

Dose Optimization and Image Quality in Digital Radiography: A Review Article

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Abstract

Imaging techniques have been upgraded due to the invention of digital radiography. This advancement has made a massive change in the development of diagnostic procedures. This technique has displaced conventional radiography with digital methods of radiography. This radiography technique was accepted in all kinds of radiography, excluding mammography. There are many assets of using a digital process for imaging, like good quality of image with less dose. It gave accurate diagnosis for assured quality of image with high resolution and to avoid overdose proper guidelines are needed. The technician should be well trained and have adequate knowledge of the appropriate use of digital radiography. The flat detector system depicts a more efficient way to form an image of high quality with a low dose; the quality of the image increases due to the storage phosphor. Many institutions have accepted this digital radiography as it has proven beneficial for diagnostic procedures. Digital radiography has a flat panel detector that results in a high-resolution image. It has been noticed that screen-film radiography has been superseded by Digital radiography. Nowadays, manufacturers have made many improvements derived from the detector and different technology to Digital radiography equipment. Due to digital imaging techniques, x-rays are allowed to store digitally that can use anytime by adjusting contrast according to the interest of vision. This technology has given assurance of not losing any radiograph and allows dispensing throughout hospitals digital by online technology derived from the web. There are so many assets of using digital radiography as it increases patient count. The vigorous high scale of the digital detector with as low as possible radiation dose for the proper usage of this technology, radiologists and radiographers should have adequate knowledge of various technical postulates & image calibre. They should know how to tackle the problem of overexposure or radiation dose.

Keywords: Digital Radiography, Conventional fluoroscopy, ALARA, Noise.

INTRODUCTION

Due to the invention of digital radiography, great diagnostic detail has become accessible to radiologists. Its innovation also helps improve the film processing process, its availability & its secure store. So many efforts have been taken to enhance the quality of images in less dosage form using digital radiography. The ALARA [as low as reasonably achievable] principle states to have adequate calibre radiograph at less dosage [1]. Digital radiograph has their advantage for the technician as it reduces the effort and time that has to be taken by the radiographer.

As we know, radiation hurts the human body. It can cause severe damage to the body and even sometimes proves fatal if overexposure has been given; therefore, regulation of dose and quantity is essential. As we are noticing, the importance of computers is increasing daily in every field, like in radiography.

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The change in quality can be easily seen in digital radiography than in computed one. Digital radiography has taken the place of manual working. Conventional radiography and fluoroscopy favour physicians to diagnose more precisely [2]. For digital radiography, precise guidelines must guarantee high image quality with less exposure and avoid misdiagnosis. The European community will decide on the following guidelines, including all parameters. Digital radiography is the one where direct radiography is taken using ionizing radiation. There are many benefits of using this type of Radiology where we can set the contrast according to our wishes. [3] Due to digital imaging techniques, x-rays are allowed to store digitally that can use anytime by adjusting contrast according to the interest of vision. This technology has given assurity of not losing any radiograph and allows dispensing throughout hospitals digital by online technology derived from the web. There are so many assets of using digital radiography as it increases patient count. With the vigorous high scale of the digital detector with as low as possible radiation dose for the proper usage of this technology, radiologists and radiographers should have adequate knowledge of various technical postulates. In previously computed radiography, storage phosphor screens (S.P.S.) were used, whereas a Flat Panel Detector (FPD) is used in digital radiography [4].

This advancement has made a massive change in the development of diagnostic procedures. This technique has displaced conventional radiography with digital methods of imaging. This imaging technique was accepted in all kinds of radiography, excluding mammography. There are many assets of using a digital process for imaging, like good quality of image with less dose. It gave accurate diagnosis for assured quality of image with high resolution. [2]

PHYSICAL PRINCIPLES OF DIGITAL RADIOGRAPHY:

Digital radiography and screen-film radiography do not have much difference in physical postulates. Still, one difference in film-screen radiography Detector and Storage mechanisms occurs on a single film. When we talk about digital radiography, only there is a detector that detects the signal or impulse, but it is stored in digital means of communication.

There are four different steps:

- GENERATION
- PROCESSING
- ARCHIVING
- IMAGE PRESENTATION

In digital radiography, x-rays are expelled from the x-ray tube then, these x-rays are captivated in the detector. After the engrossment, x-rays are converted into electrical charges. After those electrical charges get digitized and form a digital image, that image is then altered as per desire according to the diagnostic point of view. When the image is ready, it is saved in storage. Each radiograph is attached

to its patient's name or Demographic data during this procedure. We can take a hardcopy or print radiograph and visualize it on the monitor. Facilities available in Monitor are ZOOM, P.A.N., ANGLE, ROTATE, CROPPING, CONTRAST everything that helps the most during diagnosis and that image also dispenses over LAN (LOCAL AREA NETWORK) this has also proven very advantageous during diagnosis.[4]

DIGITAL IMAGING:

The digital image can be obtained by computed radiography. The flat-panel detector is used in digital radiography that captivates the x-ray photos that concerted into electrical signals that give us a digital image on the computer. The number of x-rays scattered and absorbed by the detector depends on the value of detective quantum efficiency. [4] There are two different processes for a forecast of x-ray: Digital Radiography and Conventional Radiography. In these two radiographic, ionizing radiations are used. Still, x-ray film is eternal in conventional radiography, where manipulation can't be done after, whereas the image is obtained in the detector and saved digitally. However, many users are unaware of the advancement in digital radiography, which is why they face difficulties in usage.

The imaging capacity in Digital radiography is set apart by excessive D.Q.E. [DETECTIVE QUANTUM EFFICIENCY]. It is a wide vigorous scale and has chances of rectifying other registers & conduct details. In short, we can say that we can get images at less dosage with enhanced calibre due to high quantum efficiency. Still, for the proper use of the modality, knowledge should be adequate to avoid malpractice, resulting in a smaller calibre and creating confusion in pathology. Therefore, knowing both radiography (conventional and digital) is necessary for developing new plans of regulation of dose.[5] If improper results come out because of an artefact, it can dement the pathology [2].

DETECTIVE QUANTUM EFFICIENCY (D.Q.E.)

For Image calibre, DETECTIVE QUANTUM EFFICIENCY is one of the essential/basic postulates. The word EFFICIENCY refers to the ability of the detector to captivate the x-ray photons and convert them into electrical charges, which then get transferred to computer modality by four different steps of generation- processing -archiving - Image presentation for use. Measurement of detective quantum efficiency can be done by making a comparison of the signal with Noise. It is dependent upon the input and output ratio. D detective quantum efficiency depends on D.Q.E. (D detective quantum efficiency): RADIATION DOSE, PERCEPTUAL FREQUENCY, and MODULATION TRANSFER FUNCTION (M.F.T.). D.Q.E. can also get affected by voltage and current given during exposure. If the D.Q.E. is higher than exposure needs a low radiation dose. The result of applying all aspects and quality of image can be obtained, or in other words, image calibre can be improved. D.Q.E. is the property of a detector. A perfect ideal detector should be

of one value of D.Q.E. If the D.Q.E. is of value one of the detectors, the number of scattered radiations will be less, and all the x-ray photons get absorbed into a detector, resulting in a high-resolution image. In a digital detector, the value of D.Q.E. is always less than the value of one.[4]

MODULATION TRANSFER FUNCTION:

It is the property of FLAT PANEL DETECTOR in digital radiography. Where the input is given to its output, it deals with the image's resolution, its opacity sizes etc.; This can adjust contrast. The usual range of displays ranging from 0 to 2 cycles/mm results in the demands of the higher Modulation transfer function. It helps in adjusting the contrast [4].

CLINICAL STRATEGIES:

In hospital practices, mostly abdomen, chest x-ray, and G.I.T. tract radiography is executed. In digital radiography, we can reduce the dose according to the part that must be exposed, choosing the precise examination parameter that should be dealt with between patient radiation dose and clinical situation.[6] Likewise, CT (COMPUTED TOMOGRAPHY) procedures recommend less dosage for the pediatric patient. This modification should be done in machinery, which can be done with digital radiography. During operations, a clear goal should be set by a technician that while performing any radiography, the satisfaction of physicians can be met by his radiography avoiding repeated shoot.[2]

The vast scale of imaging capacity of digital radiography permits the clinician potentiality to adjust image quality parameters. The dose for acquiring accurate results of the radiographic procedure-specific plan is needed [6].

Two important points for using Digital Imaging of modality:

1. Put in the principle of ALARA
2. Good quality of the image should be necessarily getting for diagnosis [1-2]

STRATEGIES OF OPTIMIZATION:

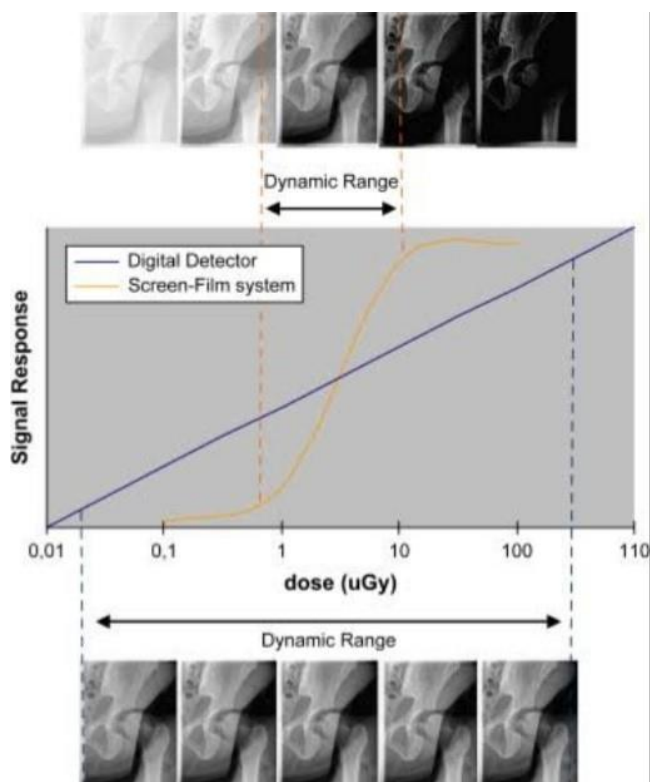


Fig 1: This image shows a dynamic range in which a digital detector concerning signal response forms a linear graph, and a screen-film system comprises a non-linear graph.

For clinical conditions, several diagnostic procedures require various types of equipment. This begins with an optimization strategy. Due to the improvement in clinical practices, the number of investigation criteria has been reduced. Reduced the radiation dose while performing radiography optimization is necessary that can be done by altering scientific limiting factors and the method used for imaging along with the preference for less threat to the victim and the radiographer. This is necessary because the radiograph should fulfil the need of physicians from which they will cure the patient, following all recommendations and everything. We can say the whole method in radiography is essential. When we are done with the image formation process, the image's calibre is similarly crucial, depending on the patient's situation.

For pathology assessment and different fractures, image calibre should be adequate. Otherwise, pathology can't be detected. For example, high image calibre is necessary to evaluate broken bones. Guidelines are improved conventional radiography to digital radiography and the medium class calibre 400 class speed with a film screening.

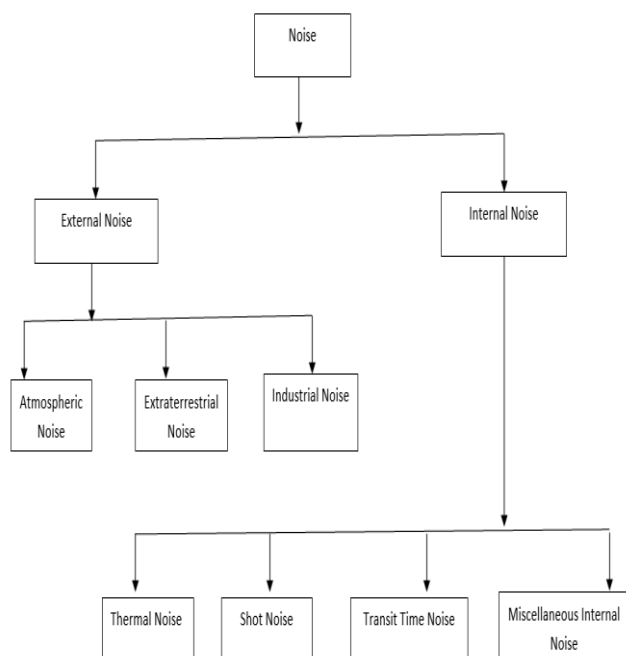
Post-processing plays a vital role in image quality for optimization & calibrations. The issue of post-processing is done by the BLACK BOX model connection between the input function. An output function can be explained by the BLACK BOX confines of the digital image. (Trojan horse) is

placed by a user input function. The output function then is examined in an exponent way. We can use phantom for experiments on image calibre [C.R. R.A.D. is an example of phantom].

Various speeds of 200,400 & 1600 get hold of with PHOSPHOR SYSTEM & FLAT DETECTOR AND FILM SCREEN COMBINATION. Calibre is distinguished into three classes low, medium & high, by exposure [2]

CONTROL ON QUALITY:

PHANTOMS exposure is helpful for quality control as it evaluates the entire chain. Post-processing storage and authentication of the film can give us Qualitative evaluation. It can be attained by considering the image calibre on the monitor. The imaging chain is divided into [ACQUISITION OF IMAGE, MONITORS, DOCUMENTATION, LASER FILMS]. Several parameters can be evaluated from the image calibre of a phantom test exposure. SMPTE TEST is used for authentication tests [2].



RADIATION EXPOSURE:

There is a high value of DETECTIVE QUANTUM EFFICIENCY (D.Q.E.) in digital radiography detectors than in screen-film radiography. Not only is the D.Q.E. factor, but also age calibre is better than screen-film radiography. It also can decrease exposure. Digital detectors have these two attributes over screen film. To avoid exposure, one must be much self-assured and confident during performing x-ray to avoid repeat shoots to reduce exposure. When we compare STORAGE PHOSPHOR SCREEN where the chances of decrement of radiation dose are less, only in Digital Radiography can be falling off due to S.Q.E. In digital radiography, as we are saying, the radiation dose is minimized. Still, the asset is there is no effect seen on image caliber [4-12].

DISCUSSION:

Busch S, Decker C, Schilz C, Busch HP.et.al (2004). Optimization of digital imaging by evaluating the image capacity of various procedures and organization pivot on dosage quantity. For this purpose, there should be a comparison between digital and film-screen radiography executed for different phantoms used for exposures.

CD-RAD phantoms are used for the differentiation of the image capacity. Several exposures were intricate in studies by using CD-RAD spirits at various kV. Four spectators were asses on their perception of the entity and were taken into account. The standardization has been observed in different convention film screens and digital radiography results. Overlapping the results is not seen in distinct organization FPD (flat panel detector) with velocity (speed class) 800 determine the similar tractability S.P.S. (storage phosphor system). A.D.S. 70 with speed class 200 is shown by the relative tractability of the distinct organization in the dose association. The quality of image, or we can say image calibre, is increasing daily with the increase in the invention in radiography or image calibre is increasing with the rise in developing generation. FPD (flat panel detector) allow the dose reduction. The clear divination in the outcome of the various procedure was seen in a distinct organization.

CD-RAD Phantom is used for studies on image capacity. The flat panel detector (FPD) determines the high image calibre compared to a conventional film-screen organization with a less effective dosage, and storage phosphor systems are used. There is an exception of speed class 400 to determine the similar superiority of flat panel detectors. Along with this, the image calibre of stored phosphor organization depends on the procreation of the system. After these experiments, it was seen that the worst results were gained in older formations as compared to a new generation. When a comparison between conventional and flat-panel detectors was made, an identical calibre was attained with less effective dosage. At that time, when experiments were carried out. The given parameters and techniques were unknown to the observer on the appraised parts. The final results were clarified into three classes (high, medium, and low). Digital analysis was graded as a high-calibre image. The film screen image was graded as a medium, and the same quality can be obtained if we give a double dose using A.D.C. 70. The digital analysis needed 25% of the amount correlated to film/screen radiography. [1] Okamura T, Tanaka S. et al. (2002): We get a proper compelling gap between the FPD (flat panel detector), film screen and phosphor storage. A flat panel detector has a high capability for reduction of the dose. The space in the image calibre between the art store phosphor organization and FPD has been reduced. The lowest calibre was generated by an older generation, A.D.C. - 70. [13-18]

When we compare conventional film screens and digital imaging, the digital organization creates immense image calibre with less dose. An increase in quantity leads directly to compelling increases in image calibre that had increased

diagnostic capability.

CONCLUSION:

Digital radiography offers many advantages by giving us the way to optimize and control image calibre. This Risk factor for patients and staff has also been reduced. Mainly it has proven too beneficial for a physician for diagnostic procedures, which reduces confusion while diagnosing any pathology. It has also provided safe storage and any time usage of store films with adjusting contrast. Its invention also helps improve the film processing Process, its availability, and its secure store. DIGITAL RADIOGRAPHY will supersede conventional screen-film radiography. There are many advantages to using FLAT PANEL DETECTOR for digital radiography over storage phosphor radiography. Later in a few days, traditional methods will discontinue radio diagnostic practice.

List of Abbreviations:

FPD: flat panel detector, A.D.C.: Analog to Digital Converter, D.Q.E.: Detective Quantum efficiency,

S.P.S.: storage phosphor system, ALARA: as low as reasonably achievable, D.R.: Digital Radiography, M.T.F.: Modulation Transfer Function, LAN: Local Area Network

Declarations:

Ethics approval and consent to participate:

Not applicable.

Consent for publication:

Not applicable.

Availability of data and material:

Not applicable.

Competing interests:

The authors declare that they have no competing interest

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