Achieve radiation dose optimization with the ImageVue DR50 Digital Imaging System

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When considering veterinary x-ray technology purchase options, it's important to appreciate the differences between systems and how those differences impact overall system performance such as diagnostic image quality and safety concerns related to radiation exposure.

This paper explores specific technical aspects of the ImageVue® DR50 Digital Imaging System and demonstrates how the system aligns with the emerging global radiation safety culture in veterinary medicine[1] using the principles of As Low As Reasonably Achievable (ALARA).[2]

IDEXX Diagnostic Imaging offers the ImageVue DR50 Digital Imaging System, which includes an indirect-conversion flat-panel detector (FPD) that uses a thallium-doped cesium iodide (CsI:Tl) scintillator layer combined with proprietary Irradiation Side Sampling (ISS) technology. Combining these two technologies along with a scintillator that is coupled to the thin-film transistor (TFT) substrate technology renders a digital radiography FPD that requires a 20%–50% lower dose of radiation (depending on anatomy) than computed radiography (CR) systems.[3,4] The improved FPD combined with anatomically specific customized postprocessing algorithms deliver optimized diagnostic images.[4] This system optimizes radiation dose while optimizing diagnostic image quality, which results in a reduction of the radiation dose to patients and staff.

Introduction

Detective quantum efficiency (DQE) relates to image quality, contrast, and levels of radiation needed to render x-ray images. The use of DQE has become the de facto benchmark to compare existing and emerging x-ray detector technologies.[5] The higher the DQE, the lower the required radiation dose for an optimized diagnostic image. The relatively high DQE of the ImageVue DR50 Digital Imaging System demonstrates the lowest optimized radiation dose while achieving optimized diagnostic image quality when compared to other digital imaging systems currently available.[6] The enhanced FPD image quality is a result of innovative flat panel design, improved manufacturing techniques, and proprietary image capture and processing algorithms.[4]

Enabling technology

Thallium-doped cesium iodide (CsI:Tl) scintillator

The CsI:Tl scintillator converts captured x-rays to visible light spectrum. The inherent lateral spread or "bloom" of the visible light is confined within the columnar structure of the CsI:Tl crystals and subsequently produces sharper images while demonstrating enhanced energy conversion efficiency by rejecting the lower energy scattered x-rays. Unlike other systems, utilization of the Irradiation Side Sampling (ISS) technology directs the light emission to the top of the panel rather than the bottom, resulting in less distance traveled by the light and therefore less degradative absorption of the light compared to conventional side sampling (CSS). The improved adhesive layer of the FPD delivers improved product durability.[6]

The method of x-ray photon utilization results in optimized conversion of the x-ray energy into a focused emitted light intensity. Because of the unique design of the FPD, there is more signal and less noise, producing an optimized image.[6]

Irradiated Side Sampling (ISS)

The ImageVue DR50 Digital Imaging System uses a Fujifilm® detector that is engineered with patented Irradiated Side Sampling (ISS) technology and designed to significantly reduce dose as much as 10%–20% compared to conventional detectors and 30%–75% compared to computed radiography (CR).[6] It shows a DQE performance that is 1.4 times that of conventional FPDs, enabling the potential for a reduced dose while optimizing diagnostic image quality.[6]

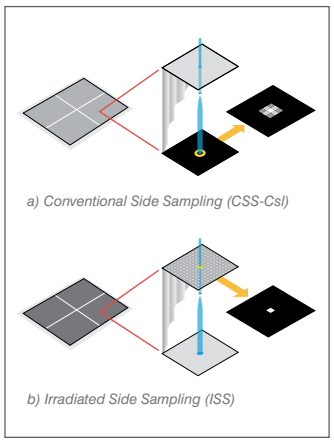

Figure 1. CSS-CsI versus Fujifilm's ISS[6]

System performance is further enhanced with ClearCapture Dx® Image Processing Software and radiation safety resources,[1,4] including site-specific technique charts that support optimized radiographic dose.

Benefits of ISS over CSS

- Increased sensitivity
- Improved image quality
- Higher detective quantum efficiency (DQE)
- Optimized radiation utilization due to improved energy conversion

When compared to the CSS method, the ISS method offers increased sensitivity with greater retention of signal and less (noise) degradation to image sharpness compared to a thicker scintillator layer.[7]

What makes ImageVue DR50 unique

The ImageVue DR50 FPD merges CsI:Tl technology and the ISS method, which is unique. The novel CsI:Tl FPD combines an adhesively coupled structure with the ISS method to provide significant image quality improvement and an optimized, reduced x-ray exposure for patients and clinical staff when compared to conventional CsI:Tl FPDs.[6]

Conversion layer methods to enhance x-ray absorption and reduce radiation dose

Image quality can be negatively affected by x-ray scatter (limited/reduced absorption), which contributes to nondiagnostic light conversion, signal loss (increased noise), and blurring (lateral spread, resulting in loss of contrast resolution). Imaging systems manage these factors with increased x-ray absorption using one of the two following methods:

Indirect-conversion FPDs, like the ImageVue® DR50 Digital Imaging System, sample scintillator light with less attenuation, diffusion, and scatter at the photodiode elements of the TFT substrate, resulting in more signal and less noise.[6]

Conventional FPDs improve x-ray absorption by increasing the thickness and density of the scintillator layer to improve scattered x-ray absorption. Since the generated light must travel a greater distance and scatter, the result is more noise and susceptibility to attenuation or loss of intensity (signal loss) due to increased light travel distance and lateral spread (resulting in bloom and blurring). In other words, less signal and more noise.[6]

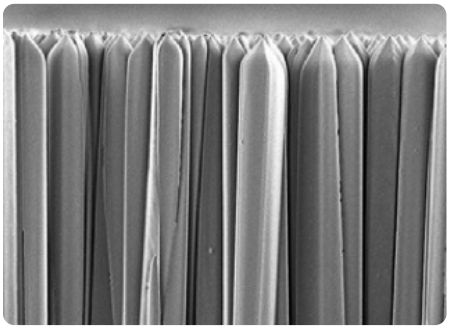

Figure 2. Scanning electron microscope (SEM) image of CsI crystals[4]

Gadox versus cesium

Cesium provides increased imaging efficiency and throughput, while delivering lower radiation to staff and patients.[6] Cesium iodide (CsI) when compared to gadolinium oxysulfate (Gadox or GOS) scintillators respond to a lower radiation dose to produce an optimal diagnostic image. This is due to the higher DQE of CsI compared to the unstructured granular GOS phosphor screen. Increased resolution of the CsI panels is also exhibited from the discrete parallel needle structures of the CsI scintillators, as well as higher contrast due to lower scatter collected by the crystals. The cesium detectors require less radiation dose for an optimal diagnostic image due to a higher light yield of the CsI, affording a lower dose to staff and patients.[8] Because CsI systems are 4–5 times more sensitive to radiation dose compared to GOS systems, a smaller increase in dose to CsI structures results in a more positive image quality improvement.[8]

Figure 3. ImageVue DR50 Digital Imaging System

Performance of the ImageVue DR50 system

Figure 4 shows the DQE and Modulation Transfer Function (MTF) results of the ImageVue DR50 detector and a conventional CsI:Tl FPD (Canon CXDI-55C Digital Radiography System®) performed under the same evaluation conditions.[6] The x-ray beam quality is RQA5 as specified by IEC standard,[9] at a dose of 1mR. The ImageVue DR50 FPD shows about 1.4 times the DQE performance as the Canon CXDI-55C system at 1 cycle/mm and makes it possible, in principle, to reduce x-ray exposure to the patient.[6] The ImageVue DR50 FPD also shows better MTF performance in the 1–2 cycle/mm range, improving the visualization of fine anatomical structure, such as bone trabeculae, pulmonary blood vessels, etc.

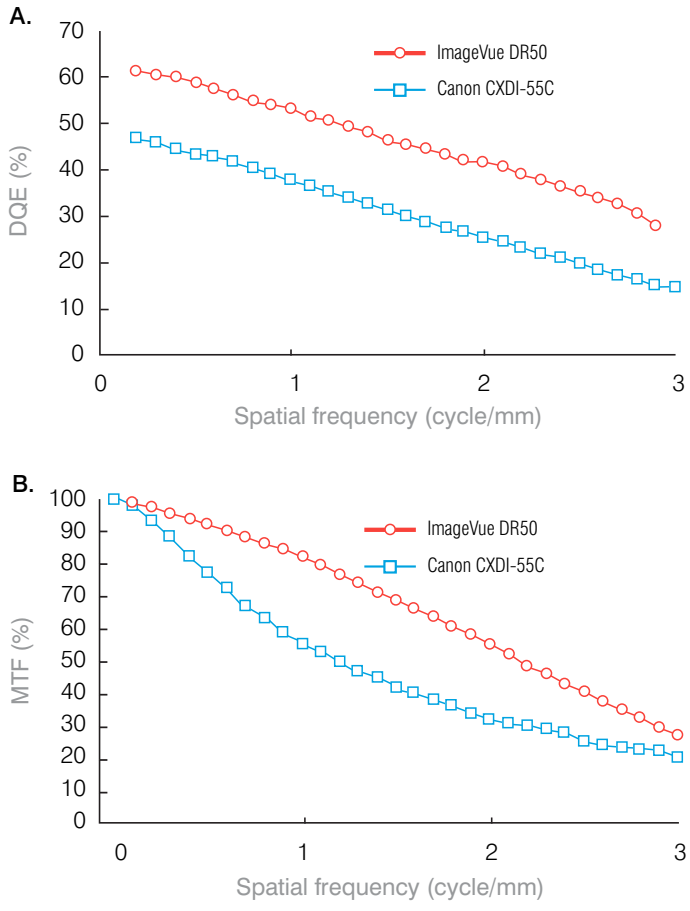

Figure 4. DQE (A) and MTF (B) curves of the ImageVue DR50 Digital Imaging System and conventional FPD based on panel-to-panel comparison[6]

Summary

IDEXX Diagnostic Imaging and Fujifilm have partnered to develop a higher-grade FPD model called the ImageVue DR50. It takes advantage of the potential of CsI:Tl scintillators not possible in conventional FPDs and demonstrates a superior DQE that is 1.4 times that of conventional FPDs.[1,6] In addition to the FPD, integration of ClearCapture Dx® Image Processing Software is advantageous for the promotion of a radiation safety culture by enabling the potential for a reduced radiation dose while improving image quality,[1,4] as referenced in IDEXX's *Radiation Safety Culture Management in Veterinary Medicine*. The ImageVue DR50 Digital Imaging System requires the lowest, optimized radiation dose while achieving optimal diagnostic image quality as compared to other digital imaging systems currently available.[4,6] The system is uniquely able to support fast, accurate clinical care.

IDEXX is dedicated to the advancement of safe, quality veterinary medical care.

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