processing workstation and other components.

Object

Objects are humans or human body parts, which are scanned by radiologists.

The disadvantages of this technology are:

1) The technology is expensive

2) Digital X-ray technology is generally less flexible and less portable than traditional X-rays.

CONCLUSION:

Digital X-ray machines, which are at one of the highest points of current development speed when it is compared with traditional X-rays, these X-rays have less radiation, have the advantages of digital imaging and high energy processing, determine where to get the image. It also has a motion detector and is slightly easy to use.

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