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# An option for optimising the radiographic technique for horizontal beam lateral (HBL) hip radiography when using digital X-ray equipment

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ABSTRACT

*Aim:* To investigate the optimum technique for the horizontal beam lateral (HBL) hip projection considering image quality and radiation dose.
*Methods:* Using digital radiography equipment an anthropomorphic phantom was positioned for a HBL projection of the hip. Radiographic exposures were undertaken across a range of acquisition parameters (tube potentials, source to image distances, object to detector distances, with and without an anti-scatter radiation grid/additional copper filtration). Each acquisition combination was imaged three times and the dose area product (DAP) and post-AEC mAs recorded. 168 images were acquired. A single observer evaluated five anatomical areas on all images using a two-alternative force choice technique. The reference image was selected based on the current locally accepted technique. 50 images out of the original 168 were independently assessed by a further four observers to ensure reliability of the results.
*Results:* Image quality, when comparing all the images to the reference, was improved on in two cases; however the radiation dose had increased. 18 images had equal image quality with some having an 80% reduction in the DAP. In terms of the diagnostic acceptability, 51 were considered acceptable with a lower radiation dose.
*Conclusion:* By optimising acquisition factors for the HBL hip projection the radiation dose to the patient can be reduced. Based on the findings the factors proposed for HBL hip projections are 90 kVp, 135 cm SID, 45 cm ODD, grid and 0.1 mm copper filtration.


## Introduction

Hip fractures are one of the most common injuries amongst the elderly, with females being up to three times more at risk than males.[1] Due to the nature of the injury and other co-existing morbidities hip fractures are associated with a high mortality.[2] In order to treat these patients effectively, high quality radiographic imaging is needed.[2] Standard practice is to perform two projections perpendicular to one another, an anteroposterior (AP) and a horizontal beam lateral (HBL).[2] HBL projections can be difficult to undertake and concerns have been raised regarding the resultant image quality. Cannon, Silvestri and Munro in 2007 investigated missed hip fractures and concluded that the low sensitivity in some cases may have been attributed to poor image quality. One possibility for generating a suboptimal image is that the examination was not optimised for the individual patient or the imaging equipment. Legislative requirements within the United Kingdom specify that all examinations involving ionising radiation are optimised whereby the lowest radiation dose is used to produce an image of acceptable diagnostic quality.[3] Rapid introduction of digital radiographic (DR) technologies has often, in the authors' opinion, resulted in conventional film-screen or computed radiography (CR) acquisition parameters simply being transferred from system to system. As a result of this rapid transition it is highly likely that some examinations are no longer optimised, an example of this could be the HBL hip projection and may adversely affect diagnostic rates and the resultant radiation dose.

In order to better understand the acquisition factors which can lead to the lowest possible radiation dose whilst maintaining acceptable image quality (optimisation) a review of the literature

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was undertaken. X-ray tube potential (kVp), inclusion of an anti-scatter radiation grid, object to detector distance (ODD)/air-gap technique, SID and the additional use of filtration including copper as variables which may influence the radiation dose and resultant image quality.[4–6]

Using a comparison against current clinical practice, the aim of this study was to identify the optimum acquisition parameters for HBL hip radiography when using DR.

## Materials and method

### *Imaging equipment*

The study was prospectively undertaken in a large NHS hospital in the north-west of England. Image acquisition was based on a Siemens Ysio (Siemens Medical Systems, Erlangen, Germany) digital X-ray room. Such a system comprised of a table mounted, wall mounted and freely movable DR detector. The same detector, mounted in the wall stand, was used throughout this study. Routine quality control, in line with national standards, was performed prior to image acquisition in order to ensure reliability and consistency in the tube mA, kVp and collimation.

### *Phantom and imaging technique*

Image acquisition was undertaken using an Alderson anthropomorphic pelvis phantom (Radiology Support Devices Inc, Long Beach, CA) positioned on an X-ray trolley (Fig. 1). A bottle of water was used to replicate the flexed contralateral leg.

### *Acquisition parameter variation*

The choices of factors (Table 1) in which to vary were based on evidence within the literature and included the kVp,[6,7] object to detector distance (ODD), source to image distance (SID), use of an anti-scatter grid and inclusion of additional copper filtration.[8] Within the study several acquisition parameters were fixed and these included the use of a central automatic exposure chamber, broad focal spot size, collimation at the skin surface and post-acquisition image processing. For ODD and SID there were physical restrictions which limited the options available. The smallest ODD was 45 cm, so this was assessed along with the largest achievable 60 cm. The shortest SID achievable was 135 cm and by applying 15 cm increments this was increased until 180 cm. All of these factorial sets were acquired with and without a 15:1 ratio anti-scatter radiation grid (80 lines/cm) focussed at 180 cm. Additional Cu filtration is not widely used within radiography a comparison between no additional filtration and 0.1 mm of copper was chosen. All acquired images were sent to a departmental picture archiving and communication system (PACS) in DICOM format. In addition, for each exposure the dose-area-product (DAP) was recorded together with the post-exposure mAs values, each measurement was obtained three times for three consecutive exposures, each at the same acquisition setting.

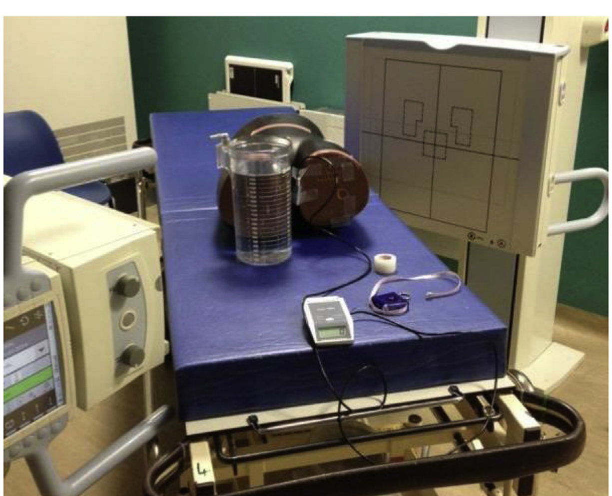

**Figure 1.** Phantom and equipment set up in the experiment.

**Table 1**
Summary of acquisition parameters used within the study.

| Type | Parameter |
|---|---|
| Variable | kVp, 70–100 (10 kVp intervals) |
| | ODD, 45–60 cm (5 cm intervals) |
| | SID, 135–180 cm (15 cm intervals) |
| | Antiscatter radiation grid 15:1 (YES/NO) |
| | Copper filtration (NO, 0.1 mm) |
| Fixed | Central automatic exposure chamber |
| | Broad focal spot |
| | Standard lateral hip post-processing |
| | Collimation at skin surface |

kVp, tube potential; ODD, object to detector distance; SID, source to image distance.

### *Visual analysis of image quality*

Images were analysed using a two alternative forced choice technique (2AFC). 2AFC compares images against a reference image and assesses the psychophysical response of the observer when two images are presented side by side. For the purposes of this study the reference image was acquired using 90 kVp, central AEC chamber, inclusion of an anti-scatter radiation grid, no additional filtration, 180 cm SID, 45 cm ODD. The reference image was permanently displayed on one reporting grade monitor whilst the experimental images were displayed in a random order on an adjacent monitor. Each experimental image was assessed by one of the study authors (CC) using a five point likert scale (much worse, worse, the same, better, much better) when compared to the reference image. Likert scales are used to obtain attitude or opinion and are deemed an accurate form of measurement.[9]

Images were graded using the Commission of the European Communities (CEC) criteria.[10] The CEC criteria have been widely used in research and are deemed valid and reliable.[11,12] The criteria were adapted slightly for use for the HBL lateral hip projections (Table 2).

Further observers would be required in order to assess the variability in the assessments of image quality. Four experienced reporting radiographers were invited to review a selected number of images, as supported by previous research.[13,14] Images were chosen using a stratified random sample of the images reviewed by the first observer and totalled 50. A computer algorithm was used assist with the sampling in order to ensure a mix of image qualities were presented to the four additional observers.

All images were viewed on a reporting grade workstation using GE Centricity software (GE Healthcare, Milwaukee, US). Each of the observers was given an instruction sheet which explained that there should be no altering of the window width/level of the images. The workstation has previously undergone Digital Imaging and communications in Medicine (DICOM) greyscale standard display calibration prior to installation.[15]