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Radiological imaging in digital systems: the effect of exposure parameters in diagnostic quality and patient dose

A imagem radiológica em sistemas de radiografia digital: estudo do efeito dos parâmetros técnicos de exposição na qualidade diagnóstica e na optimização de dose

Anexos

Index

Annex 1: Digital detector quantitative measures

The method used for measurement of digital detectors is described in subsections 5.2.1 and 5.2.2 of Chapter 5 (p77-86).

Two procedures were implemented:

1. Image acquisition;
2. Quantitative measures determination method.

1.1 Image acquisition (refer to 5.2.1)

Images for the determination and measurement of digital imaging systems were obtained using an edge test device according to the IEC 62220-1 International Standard. An opaque edge test device was assembled according to the IEC standard (Fig A1).

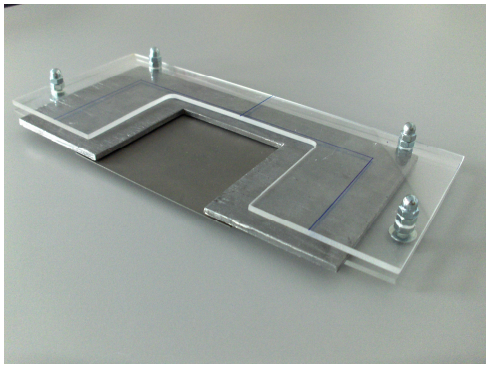


Fig A1 - Opaque edge test device

A geometrical set-up arrangement was configured according to the standard guideline (fig A2).

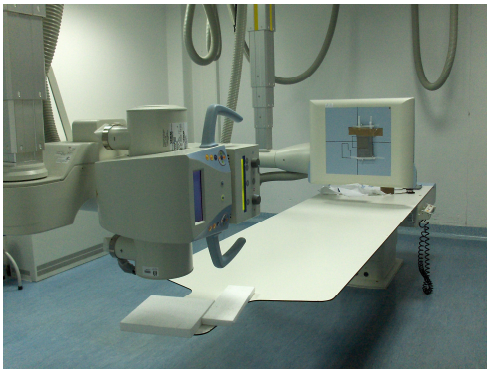


Fig A 2 – Geometrical set-up arrangement

The determination of DQE was possible by a set of MATLAB® routines that were implemented to evaluate the performance of both CR and DR systems. Pre-sampled MTF was determined in both systems using an algorithm as recommended by IEC 62220-1 standard. DQE was calculated from NPS images and edge test images were used for MTF determination.

1.2 Quantitative measures determination methods (refer to 5.2.2)

A set of MATLAB® routines were implemented to evaluate the performance of both CR and DR systems. MATLAB® scripts that were used in this thesis are included in the CD as a complement of this annex.

Annex 2: Exposure parameters evaluation

For the evaluation of exposure parameters data collection was obtained through three main routes:

1. A cross-sectional survey to identify exposure parameters being used in plain radiography by radiographers;
2. Exposure parameters obtained from the DICOM Log file;
3. Exposure parameters variation in a phantom study.

2.1 Cross-sectional survey (refer to 5.3.1)

Considering four anatomic regions - skull (PA; lateral), chest (PA; lateral), lumbar spine (AP; lateral) and pelvis (AP), inquired radiographers had indicated the technique of reflecting their own practice using this form:

1. Crânio
   1.1. PA

kV	mA	Tempo de exposição (ms)	m.As	DFD (cm)

2. Crânio
   2.1. Lateral

kV	mA	Tempo de exposição (ms)	m.As	DFD (cm)

3. Tórax
   3.1. PA

kV	mA	Tempo de exposição (ms)	m.As	DFD (cm)

4. Tórax
   4.1. Lateral

kV	mA	Tempo de exposição (ms)	m.As	DFD (cm)

5. Coluna Lombar
   5.1. AP

kV	mA	Tempo de exposição (ms)	m.As	DFD (cm)

6. Coluna Lombar
   6.1. Lateral

kV	mA	Tempo de exposição (ms)	m.As	DFD (cm)

7. Pelvis
   7.1. AP

kV	mA	Tempo de exposição (ms)	m.As	DFD (cm)

2.2 DICOM Log file (refer to 5.3.2)

Stored DICOM Log file data allows a retrospective evaluation of relevant exposure parameters for each exposure. Exposure parameters (kV; mA.s; exposure time) and dose related values (DAP; ESD) were obtained from stored DICOM Log file from a digital radiographic images (fig A3).

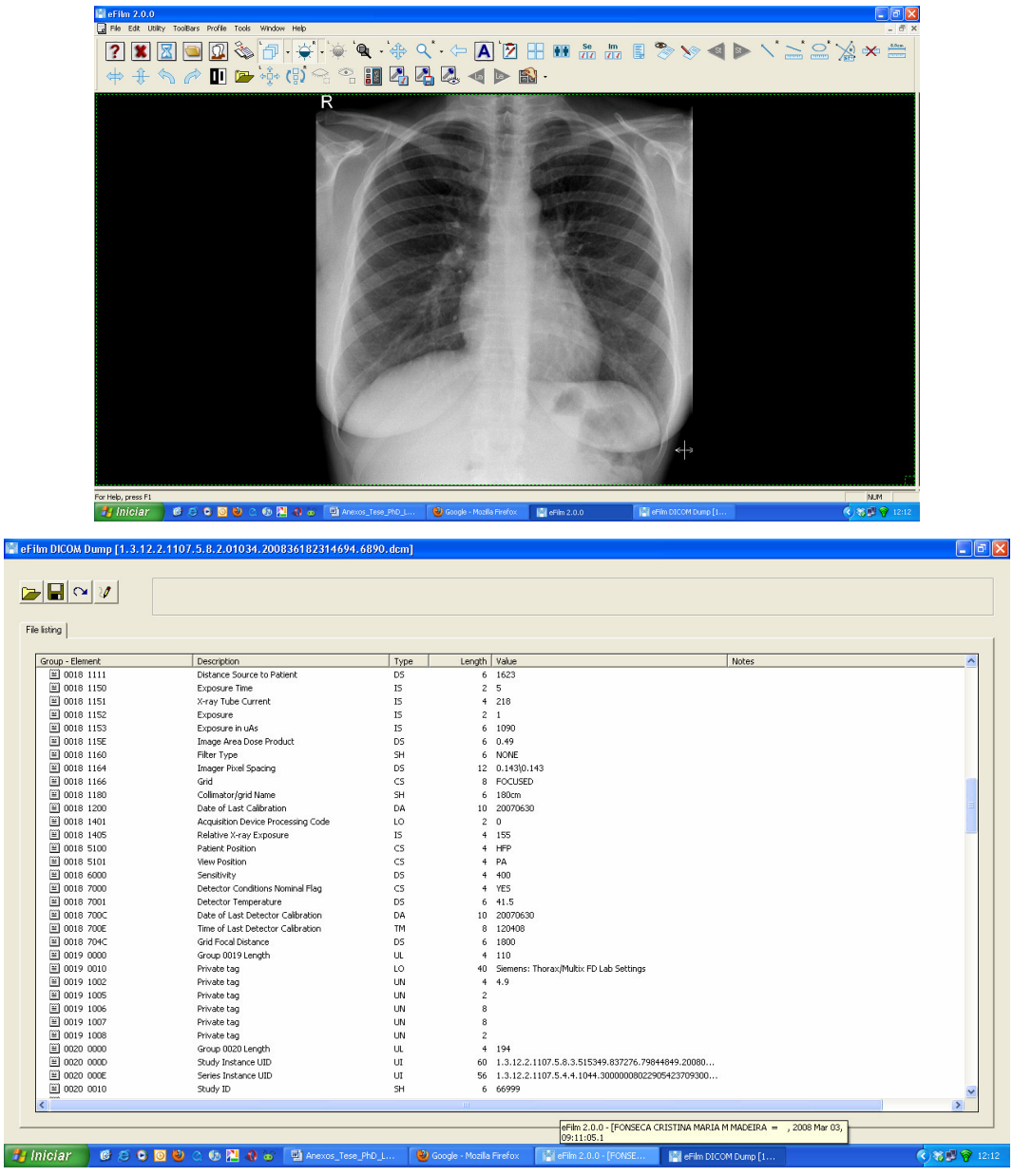


Fig A 3 – DICOM Log file and image

2.3 A phantom study (refer to 5.3.3)

In this experiment all radiographs were performed using two anthropomorphic phantoms, positioned according to the appropriate radiographic technique.

An anthropomorphic chest phantom (RS-800T Heart/Thorax Phantom – fig A4) was used for the acquisition of the chest PA radiographs.

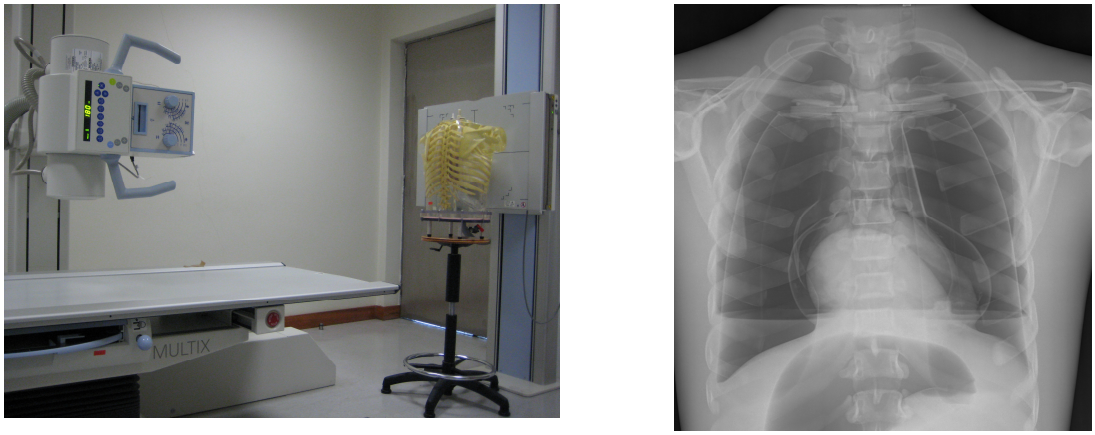


Fig A 4 – Chest phantom

A whole body anthropomorphic phantom (PIXY Whole Body Phantom – fig A5) was used for the acquisition of AP and lateral lumbar spine radiographs.

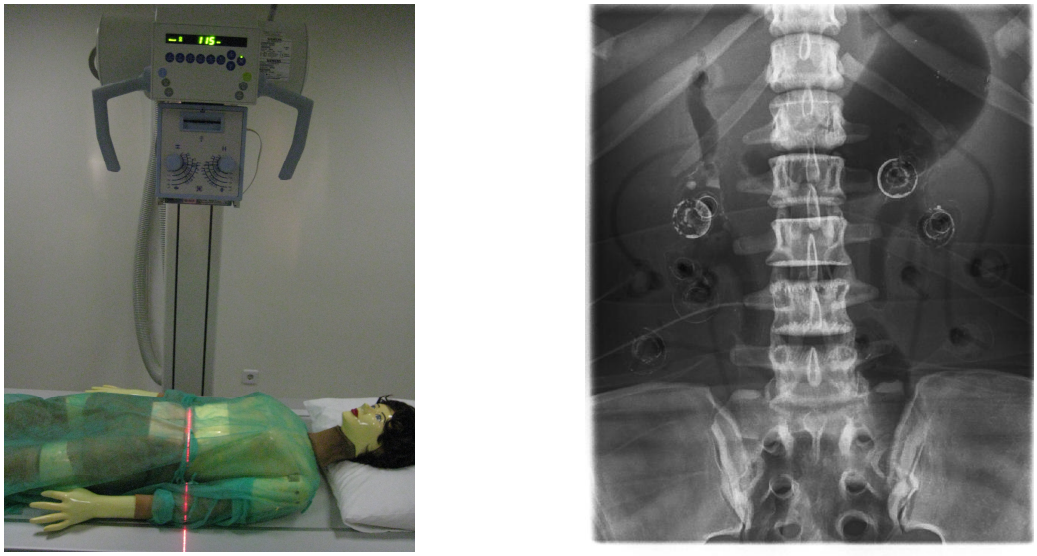


Fig A 5 –Lumbar spine phantom

Annex 3: Dose and image quality evaluation

The aim of this part of the study was to evaluate the response of the digital detectors when a dose variation is provided, both in clinical environment and in experimental environment. The data were obtained through two main routes:

1. Evaluation of exposure index (lgm) from patient CR exposures;
2. CDRAD studies (IQFInv) in CR and DR obtained from experimental exposures.

3.1 Exposure Index (lgM) (refer to 5.4.1)

A. Dados do paciente

Sexo	Biótipo	Ano de nascimento
M ☐ (1) F ☐ (2)	☐ (1) ☐ (2) ☐ (3)	_____

B. Região a radiografar e projecção efectuada (descriminar)*

Membro superior ☐ (1)	Membro inferior ☐ (2)	Coluna vertebral e bacia ☐ (3)
* _____	* _____	* _____
PA ☐ (1) AP ☐ (2) P ☐ (3) Obl ☐ (4) O ☐ (5)	PA ☐ (1) AP ☐ (2) P ☐ (3) Obl ☐ (4) O ☐ (5)	PA ☐ (1) AP ☐ (2) P ☐ (3) Obl ☐ (4) O ☐ (5)

Tórax ☐ (4)	Cabeça ☐ (5)
* _____	* _____
PA ☐ (1) AP ☐ (2) P ☐ (3) Obl ☐ (4) O ☐ (5)	PA ☐ (1) AP ☐ (2) P ☐ (3) Obl ☐ (4) O ☐ (5)

*de acordo com tabela anexa

C. Parâmetros de exposição

kV	mAs	DFD (cm)	Grelha anti difusora
_____	_____	_____	Sim ☐ (1) Não ☐ (2)

D. Parâmetros de processamento

Janela	Nível	Classe de exposição	Desvio de exposição	Níveis de exposição (lgm)
_____	_____	_____	_____	_____

3.2 CDRAD studies (refer to 5.4.2)

The imaging performance of two digital radiography systems (CR and DR) was evaluated using a contrast-detail phantom. The CDRAD 2.0 phantom (Artinis Medical Systems, The Netherlands) consists of a Plexiglas tablet with cylindrical holes of exact diameter and depth (tolerances: 0.02 mm). The phantom consists of a 15×15 array of 1.5×1.5 cm^2 cell regions in which holes are drilled. The holes are logarithmically sized from 0.3 to 8mm in both diameter and depth. Fig A6 shows the CDRAD phantom and the PTW CONNY dosemeter for expeosure measurement.

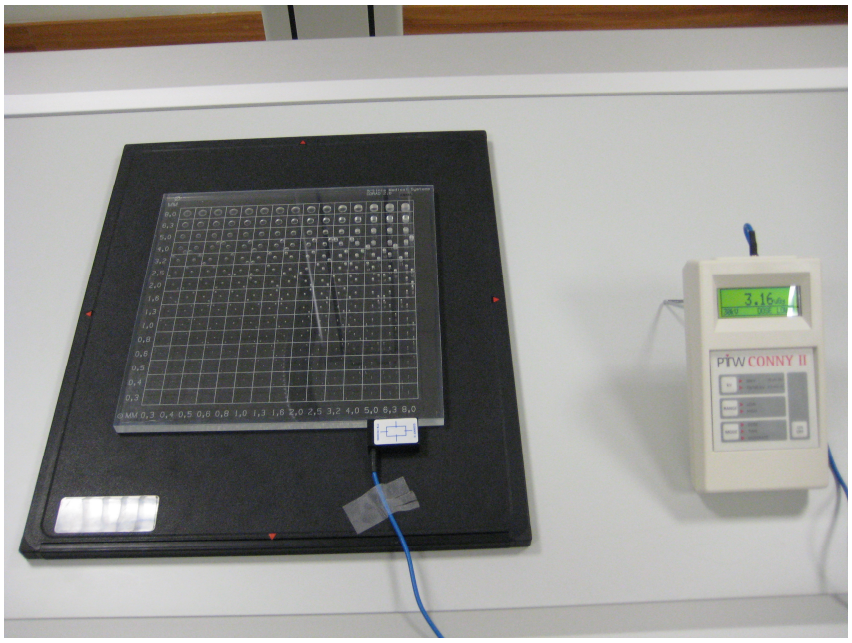


Fig A 6 – CDRAD phantom and dosemeter

The image quality metrics was provided by the inverse image quality figure (IQFinv). The IQFinv is an overall image quality index or score and can be used for quantitative comparison of the phantom images. A CDRAD analyser output is provided in fig A7, where an example of the IQFInv score is provided for several exposures.

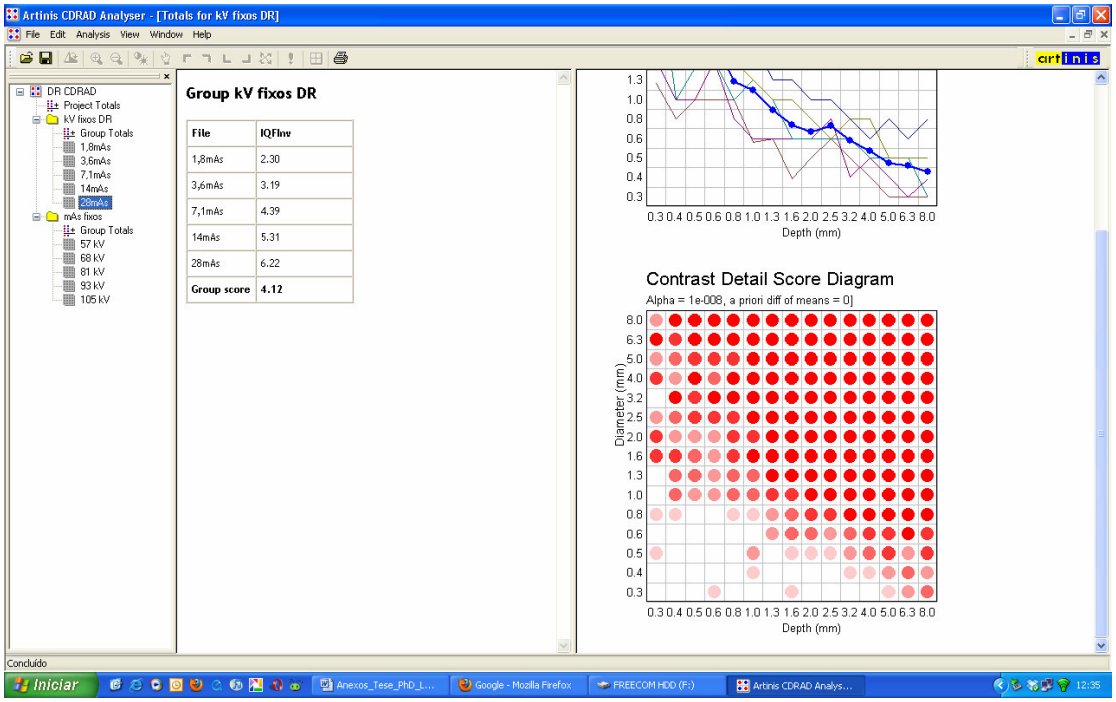


Fig A 7 – ARTINIS CDRAD analyser output

Annex 4: Digital images and diagnostic quality perception

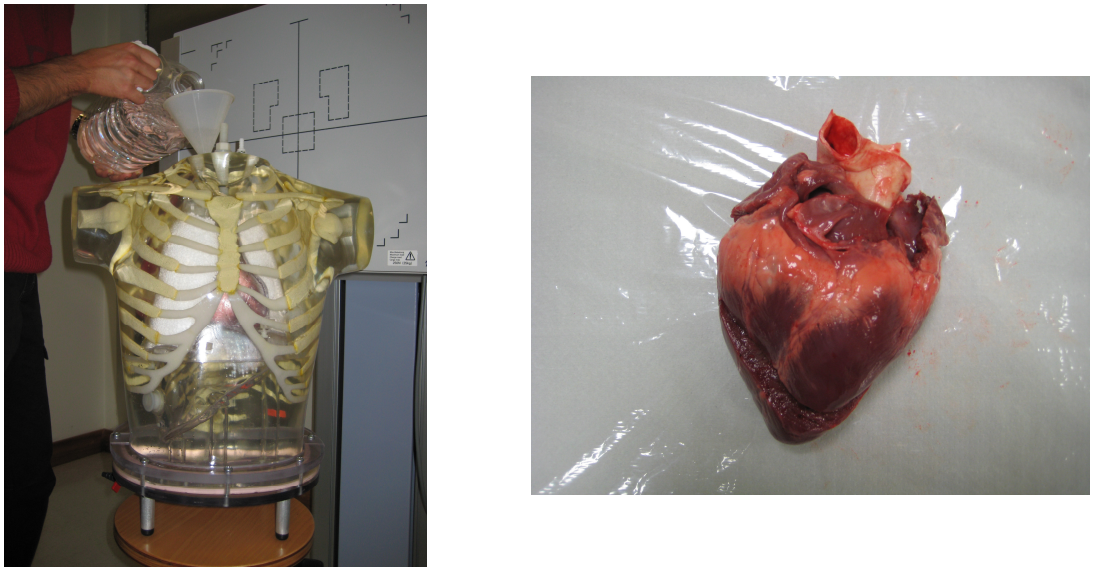
In this part of the thesis data collection were obtained through two main routes:

1. Evaluation of images from anthropomorphic phantoms;
2. Evaluation of images from patients.

4.1 Images of anthropomorphic phantoms evaluation (refer to 5.5.1)

4.1.1. Chest phantom

The chest phantom used in this study is a fully tissue-equivalent anthropomorphic heart/thorax phantom molded of polyurethane. The phantom includes the heart, the lungs, the liver and the thorax skeleton (fig A8a). A porcine heart was inserted to obtain images similar to human heart (fig A8b)



a b

Fig A 8 – Chet phantom (a) and porcine heart (b)

The phantom was filled of water to better attenuate the x-ray beam.

Images were performed using different exposures and a chest PA radiographs were obtained (fig A9).

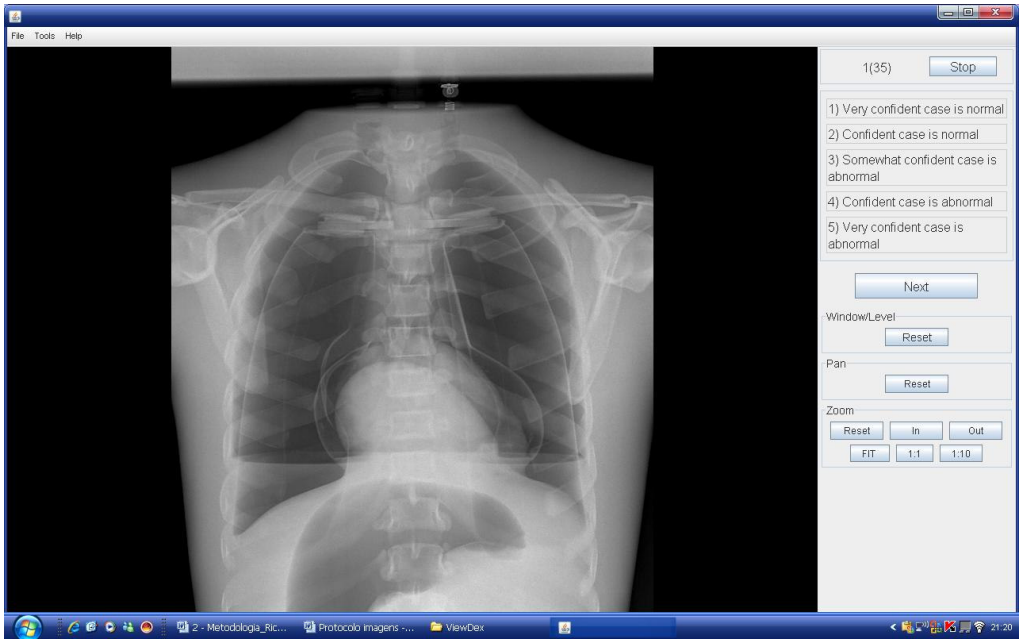


Fig A 9 – PA chest radiograph of the phantom

4.1.2. Bone phantom

A porcine femur was used in this study as a bone anthropomorphic phantom because the radiographic appearance of this bone resembles that of the human femur (fig A10)

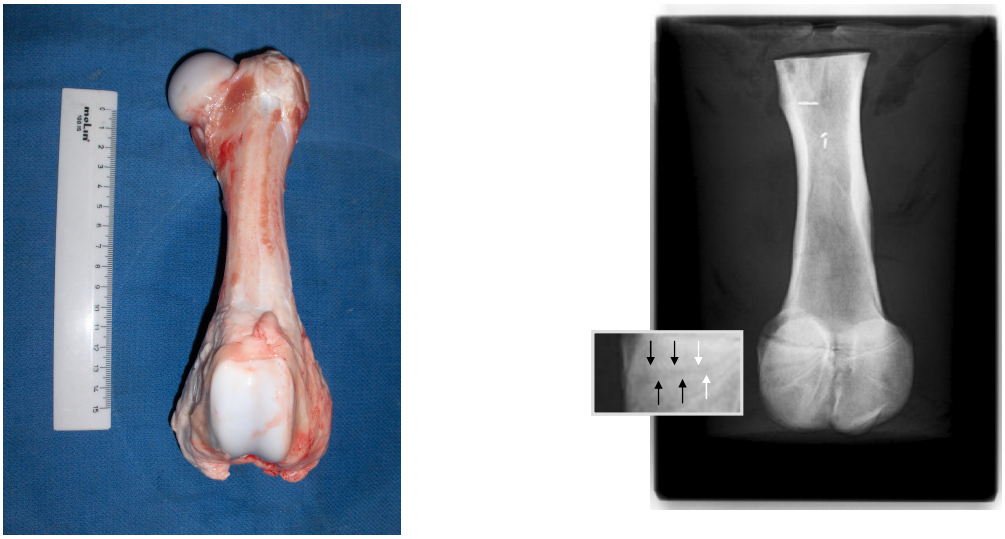


Fig A 10 – Porcine femur specimen and radiograph

Five artificial osteolytic lesions with different diameters (1 to 3mm) were created in 5 of 10 predefined regions by using a standard drilling device (fig A10).

4.2 Patient images evaluation (refer to 5.5.2)

A sample of 18 adult patients 36 lumbar spine (AP and lateral) images were evaluated using ViewDex (Viewer for Digital Evaluation of X-Ray Images) software (fig A11).

Fig A 11 – ViewDex Viewer and image quality criteria

ViewDex setup file is shown in fig A12. The 5 level scale setup is shown: clearly better than (+2); slightly better than (+1); equal to (0); slightly worse than (-1); and clearly worse than (-2) the reference image.

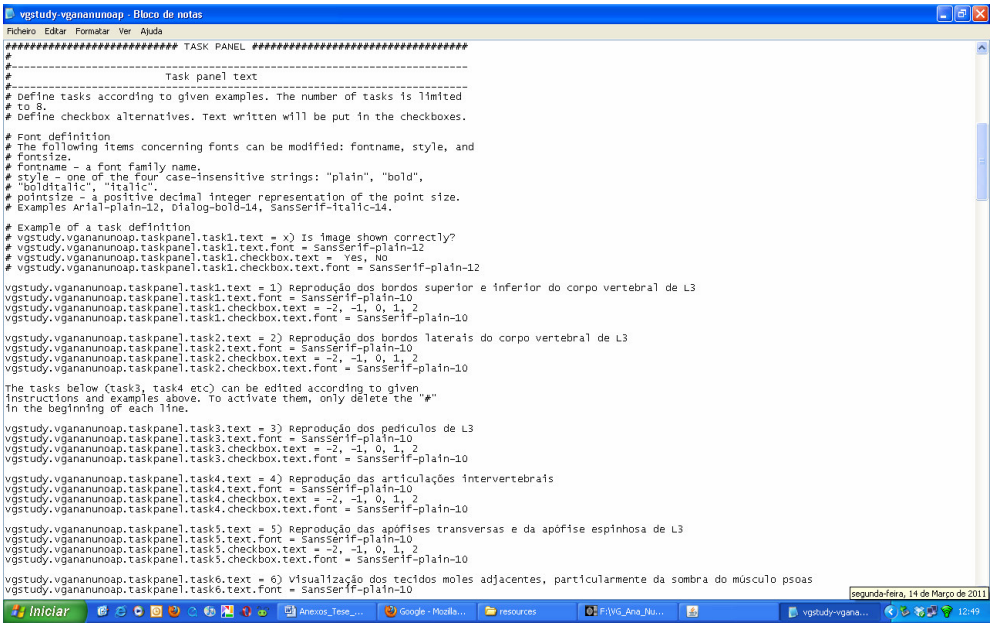


Fig A 12 – ViewDex imagem quality criteria setup

A ViewDex setup as used in this thesis is included in the CD as a complement of this annex.