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# Pelvic X-ray examinations in follow-up of hip arthroplasty or femoral osteosynthesis – Dose reduction and quality criteria

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ABSTRACT

*Objective:* Digital plain radiographs of the pelvis are frequently performed in follow-up examinations of patients who received total hip arthroplasty (THA) or osteosynthesis (OS). Thus, the purpose was to reduce the radiation dose and to determine objective quality control criteria to ensure accurate assessment.
*Materials and methods:* Institutional review board approval was obtained. In this prospective randomized study, 289 patients underwent X-ray examination of the pelvis as follow up after receiving THA or OS with standard and reduced dose. The evaluation of the plain radiographs was conducted using the following criteria: bone–implant interface, implant–implant discrimination, implant–surface character and periarticular heterotopic ossification. Two radiologists evaluated these criteria using a score ranging from 1 (definitely assessable) to 4 (not assessable). If a single criterion had been evaluated with a score of 3 or more or more than 2 criteria with 2 points, the radiograph was scored as "not assessable". The study was designed as non-inferiority-trial.
*Results:* Seven (2.4%) examined X-rays were scored as not assessable. There was no statistical inferiority between the examinations with standard (0.365 mSv) or reduced dose (0.211 mSv). Reduced dose only led to limitations in the evaluation of ceramic components with low clinical impact in most scenarios.
*Conclusion:* Plain radiography of the pelvis in patients with THA or OS can be performed with a dose reduction of about 42% without a loss of important information. The obtained quality control criteria were clinically applicable.



## 1. Introduction

Pelvic radiography is in routine use in the imaging evaluation of total hip arthroplasty (THA) and osteosynthesis (OS). It can be performed fast, is widely available, cost effective and allows for the assessment of most postoperative abnormalities, such as septic and aseptic loosening, dislocation, periprosthetic/periosteosynthetic fracture and hardware failure [1].

The diagnosis of these abnormalities is often based on the evaluation of the metal–bone interface – in case of suspected loosening or fracture – and the position of the implant components with respect to each other – in case of suspected hardware failure or dislocation. This presents a particular challenge to projection radiography, because of the limited ability of diagnostic X-rays for penetrating metal.

On the one hand, computed tomography (CT) is gaining importance in imaging of THA [2,3] and as an established tool in the diagnosis of non-union. On the other hand, with longer survivorship of artificial hips, young patients become more and more candidates for THA, as other surgical options are limited [4]. For this reason, radiation exposure is increasingly becoming a focus. Though plain radiography is only about 1/10 of the radiation dose of a CT of the same region, the frequent repetition in the follow-up does make considerations of radiation exposure necessary and confronts the radiologist with the challenge of dose reduction.

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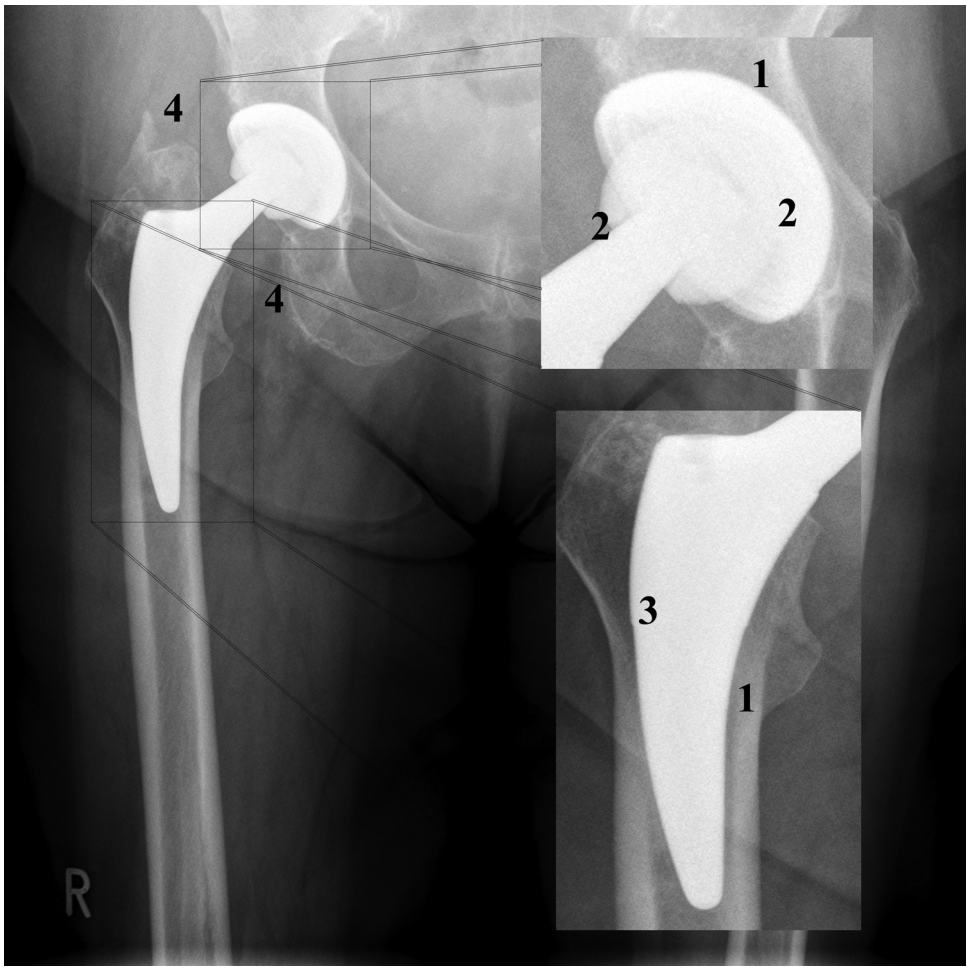


**Fig. 1.** Quality criteria: interface (1), components (2), surface (3), periarticular heterotopic ossifications (4).

Thus, the purpose of the present prospective randomized study is the reduction of radiation exposure in pelvic radiography in patients with THA or OS. This seems to be feasible because of the higher detective quantum efficiency (DQE) of digital radiography, compared to conventional state-of-the-art plain radiography systems [5–7].

To ensure diagnostic quality of radiography with reduced dose, the dose reduction will be carried out and monitored with the aid of standardized quality criteria, based on common orthopedic assessments necessary for therapeutic decisions and therapy monitoring.

## 2. Materials and methods

### 2.1. Patient population

The institutional review board approved this prospective, randomized controlled, blinded, two-armed single-center study and informed consent was obtained from all participants. Between December 2010 and October 2012, a total of 289 patients – 129 male and 160 female – underwent pelvic X-ray follow-up after receiving THA or osteosynthesis. Median age was 66.5 years (range 17.4–97.8 years). With reference to the age and gender at the time of inclusion, both trial-arms were balanced (age: $p$-value 0.59, Wilcoxon-rank sum test; gender: $p$-value 0.07, chi-square test).

### 2.2. Radiographs

The pelvic radiographs were recorded on a digital radiography system consisting of X-ray tube (SRO 33100), generator (Optimus 50) and digital flat panel detector ("Digital Diagnost", all Philips Healthcare, Best, Netherlands) with the patient in supine position and both feet and legs rotated internally of about 15°–20°. Image receiver size was 35 cm × 43 cm and X-ray tube voltage potential 80 kV. The images thus obtained were sent to a picture archiving and communications system (PACS) workstation (Centricity® PACS 4.0, GE Healthcare, Barrington, IL).

The selection of the radiation dose was carried out using different exposure classes (similar to the term "speed class" used with screen film systems and therefore abbreviated as SC). Exposure class is used to describe nominal radiation exposure required to obtain a proper radiograph. For skeletal surveys a medium-speed system (SC of 400) is recommended by the German medical association [8]. Thus, SC of 800 was used in order to obtain images with reduced radiation dose.

### 2.3. Image analysis and quality criteria

Two radiologists with 14 and 8 years of experience in musculoskeletal radiology, who were blinded to the exposure class, assessed all structures necessary to measure the defined parameters using the PACS. The following criteria, which have been defined together with a consultant orthopedic surgeon, where taken into account (Table 1; Fig. 1):

1. Interface: bone–implant and bone–cement interface to assess septic or aseptic loosening.