Evaluation of T2-weighted Slice Encoding for Metal Artifact Correction in Patients with Recalled Orthopedic Hip Implants

Conny Ström[1], Jörgen Strinnholm[1], Sead Crnalic[2], Morten Bruvold[3], Ulrike Blume[4], Chiel den Harder[3], and Clemens Bos[5]

[1]*Department of Radiation Sciences, Umeå University, Faculty of Medicine, Diagnostic Radiology, Umeå, Sweden,* [2]*Department of Ortopedy, Umeå University, Faculty of Medicine, Umeå, Sweden,* [3]*Philips Healtcare, Best, Netherlands,* [4]*Philips Healtcare, Hamburg, Germany,* [5]*Division Image, University Medical Center in Utrecht, Utrecht, Netherlands*

Introduction

Orthopedic implants as replacement of worn-out joints are subject to high mechanical workload. Particularly hip implants require high quality material composition for durability. Despite being considered as state-of-the-art design and material, older metal-on-metal implants do frequently cause problems as the alloy releases metallic debris from tear and wear leading to bone destruction, osteolysis, inflammatory pseudotumor and synovitis and secondary loosening of the metal implant. Issues with hip implants have caused a large recall program for some products and it is of high interest to evaluate whether the implant will be subject to complications or not, even before any clinical symptoms are apparent. MRI is the gold standard method to clarify the extent of these soft tissue complications. T2 weighted (T2w) imaging shows inflammatory pseudotumor and synovitis in good contrast. Slice Encoding for Metal Artifact Correction (SEMAC, [1]), resolves in-plane distortion using View Angle Tilting (VAT, [2]) and slice profile distortions by additionally applying phase encoding. Previously, Proton-Density (PD) and Short-Tau Inversion Recovery (STIR) SEMAC sequences have been evaluated in hip metal imaging [3]. In this work we investigate the potential of T2w SEMAC in showing soft tissue changes close to the metal implant in an asymptomatic cohort.

Materials and Methods

The study population consists of 40 patients who received a hip replacement about 5 years ago at the orthopedic clinic. Some patients received surface arthroplasty while others received a conventional femoral stem, and a large femoral head. In all cases, the acetabular portion is made of metal and the prosthesis has a so-called metal-on-metal articulation. Wear of these prostheses has been shown to generate soft tissue swelling around the prosthesis and high metal levels in blood. A sub-cohort of 23 asymptomatic patients subject to implantation of one or two hip implants (ASR Johnson & Johnson) were referred from the Orthopedic Surgery department to evaluate any potential complications and need for recall. T2w SEMAC was implemented on a clinical 1.5T scanner and images were made using a 32-element cardiac RF coil. A conventional axial T2w TSE (48 slices, 0.7x0.83 mm in-plane resolution, 4 mm slice thickness, TR=2800ms/TE=100ms, SENSE 1.5, read-out bandwidth of 626 Hz/pixel) sequence was compared to a SEMAC implementation with the same orientation and weighting (48 slices, 13 slice phase encoding steps, 0.9x1.4x4 mm, SENSE 2, TR=2200ms/TE=90ms, read-out bandwidth 794 Hz/pixel) with Off-Resonance Suppression [4] to avoid through-plane back-folding. Images were assessed for artifact size, and the presence and visible area of any fluid collection or pseudotumor, and osteolysis. Artifact sizes were compared using a paired T-test. Differences in visualized area of pathology were evaluated using Wilcoxon Signed-Rank test.

Results

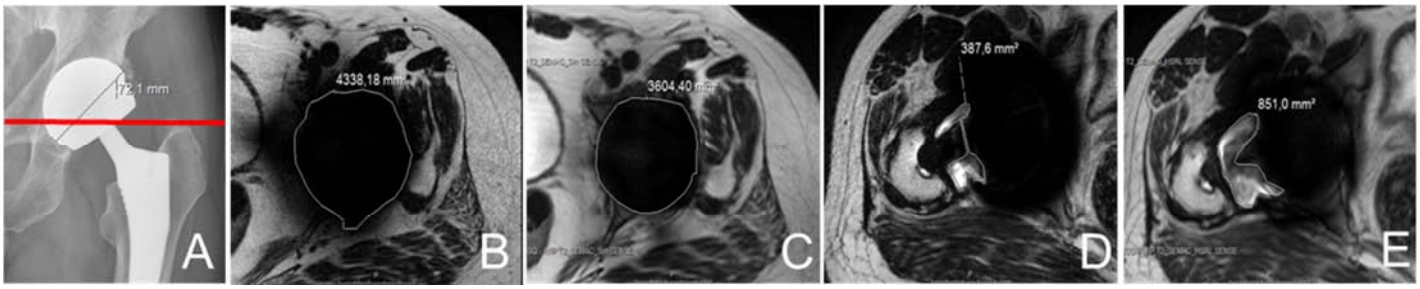

Figure 1. The diameter of the acetabular cup was measured using X-ray (A). Sample axial images and artifact contours positioned at the crossing of the acetabular head and the femoral part (red line) are shown for T2w in (B) and for T2w SEMAC (C). The effect of imaging closer to the implant is shown for the maximal extent of fluid and pseudotumor in conventional T2w (D) and T2w SEMAC (E).

The diameter of the prosthesis acetabular component was between 51 and 80mm (70mm ± 6.6mm). Artifact area was smaller on T2w SEMAC than on T2w TSE: 3490 mm2 (SD 520 mm2) vs. 4460 mm2 (SD 600mm2), P<0.001. There was a clear correlation between artifact size and acetabular component diameter which improved for T2w SEMAC (R^2 of 0.20 vs 0.48 P<0.01).

After consensus reading, 5 cases of osteolysis were reported, on both T2w and T2w SEMAC, and more of the lesion could be seen on T2w SEMAC: 144 mm^2 (Range 68-322 mm^2) vs. 111 mm^2 (Range 45-233 mm^2), P<0.05. Fluid collection or pseudo tumors were found in 21 patients on T2w TSE and in 22 patients on T2w SEMAC. When present, more of the lesion could be seen on T2w SEMAC: 394 mm^2 (Range 62-2060 mm^2) vs. 216 mm2 (Range 32-1248 mm^2) P<0.001.

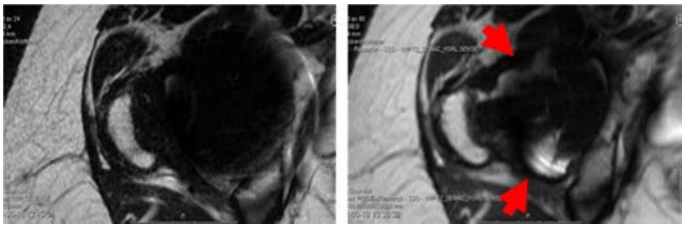

Figure 2. Clinical reading of fluid or pseudotumor. The artifact extension in the T2w (left) covers the pathologic edema around the implant where T2w SEMAC (right) is decisive.

Discussion and Conclusion

MRI serves as one of several modalities to guide the orthopedist in the decision on prosthesis replacement. Replacing hip implants before clinical symptoms appear reduces the invasiveness of the surgery and saves the patient painful waiting time and improves recovery. A screening of asymptomatic patients with hip implants puts an even higher demand on the metal imaging protocol than in patients with severe changes in bone structure and soft tissue. The study is somewhat limited by its focus on a single weighting, so we could not assess the diagnostic accuracy of MR using an optimal combination of weightings. In conclusion, this work shows that SEMAC allows MR imaging substantially closer to the implant to unveil more of the fluid collections, pseudotumors or osteolytic areas, in diagnostically valuable T2w contrast.

References

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