EVALUATION OF A MAMMOGRAPHY FILM-SCREEN COMBINATION TO TAKE BONE RADIOGRAPHS IN SMALL ANIMALS

Mammography bone radiographs in small animals

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RESUMEN

Se han estudiado los factores de exposición y la calidad de las imágenes de radiografías del sistema óseo en 5 gatos con peso medio de 3.8 Kg. y 5 perros con un peso medio de 16.8 Kg. Para ello se han empleado dos combinaciones de película-pantalla, uno convencional ortocromático fine de tierras raras y otro de mamografía, utilizando un aparato de rayos X estándar. El estudio refleja que la combinación película-pantalla de mamografía es superior al sistema convencional ortocromático fine en resolución y contraste, para obtener radiografías del sistema óseo de zonas con poco grosor y escasa masa muscular en pequeños animales. Además, los factores de exposición requeridos para obtener radiografías con esta técnica, son similares a los necesarios para el sistema convencional.

Palabras clave: Mamografía; Pantallas reforzadoras; Radiografías óseas; Perro; Gato.

ABSTRACT

The use of a mammography film-screen combination to take bone radiographs in five cats and five dogs using a standard X-ray equipment was assessed in comparison to the fine orthocromatic rare-earth system. The radiographic quality and exposure factors were evaluated. This study suggests that the mammography film-screen combination using a standard radiographic equipment, is a superior alternative to the fine orthocromatic film-screen to take bone radiographs of thin body parts of small animals (3-25 Kg.). Moreover, the exposure factors required to take radiographs with this technique were similar to the standard system.

Key words: Mammography; Screen; Bone radiographs; Dog; Cat.

INTRODUCTION

The radiographs of bone require a high contrast and detail images (Allan 1992). The most important contributors to good radiographic detail are: absence of subject movement and use of a detail film-screen combination (Allan 1992).

Mammography technique is used to identify small abnormalities in breast tissue and requires both high contrast and high resolution at the lowest radiation dose possible (Haus 1987). This technique has been successfully used for evaluation of bone and soft tissue in reptiles (DeShaw et al. 1996). The use of this technique for evaluation of bony structures in small animals has not yet been well described.

The goal of this study was to assess a mammography film-screen combination to take bone radiographs of small animals in comparison to a fine orthocromatic rare-earth system using a standard radiographic equipment. This aim was based on two objectives: (1) to evaluate the quality image (2) to study the exposure factors.

MATERIALS AND METHODS

Animals

Five healthy, adult domestic shorthair cats (three male and two female), ranging in weight from 3 kg to 5 kg (mean 3.8 kg) and five healthy, adult mixed-breed dogs (three males and two females), ranging in weight from 9 kg to 25 kg (mean 16.8 kg) from the animal laboratory of the University of Murcia were used. The dogs were vaccinated against canine distemper, canine hepatitis, and leptospirosis, and the cats were vaccinated against feline panleukopenia, calici and rhinotracheitis viruses.

Experimental protocol

Prior to examination, food was withheld overnight (water was available ad libitum). The dogs were sedated with acepromazine (0.03 mg/kg) (Calmo Neosan, Pfizer) intramuscularly. General anesthesia was induced with thiopental sodium (10 mg/kg) (Tiobarbital, B Braun Medical S.A.). After orotracheal intubation, general anesthesia was maintained with halothane (Fluothane, Zeneca Farma S.A.) in oxygen (100 %).

The cat was anesthetized with a combination of xilacine (1 mg/kg) (Rompun, Bayer,) and ketamine hydrochloride (8 mg/kg) (Imalgene 500, Rhone Mérieux) administered intramuscularly.

Two matched film-screen combinations, a) mammography with one screen (Mamoray Detail, Agfa) and a single emulsion film (Mamoray MRG, Agfa) b) fine orthocromatic rare-earth with two screens (Ortho Fine, Agfa) and double emulsion film (Ortho CP-PLUS, Agfa) were employed using a standard 400 mA X-Ray machine (Heliophos, Siemens). Each combination was used to take radiographs of eleven bony structures: head, spine (cervical, thoracic, lumbar), shoulder, elbow, carpus, hip, femur, stifle and tarsus. Lateral and craniocaudal or ventrodorsal views were taken of each bony structure.

The exposure parameters used for each combination were based on the existing technique charts established for the orthocromatic system, which are routinely used at the Veterinary Teaching Hospital of the University of Murcia. All the radiographs were taken under the same conditions and using identical kVp (Kilivoltage peak) setting, with different mAs (milliamperage per second) adjustments according to the film-screen combination used. The grid was used when the anatomical structure was thicker than 11 cm. The conditions for film processing were the same for both films, using an automatic film processor (Curix 60, Agfa).

The border of the films were removed to eliminate the identification labels or marks, then the individual films were randomly numbered.

The individual films of each bony structure were assessed and scored for relative film quality independently by three veterinarians who were

Table 1. **Exposure factors**

Regions	Species	Focal spot	KVp	mAs FO	mAs M	Grid 10:1
Elbow Carpus Stifle Tarsus	Feline	Small	46	10	8	N.U
Shoulder Humerus Femur	Feline	Small	48	10	8	N.U.
Carpus Tarsus	Canine	Small	48	10	8	N.U.
Cervical spine	Feline	Small	48	10	8	N.U.
Shoulder Elbow Stifle Carpus Tarsus	Canine	Small	50	10	8	N.U.
Thoracic spine Pelvis	Feline	Small	52	10	8	N.U.
Femur Elbow	Canine	Small	52	10	8	N.U.
Lumbar spine Head	Feline Feline	Small Small	54 56	10 10	8 8	N.U. N.U.
Femur Humerus	Canine	Small	56	10	8	N.U.
Lumbar spine Shoulder Cervical spine	Canine Canine Canine	Small Small Small	58 58 60	19 10 19	12 8 12	N.U. N.U. N.U.
Head Pelvis Cervical spine Lumbar	Canine	Large	62	48	32	Yes
Thoracic spine Head Thoracic spine Pelvis	Canine Canine Canine	Large Large Large	68 70 80	48 48 48	32 32 32	Yes Yes Yes

kVp: Kilovoltage peak
mAs: milliamperage per second
FO: Fine Orthocromatic
M: Mammography
N.U: Grid not used

Table 2. **Mean ± SEM score of the radiographic evaluation in the cats. Mean values are based on judgements of 3 investigators, recording 3 as the best score and 0 as the worst**

REGIONS		SCREEN-FILM COMBINATION		P
		FO	M	
Head		2.±0.00	3±0.00	*
Spine				
	• Cervical	1.6±0.2 (1-2)[Ψ]	3±0.00	**
	• Thoracic	2.67±0.11 (2-3)	2.33±0.16 (2-3)	NS
	• Lumbar	2.83±0.17 (2-3)	2.33±0.21 (2-3)	NS
Shoulder		2.33±0.21 (2-3)	2.83±0.17 (2-3)	NS
Elbow		2.17±0.17 (2-3)	2±0.00	*
Carpus		2.12±0.19 (2-3)	2±0.00	**
Hip		2.83±0.17 (2-3)	2±0.00	NS
Femur		2.17±0.17 (2-3)	3±0.00	**
Stifle		2.33±0.21 (2-3)	3±0.00	*
Tarsus		2.17±0.17 (2-3)	3±0.00	**

FO: Fine Orthocromatic, M: mammography
[Ψ] Range
** =P<0.001, * =P<0.01, NS= P>0.05

unaware of the screen-film combinations used. The assessment was made using a four point ranking score (0=poor, 1= fair, 2= good, 3= excellent). The image quality was assessed on the basis of the high contrast and detail (ability to delinate the trabecular bone).

Statistical analyses

The scores of radiographic evaluation were analyzed for statistical significance using the chi-square and Fisher´s exact test (2-tail). Statistical comparison was made using a computerized system (Ato et al. 1990). The P<0.05 level was chosen for determining statistical significance.

RESULTS

A. Exposure factors

The exposure factors used in this study are shown in the Table 1.

The mAs used was always greater for conventional system than for mammography technique.

B. Image quality

The mammography technique was superior (P<0.01) in the cat in the majority of bony structures (Fig 1) except for spine (thoracic and lumbar), shoulder and hip (Table 2).

On dogs, there were no significant differences (P>0.05) in the image quality obtained with both screen-film combinations (Fig 2), except for the images of hip and spine (thoracic) where the orthocromatic system was superior (P<0.01), and for radiographs of carpus and tarsus where the mammography technique was better (P<0.01) (Tables 3) (Fig 3).

Figure 1. **Lateral radiographs of a cat´s stifle made with mammography (A) and standard (B) film screen combinations. Notice that the detail of the trabecular bone is superior (P< 0.01) in the radiograph obtained with mammographic system.**

Table 3. **Mean ± SEM score of the radiographic evaluation in the dogs. Mean values are based on judgements of 3 investigators, recording 3 as the best score and 0 as the worst**

REGIONS		SCREEN-FILM COMBINATION		P
		FO	M	
Head		2.83±0.17 (2-3)[Ψ]	2.17±0.17 (2-3)	NS
Spine				
	• Cervical	2.17±0.17 (1-2)	1.5±0.22 (1-2)	NS
	• Thoracic	2.83±0.17 (2-3)	1.5±0.22 (1-2)	*
	• Lumbar	2.17±0.17 (2-3)	1.5±0.22 (1-2)	NS
Shoulder		2.67±0.21 (2-3)	2.33±0.21 (2-3)	NS
Elbow		2.17±0.17 (2-3)	2.83±0.17 (2-3)	NS
Carpus		2.17±0.17 (2-3)	3±0.00	*
Hip		2.83±0.17 (2-3)	1.5±0.22 (1-2)	*
Femur		3±0.0	2.33±0.21 (2-3)	NS
Stifle		2.33±0.21 (2-3)	2.83±0.17 (2-3)	NS
Tarsus		2.17±0.17 (2-3)	3±0.00	*

FO: Fine Orthocromatic, M: mammography
[Ψ] Range
* =P<0.01, NS= P>0.05

DISCUSSION

This experimental investigation was undertaken to evaluate the screen-film mammography system, using a standard radiographic equipment, in comparison to the standard radiographic technique. The fine orthocromatic rare-earth system was chosen as the standard because it is routinely used in our Teaching Hospital to take bone radiographs.

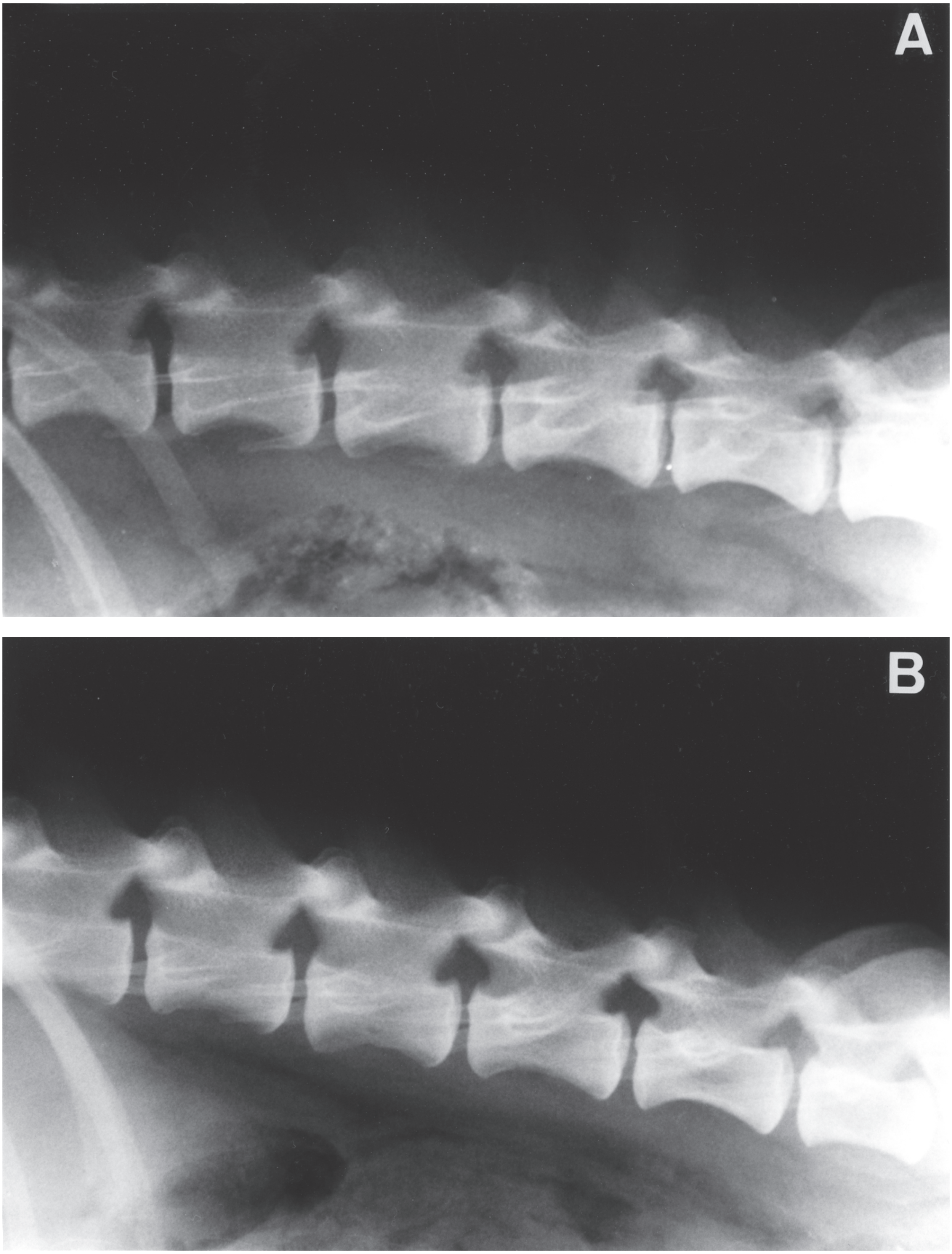

Figure 2. **Lateral radiographs of the lumbar spine of a dog weighing 15 kg, obtained with mammography (A) and standard (B) film-screen combinations. The contrast radiographic is superior in the image taken (P< 0.01) with fine orthocromatic film-screen combination.**

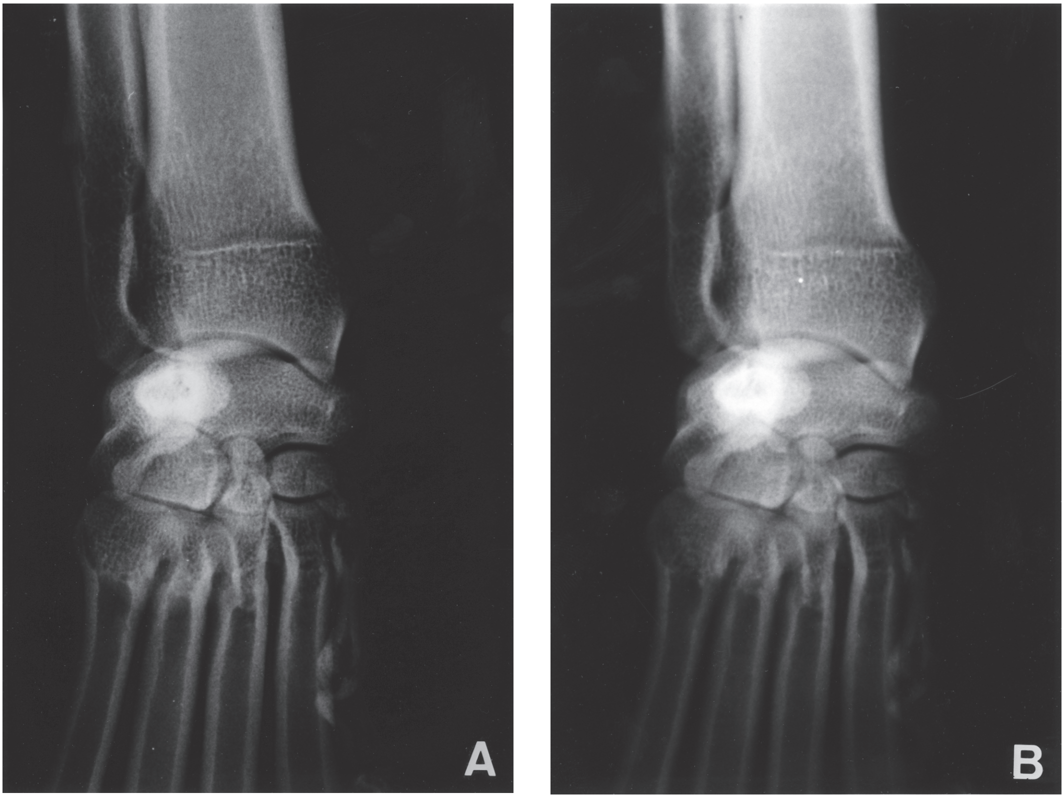

Figure 3. **Craniocaudal radiographs of the carpus of a dog weighing 25 kg, made with mammography (A) and standard (B) film-screen combinations. Observe that the detail and contrast are superior (P< 0.01) in the image obtained with the mammography film-screen combination.**

In all animals, the detail image was superior with the mammography system. This may be explained by two major reasons: the thickness of the screen and the number of screens used (DeShaw et al. 1996). The conventional radiography uses thick screens while mammography system uses thinner screens (Haus1990; Yaffe 1990). In the thicker screen, there is a greater range of distances between the point where the X-ray interacts and the film. The energy of the X-ray is converted into light, and it can be assumed that the light is emitted isotropically and spreads out from the point of its creation having a greater opportunity to spread laterally before the film is encountered, and resulting in lower resolution images (Yaffe 1990). With the thinner screen, the distance between the point where the X-ray interacts and the film is closer. There will be less spread and thus the image will have greater resolution (Yaffe 1990). This also results in a higher Modulation Transfer Function (MTF) for images produced by mammography screens compared to images produced by conventional radiography (Yaffe 1990). Thus, screen-film combinations used for mammography have much higher spatial resolution than those used for conventional diagnostic procedures (Haus 1990). The conventional radiographic system shows a limiting resolution of approximately 5-6 line pairs per millimetre, whereas the mammography system might well resolve greater than 15 line pairs per millimetre (Yaffe 1990).

The conventional radiographic system uses two screens, one on each side of the film. Double screens, while reducing the radiation dose to the patient, cause crossover effect (Morgan 1993). Crossover effect is the light produced from one screen passing through the film base and exposing the opposite emulsion of the film, and viceversa. This effect results in image blur (Yaffe 1990). Another problem is that double-emulsion film system may create a parallax effect that would result in reduced resolution (Yaffe 1990). Mammography uses, single thin film-screen combinations, eliminating light crossover and minimising image blurring by decreasing the spreading of light emitted before the film is exposed (Haus 1990). The single screen is used as a back screen for mammography. Since, if it was used as a front screen, X-ray absorption would be higher in the plane of the screen farthest from the emulsion contact surface. This design causes greater light spread (blur) than when the single screen is used as a back screen because X-ray absorption is highest near the screen-emulsion. Both parallax and crossover effects are eliminated in a single back-screen configuration (Haus 1990).

In this trial, the image quality obtained with mammography system was usually superior to the standard system. However, in the dogs, the radiographic images of thick body parts such as the hip and thoracic spine obtained with the standard system were superior ($P<0.01$), since the radiographic contrast was higher resulting in a superior image quality. These findings are broadly in agreement with previous studies performed in reptiles (DeShaw et al. 1996) and humans (Hubbard 1990) which observed that the radiographic contrast for thick body parts was not as good as that for thin body parts when mammographic system was used.

Radiographic contrast refers to the magnitude of the optical density difference between the structure of interest and its surroundings (Morgan 1993). Radiographic contrast is influenced by two factors, subject contrast, which is affected by x-ray equipment, and film contrast (Haus 1987). Film contrast is affected by film type, processing conditions and optical density level. Film contrast is defined in terms of the slope or steepness of the characteristic curve. The steeper the curve, the higher the contrast (Haus 1987). In this study, the films used in both the mammography and conventional systems were of high film contrast. The manufacturer indicated that the shape of the characteristic curve of conventional film is the recommended to perform radiographic studies of bones.

Subject contrast in mammography is influenced by patient thickness and density, radiation quality (kVp, filtration) and radiation scatter (Haus 1987). The kVp used in our trial was higher than the employed in the mammography system. Mammography uses a voltage of 22-35 kVp (Resnick and Niwayama 1988), whereas we have employed from 46 to 80 kVp, because a standard radiographic equipment with a minimum kVp of 40 was used in this experience. For this reason, the mammographic film-screen combination using a standard radiographic equipment imposes limitations on the subject´s thickness. The reduced penetration of the low-kVp beam makes it best suited for evaluation of thin body parts in human, such as hands and feet (Resnick and Niwayama 1988), puppies (Kramers 1997) and small to medium sized reptiles and amphibians (DeShaw et al. 1996), such as we have observed.

Another factor that affects the image quality is radiation scatter, which acts reducing image contrast (Allan 1992). The most effective and practical method of reducing scatter is the utilization of a grid (Allan 1992). However, the use of a grid necessitates an increase in the amount of radiation (Haus 1987). In this study, when the Bucky technique was used, to take radiographs of thick body parts with the mammography system, the images were judged as poor and the contrast was better in radiographs obtained with the conventional system. These results are similar to the results obtained in other trials (DeShaw et al. 1996) where table-top images where always preferred to corresponding Bucky images.

In this study the exposure factors were similar in both combinations, these results may be attributed to many significant technologic improvements in screen-film combinations achieved during the last years (Agfa-Gevaert N.V. 1999)

In subjective evaluation of the radiographic image quality, obtained with the mammography film-screen combination using a standard radiographic equipment, this technique was judged to produce superior film quality over the fine orthocromatic film-screen in taking bone radiographs of thin body parts of small animals. Moreover, the exposure factors required to take the radiographs with this technique were similar to the standard system.

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