DIGITAL RADIOGRAPHY BUYERS GUIDE: I BET YOU CAN'T DO THIS WITH YOUR CAMERA PHONE

BRIAN A POTEET, MS, DVM, DACVR, DABSNM

PRESIDENT AND MANAGING DIRECTOR, VITALRADS RADIOLOGY CONSULTANTS

ASSOCIATE PROFESSOR, COLLEGE OF VETERINARY MEDICINE, TEXAS A&M UNIVERSITY

ASSISTANT PROFESSOR, SCHOOL OF VETERINARY MEDICINE, ST. MATTHEWS UNIVERSITY

DIGITAL X-RAY

- Not a digital x-ray machine
- All digital x-ray systems use conventional x-ray machines found in all practices, hospitals, dental clinics and airport security stations

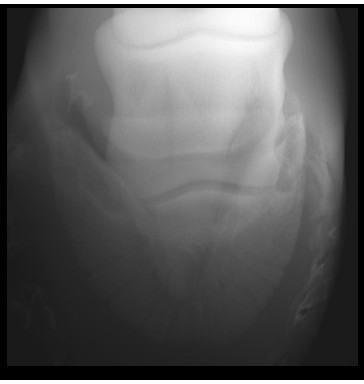
WHAT IS A "DIGITAL" RADIOGRAPH?

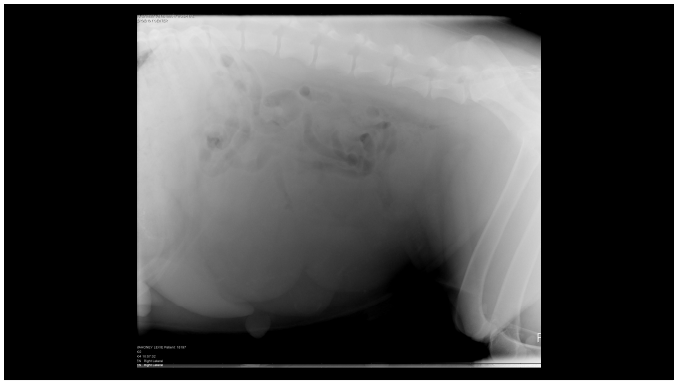
- Radiographic image that is obtained without using conventional film-screen techniques
- Images are stored electronically on a computer hard drive and can be viewed quickly on any networked monitor
- Can be exported to radiologists, clients or colleagues

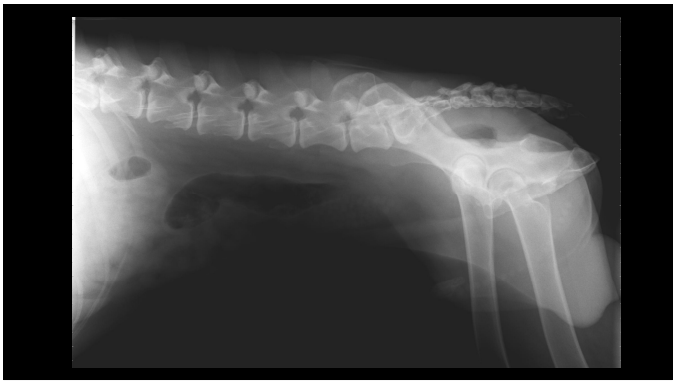
Large body parts are difficult with film

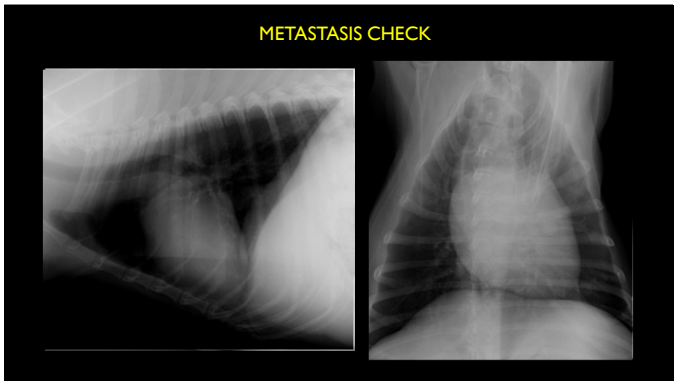
but portable digital systems

Digital image

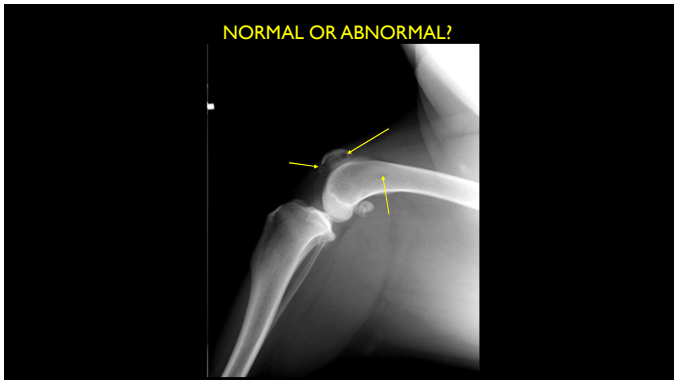







METASTASIS CHECK


NORMAL OR ABNORMAL?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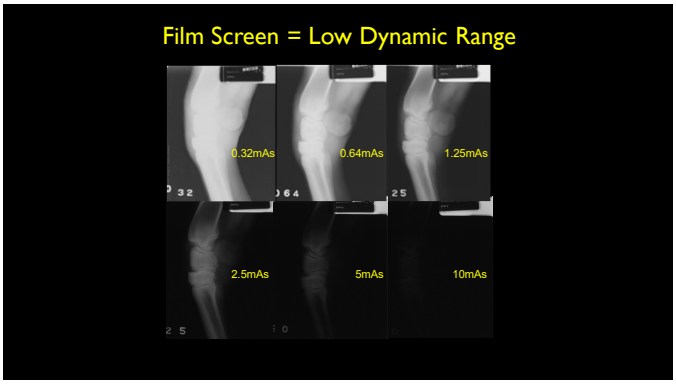
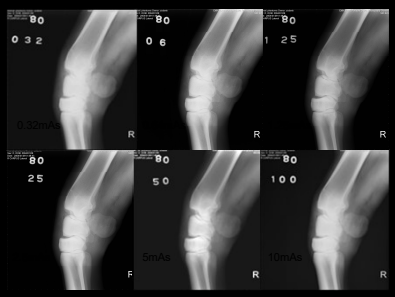
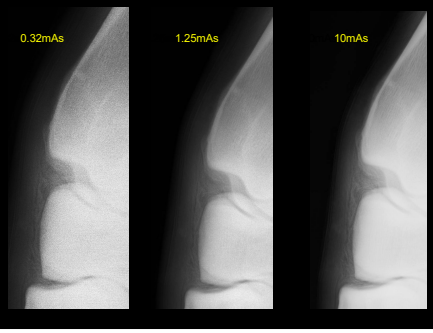

Film Screen = Low Dynamic Range
0.32mAs
0.64mAs
1.25mAs
2.5mAs
5mAs
10mAs

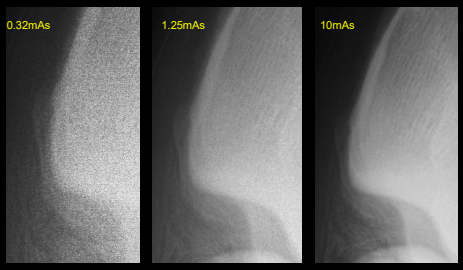
Digital Radiology = High Dynamic Range



WHEN THE IMAGES ARE ZOOMED…



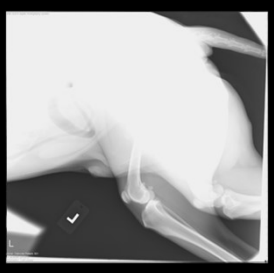
…NOISE!



Pixels and Line Pairs Don't Mean As Much As……Image Quality

Best and Easiest Test? Blow The Images Up!!

Can You See The Entire Image?



Do You Need To Adjust The Image To See Everything?

IMAGE PROCESSING SHOULD DO THIS FOR YOU!

TYPES OF DIGITAL SYSTEMS

- Several types of systems
  - Computed radiography (CR)
  - Digital radiography (Direct Radiography, DR)
- This talk will introduce you to these systems

WHAT'S THE BUZZ
TELL ME WHAT'S HAPPENING

- What is wrong with conventional film-screen imaging?

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  - Film-screen is still considered the "gold standard" by which all new imaging systems are measured
- Then why go Digital?
  - Getting the perfect radiographic film (or even an acceptable radiograph) is **HARD TO DO!**
  - Good digital systems make it **EASY TO DO!!**
  - Digital imaging offers many advantages, besides high image quality, that film-screen systems cannot

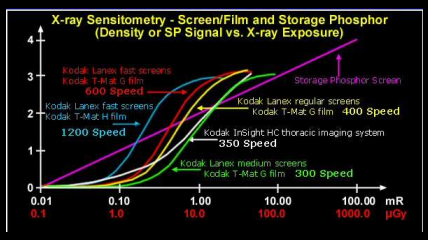
DIGITAL RADIOGRAPHY ADVANTAGES

1. Quick – 4 sec (DR) to 1 minute (CR)
2. Fewer repeat films – forgiving technique
3. Images sent easily for consultation
4. Increased dynamic range
5. No more lost films
6. No film degradation over time
7. No caustic processing chemicals
8. Savings – over time
9. Duplicate images to give to client
10. No "file room"

CR AND DR EFFECT ON SUBJECT CONTRAST

- Film-Screen
  - Completely dependent on kVp and mAs
- Digital
  - Much less dependent on kVp and mAs, ie, **you can really screw up the settings and STILL get a great radiograph!**
  - Highly dependent on post-processing such as windowing, contrast, etc.
  - Results in significant reduction in retakes*

HIGH LATITUDE COMPARISON



DIGITAL IMAGE CAPTURE DEVICES

- Hybrid Systems
  - Cameras on a stick, cameras in a box, cameras under an x-ray table, film scanners
- Computed Radiography
  - CR, DLR (Digital Luminescence Radiography), SPR (Storage Phosphor Radiology)
  - Indirect Digital Radiography (IDR)
- Digital Radiography
  - DR, DDR (Direct Digital Radiography), FPR (Flat Panel Radiography)

DIGITAL CAMERAS

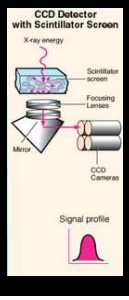
- Use a small (~2 cm) CCD detector to capture image
- High resolution cameras now have 6-12 mega pixels in an X-Y coordinate matrix
- 15 pixels in 3 x 5 matrix (poor resolution)

DIGITAL CAMERAS

- Z plane – number of possible values per pixel (or number of shades of gray)
  - May be limited to 8 bits (2^8 = 256 shades of gray) set on "greyscale or B/W.
  - Chest radiograph has thousands of shades of gray
  - These extra shades of grey must be "mapped" or compressed down to "pigeon hole" them to fit in one of the 256 bins
- Greatly limits ability to change image once acquired

CCD BASED X-RAY SYSTEMS

- The de-magnification (shrinking) of the aerial image must be done using a series of mirrors or an array of CCD's or use an image intensifier tube, as in fluoroscopy systems
- This introduces many errors such as decrease in the number of photons that reach detector, geometric distortion and optical scatter. These variables cause a decrease in spatial resolution, increase in image noise and decreased image quality

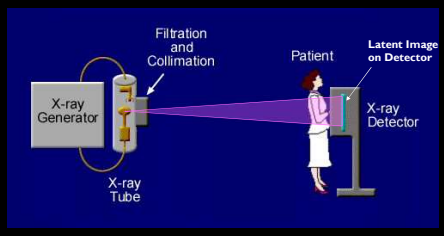


CONSUMER WARNING – IMPORTANT!!

- The CCD based systems are
  - Low quality systems (compared to CR and DR)
  - May or may not be less expensive
  - Always come with a new X-ray machine
    - The digital camera is attached to the x-ray machine
  - Are marketed by the sales people as "DR" systems
    - Because the produce an image within a few seconds
  - Not recommended
  - You get what you pay for!

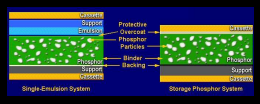
COMPUTED RADIOLOGY (CR)

X-RAY PRODUCTION AND LATENT IMAGE FORMATION



CR VS. FILM SCREEN

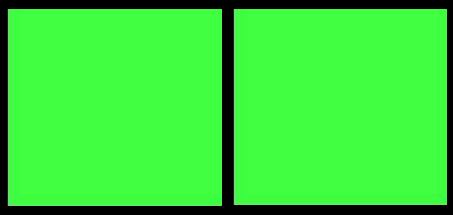
- Both use screens to absorb x-rays
- Both have similar screen structure (light emitting phosphor crystals)
- Both emit light promptly (photoluminescence)
- Both systems' screens can be used for thousands of exposures
- Only CR screens retain a portion of the x-ray energy that can be extracted during read-out (latent image)



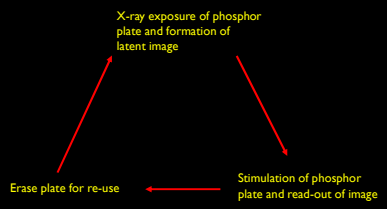
TERMINOLOGY

- Luminescence – non-thermal emission of optical radiation (light) upon some form of excitation
  - Fluorescence – light persists for very short time (10^{-8} sec) after stimulating source is removed
    - Fluorescent lamps, LED's
  - Phosphorescence – light persists for a longer time after the stimulating source is removed
    - Television screen, firefly

FLUORESCENCE VS. PHOSPHORESCENCE



CR CYCLE



DIGITAL RADIOLOGY (DR)

DIGITAL RADIOGRAPHY OR "FLAT PANEL" RADIOGRAPHY

- Image is displayed in seconds (3-8) on a monitor
- Repeat radiographs can then be done, if needed
- No film reader needed
- Uses a "flat panel" detector that is mounted under the table top in the Bucky Tray

DR PLATE – X-RAY MACHINE COUPLING

- The DR plate must be made ready (electronically erased or "blanked" of any "noise" it has picked up) prior to each exposure
- It must be electronically synchronized to the x-ray machine for each exposure
- In other words, the x-ray machine must be able to tell the plate when to turn on and off in order to detect the x-rays

DIGITAL RADIOGRAPHY OR DIRECT RADIOGRAPHY

- DR
- Direct Digital Radiography (DDR)

TWO TYPES OF DR SYSTEMS

- Direct DR – x-ray → electric charge
  - Plate converts x-ray energy to a digital signal directly
- Indirect DR – x-ray → light → electric charge
  - Plate converts x-ray energy to a flash of light (via a layer in the plate called a "scintillator") and then the flash of light is converted to the digital signal

DR AND CR IMAGE MANIPULATION (POST PROCESSING)

- Once the image is converted into an electronic image, the storage, processing and manipulation of that image is similar with both CR and Dr
- Not so with hybrid systems (cameras, scanners) where post-processing is limited

IMAGE MANIPULATION VS. POST PROCESSING

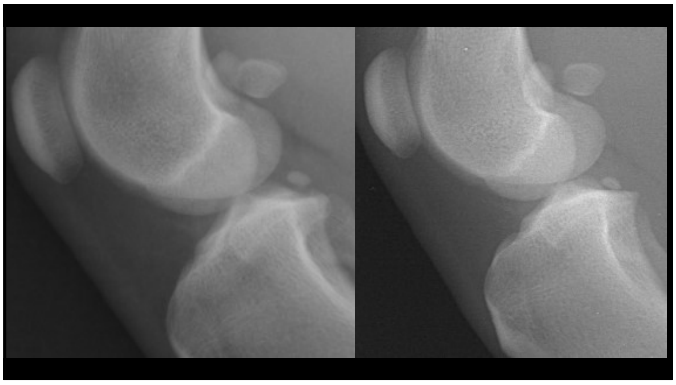
- Image Manipulation
  - Digital Image allows for changing several image parameters AFTER it has been acquired
    - Contrast and Windowing
    - Filtering
    - Magnification
    - Rotating
- Image Processing is done by the computer system before you even see the image
  - Adjusting image dynamic range so you can see the entire image
  - Auto-cropping and then adjusting the image only to the cropped area

DR AND CR COMPARED

- Conventional film screen technology
  - Technique must be perfect to get a great film (not to mention processing problems, etc)
- CR is more forgiving than film
  - Must be in the "ball park" to get a great image, ie within 15 kVp (good image latitude)
- DR is very forgiving as far as technique
  - You can really screw it up and still get a great image (excellent image latitude)
- With both CR and DR, hedge on the "dark side"
  - Too light (white) equals no data to work with

DR AND CR QUALITY COMPARISON

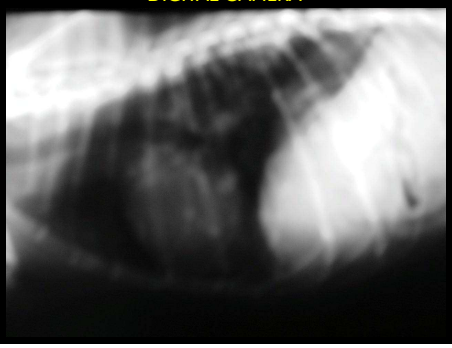
- Screen Shots of side by side images of same dog within minutes of each other
- Saved as lossless TIFF format
- Images "as is" ie, no digital "doctoring"



WHAT ABOUT DIGITAL CAMERAS AND FILM SCANNERS ?

DIGITAL CAMERA

DIGITAL CAMERA



REVIEW OF WHAT WE HAVE LEARNED

	CR	DR
Image Quality	Good*	Excellent*
Clinically Accepted and Proven	√	√
Gateway to Digital "World" (PACS)	√	√
Speed	~1 min	~ 3-8 sec
Cost per System	$	$$-$$$
Multiple Room Usage with One System	√	X
Film Replacement	√	√

*There are a lot of sub-optimal systems sold to veterinarians. Buyer beware. Ask a radiologist's opinion!!