Heavy reading in heavy metal
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Citation for published version (APA):
Boomsma, M. F. (2017). Heavy reading in heavy metal: Unraveling the mystery of hip tissue in metal on metal total hip arthroplasty
Chapter 9

Summary
HEAVY READING IN HEAVY METAL
Unraveling the mystery of hip tissue in Metal on Metal Total Hip Arthroplasty

In this thesis we described our radiological experience with pathological capsular reactions after metal-on-metal (MoM) hip arthroplasty (HA) using computed tomography (CT) (chapter 2). We showed that CT is an accurate and reliable method for the pre-operative evaluation of femoral head and neck deformities, for the diagnosis of femoro-acetabular impingement either pre-operatively or post-resurfacing and for diagnosing post-operative capsular and bursal reactions when evaluating HA. CT imaging is superior in detecting and delineating osteolytic lesions compared to plain x-radiography. Since current CT scans are acquired in supine position, measurements of the inclination and version of the acetabular component do not take the pelvic tilt into account and cannot be simply extrapolated to the standing position or compared to measurements on standing radiographs. When the ipsilateral knee is included, adequate measurement of femoral anteversion relative to the retrocondylar axis of the knee can be performed (chapter 2). In this way we can identify malpositioning of HA components and the need for a revision in one CT scan session.

We established a CT grading scale for diagnosing post-operative capsular and bursal reactions found in patients with HA (chapter 2). This grading scale was used in two different patient cohorts: 1. large head MoM total hip arthroplasties (MoM THA; chapter 3) and 2. MoM hip resurfacing arthroplasties (MoM HRA) with the so-called Birmingham Hip Resurfacing (BHR; chapter 4). The presented CT classification of the hip capsule in capsular reactions showed good intra- and interobserver reliability and was independently associated with revision surgery. In a multiple logistic regression prediction model together with other unilateral significant MoM-related variables of interest when considering revision, a simplified version of grading scale showed to be the most reliable independent predictor for revision (chapter 3). Our results with the BHR HRA showed that pseudotumour formation occurs in 28 % of the patients as seen on CT scans after an average follow-up interval of forty-one months but most pseudotumours (72.5 %) in BHR HRA are asymptomatic. Failure of the BHR implant occurred in 8.4 % of the patients (5.6 % due to a symptomatic pseudotumour) after an average follow-up of forty-one months (chapter 4).

In addition, we investigated whether it was feasible to investigate bone mineral density (BMD) of the acetabular roof without the use of a phantom. We have shown that internal references of fat and muscle are of similar accuracy when compared to references obtained from an extra-corporal phantom at the level of the acetabular roof in patients with a one-sided MoM THA. The intra-class correlation coefficient showed excellent agreement between the two different references. Thus, there is no need to use an external phantom to quantify CT density measurements of body tissue.
(chapter 5). We combined the specific CT based findings of the post-operative hip capsule and bursa with clinical outcome parameters such as revision (chapter 3) and BMD. With the use of CT a statistically significant bone density difference with respect to the contralateral side between the acetabulum at the side of the prosthesis and the contralateral side after 2.8 year postoperative follow-up in patients with unilateral MoM total hip replacements was shown. Only the in situ time of the MoM THA showed a significant correlation with the bone density difference. Pseudotumour formation did not correlate with bone density differences (chapter 6).

A challenge in reading MoM bearings by means of CT are the metal artefacts for which a dedicated orthopaedic metal artefact reduction software tool is available named O-MAR. We quantified the visual clearly positive effect of O-MAR on metal artefacts in a hip phantom. Our phantom study shows significant reduction of metal artefacts by O-MAR caused by MoM THA. The reduction is relatively dependent on the amount of disturbance in attenuation caused by the metal artefacts and the strength was dependent of the location and severity of metal artefacts between 32 and 68 %. O-MAR showed a significant improvement in contrast-to-noise-ratio (CNR) as well. The decrease in CNR decrement is also dependent on attenuation disturbance by the metal artefact and varies between 52 and 72 % (chapter 7).

We are confident that in the near future the combined use of O-MAR with up-to-date model-based iterative reconstruction techniques will allow significant dose reduction while maintaining and even increasing image quality and thus resemble state of the art CT imaging of the pelvis with large metal implants. We will just see more with less radiation dose. This will be beneficial for quantification of CT findings in general and will also result in a better positioning of CT imaging in orthopaedics as it can more easily be applied in clinical outcome studies.