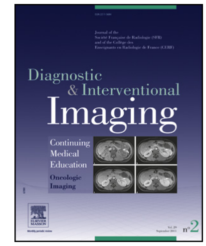
Diagnostic and Interventional Imaging (2016) **xxx**, xxx—xxx



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CT of hip prosthesis: New techniques and new paradigms

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KEYWORDS
Computed tomography;
Dual-energy;
Metal artifact reduction;
Prosthesis;
Hip

Abstract Patients with hip pain after joint replacement are first assessed by analyzing the clinical presentation and conventional radiography findings. When this first step is inconclusive, various different imaging techniques can be used to identify the anomalies. Based on our experience, computed tomography (CT) is the cornerstone for diagnosing the main prosthesis-related complications. In this article, we describe the different CT techniques used for this kind of investigation and provide indications for each technique.

Despite improvements in hip replacement, the number of prosthesis-related complications is currently increasing due to the growing number of patients who undergo surgery, the younger age at surgery and overall population aging [1]. Such complications, the most common of which is aseptic loosening, generally result in revision surgery. Revision surgery can be challenging. Total hip revision surgery is often associated with higher morbidity and complication rates than first-line hip replacement, especially when joint damage has worsened over time. Precise assessment of the joint and specific preoperative planning are therefore an important step of patient management [2].

The diagnosis of prosthesis-related complications is based first and foremost on conventional radiography, nevertheless, the use of other imaging methods becomes necessary when the initial clinical/X-ray examination is inconclusive. With its latest technological developments, computed tomography (CT) is now the most versatile, the most widespread and probably the most cost-effective method for investigating replacement joints.

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http://dx.doi.org/10.1016/j.diii.2016.07.002
2211-5684/

The indications for CT are currently broadening, and this modality can be indicated in four circumstances: screening for complications in asymptomatic patients at risk for complications, diagnosis of complications in patients for whom the clinical/X-ray examination is inconclusive, preoperative planning for patients with severe joint damage and monitoring sarcoma patients having undergone proximal femur resection and joint replacement.

In this article, we describe the various CT scanning techniques and their indications for investigating the prosthetic hip. The aim of this article is not to describe the imaging semiotics of prosthesis-related complications, which have previously been described at length in the literature [3—5].

Scanning the prosthetic hip

Conventional technique — general principles

CT has been used for long to investigate metal implants, but up to recently it did not perform well owing to the presence of metal artifacts [4,6,7]. Such artifacts were all the more pronounced for prostheses comprising a high portion of metal and in patients with bilateral hip prostheses. Artifact intensity also depends on the kind of metal used, with more intense artifacts observed with chromium-cobalt than stainless steel, which in turn causes more artifacts than titanium [8].

Technically, the artifacts were partially overcome by using high exposure settings (kV and mAs), pitch < 1, thin section acquisition and images reconstructed from thin sections with a standard convolution filter. Based on these findings, Roth et al. recommended acquisition parameters of 140 kV and 350—450 mAs in patients with a single hip prosthesis and 450—650 mAs in patients with bilateral hip prostheses [5]. Nonetheless, other authors recommend using 120 kV since the ability of the photon beam to penetrate metal is not improved with higher energies [9]. For patients with bilateral prostheses, Morvan et al. suggested raising the side to be investigated so that both acetabula are never on the same slices in the axial plane. This reduces the artifacts substantially, particularly the linear artifact projected between the implants [6].

The scan volume is usually delimited to cover the entire prosthesis but, in specific cases, it is acknowledged that limiting the volume reduces exposure to radiation. Reconstruction fields should be adapted to the regions investigated with centered reconstruction and a small field to improve image quality, and bilateral reconstruction when measuring implant position.

The use of multiplanar reconstructions (MPR) is essential. MPR should be performed in both the coronal and sagittal planes to assess the acetabular component, as well as along the axis of the femoral stem. Careful patient positioning prior to scanning (internal rotation of the limb) often reduces the number of reconstructions required.

Lastly, images must be analyzed without fail with three different window settings specifically adjusted for viewing the different tissue types and implant components: soft tissue window, bone and cement window and implant component window (W = 8000 HU, L = 1000 HU) (Fig. 1). Of course, metal artifacts prevent proper assessment of periprosthetic structures with the soft tissue window.

Iterative reconstruction

Iterative reconstruction is mainly used to lower image noise, and ultimately to reduce the exposure to radiation for patients. Several algorithms have been described. There are two main types of algorithms: hybrid algorithms that combine analytical and iterative methods, and model-based iterative reconstruction (MBIR) algorithms that take into account system geometry, the scanning process and the statistical model describing the interaction of photons with matter [10].

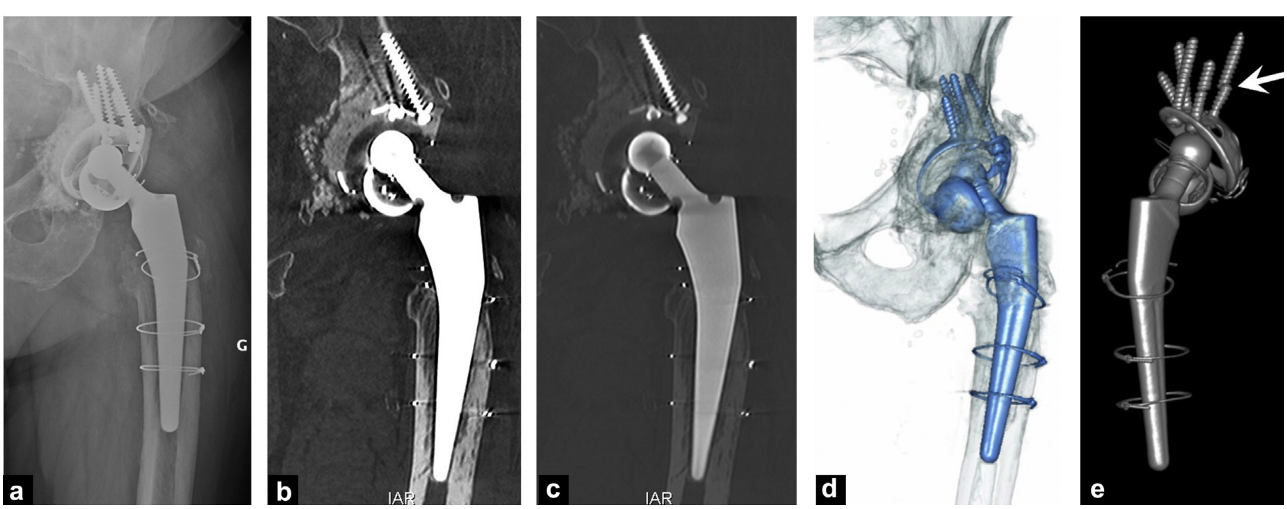

Figure 1. Preoperative computed tomography (CT) scan of a multioperated 83-year-old man shows implant loosening with component migration and screw fractures (arrow): a: conventional radiography; b and c: multiplanar reconstructions in the coronal plane of an (iterative reconstruction) with bone and implant component window settings to respectively assess bone and implant components; d and e: 3D reconstructions (volume rendering technique [VRT]) based on images obtained with iterative reconstruction provide a global view of the migration and implant fractures.

Please cite this article in press as: Blum A, et al. CT of hip prosthesis: New techniques and new paradigms. Diagnostic and Interventional Imaging (2016), http://dx.doi.org/10.1016/j.diii.2016.07.002