CLINICAL TECHNIQUE: DIGITAL RADIOGRAPHY IN EXOTIC PETS—IMPORTANT PRACTICAL DIFFERENCES COMPARED WITH TRADITIONAL RADIOGRAPHY

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Abstract

The future of radiography will be digital. In exotic pet radiography, where some of the animals have a very low body weight and anatomic structures can be small, detail rendition plays an important feature in image quality. Veterinarians should be familiar with the technical principles, image quality criteria, and radiation exposure issues associated with the various types of digital systems currently available. This article discusses basic principles of digital radiography, technical solutions, and selected parameters characterizing detectors, processing, and monitors. An overview of reported experiences is given, and results from experimental clinical studies are reviewed to evaluate the current options and limitations in applying digital radiography to exotic pet medicine. Copyright 2012 Elsevier Inc. All rights reserved.

Key words: computed radiography; digital radiology; exotic pets; flat-panel detector; image processing; image display; radiology

Because of the advantages that digital image acquisition, distribution, storage, and display offer, digital radiology has become an established technology in veterinary practice.[1,2] The technical requirements that digital imaging systems have to fulfill mainly depend on the diagnostic task being performed. The majority of exotic pets are challenging cases for radiographic imaging because of their low body weight, subtle size of diagnostically relevant anatomic structures, low object contrast, and patient movement. Therefore, veterinarians working with these animals should be knowledgeable of the basic radiographic parameters, including technical principles, factors affecting image quality, and radiation exposure issues, to maximize the benefit of using radiography in these animals.

This article provides an overview of general principles and terms and technical requirements to be considered if a digital system should be used in exotic pet medicine, and individual case experiences. Detailed characteristics related to image quality and dose effects are also included. Other components, such as picture archiving and communication system and network strategies, are beyond the scope of this article and may be reviewed in other publications.

BASIC PRINCIPLES

The transition from conventional to digital radiography means that traditional principles of radiography have been abandoned. One of those differences relates to the fact that the images are electronically captured, distributed, viewed, and stored. For each of the individual elements of this imaging chain, several technical solutions are available (Fig 1). The steps can be optimized separately and therefore be adjusted to a specific user's predefined require-

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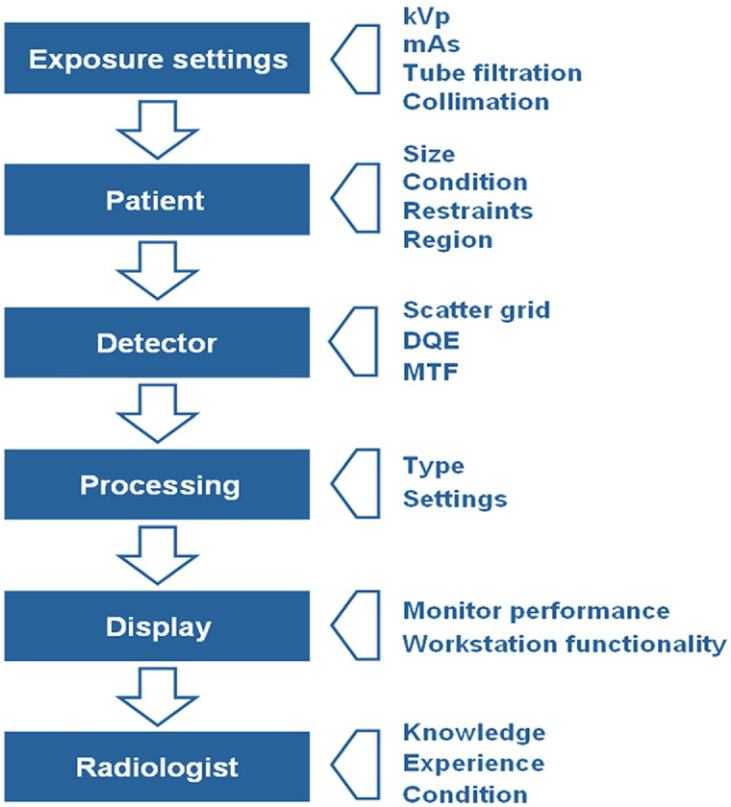

FIGURE 1. Factors affecting image quality: patient characteristics, performance of technical components, exposure settings, and interpretation steps.

ments. It has been shown that the performance of the individual elements of the imaging chain (e.g., signal acquisition, signal processing, image presentation), the adjustment of the links, and the exposure setting applied had to be optimal to achieve the needed level of image quality. Image quality is limited by the weakest step within the imaging chain.[3,4] Another important difference in screen-film radiography is that the dynamic range of digital detectors—its ability to record radiograph absorption differences—exceeds the range of screen-film systems more than 100 times (Fig 2).[4] The wider dose range can be used to record images with reduced exposure settings. On the other hand, the automatic adjustment of the grayscale makes it almost impossible to determine the dose applied for acquisition. Therefore, even obvious overexposures often do not affect the ability of one to adequately interpret a radiographic image (Fig 3).

The most fundamental physical image quality parameters are spatial resolution, contrast, and noise.

IMAGE QUALITY

The most fundamental physical image quality parameters are spatial resolution, contrast, and noise.[5] The emphasis of the 3 parameters differs between screen-film and digital radiography. In screen-film radiography, image quality is contrast limited, whereas in digital radiography noise is the major limiting factor in object detection. Consequently, the digital image quality is dependent on quantum statistics during image recording combined with contrast and spatial resolution enhancement methods that occur while the recorded signal is processed.[6]

Studies investigating detector characteristics required for veterinary practice have shown that systems currently used in human medicine also permit a sufficient image quality in animals.[7,8] Even in small animals with a body weight between 240 and 850 g (e.g., rodents, small reptiles, small birds), the achieved image quality was comparable with or even superior to those of screen-film systems.[9-11]

Spatial Resolution

Spatial resolution describes the ability of the system to individually distinguish neighboring structures. Spatial resolution is correlated with the intrinsic sharpness of the detector, which contributes substantially to the overall sharpness of the image. Other factors influencing the sharpness of a digital image are patient movement and subject contrast, which again are determined by object characteristics including beam quality, scatter radiation, and blur caused by the size of the radiograph focal spot.[12] The intrinsic sharpness of the detector can be characterized with a parameter called modulation transfer function (MTF). MTF represents how well an imaging system reproduces high contrast structures of varying size in the resulting image (Fig 4).[4]

Contrast

Contrast describes the brightness difference between 2 adjacent structures. The so-called characteristic curve can be used to characterize grayscale response of a radiographic system. The curve of screen-film systems is S-shaped, whereas the curve of a digital detector is linear (Fig 2).[4] Because of the wide dose range, digital systems "forgive" the vast majority of exposure faults. Image retakes due to inadequate exposure settings are very seldom required with digital imaging systems. However, extreme underexposure leads to grainy digital im-