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

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Introduction

Wear and tear of orthopedic implants is seen in a significant amount of patients approximately fifteen years after the intervention with prostheses that were considered state-of-the-art design and material. Debris deposited around the acetabular capsule results in bone destruction, osteolysis, inflammatory pseudotumor and secondary loosening of the metal implant. It is crucial for the clinician to clarify the extent of these complications to evaluate if and to what extent implant replacement is necessary and to determine the optimal treatment of the relatively large patient group. Evaluation for osteolysis requires imaging in the direct vicinity of the implant. CT reveals bone density and dimensions of bone and implant but is not appropriate to get information about soft tissue changes such as pseudotumor. MR provides soft tissue imaging but suffers from distortions and artifacts observed around metallic objects. Recently, Slice Encoding for Metal Artifact Correction (SEMAC, [1]), was introduced that resolves in-plane and through-plane distortion, using View Angle Tilting (VAT, [2]) and phase encoding of the slice profile, respectively (example shown in Fig. 1). Here, the utility of SEMAC is compared to standard high-bandwidth TSE for imaging of osteolysis and soft tissue lesions in patients with total hip replacements.

Materials and Methods

Twenty patients who received a total hip replacement in the late 1990's were referred from the Orthopedic Surgery department. SEMAC was implemented on a clinical 1.5T MR scanner. Images were acquired using a 32-element cardiac RF coil. High bandwidth conventional axial Proton Density Weighted (PDW TSE, 56 slices of 4mm, 1.07mm×1.0mm in-plane resolution, TR=3000ms/TE=10ms, BW 946Hz/pixel) and coronal Short Tau Inversion Recovery (STIR, 22 slices of 4mm, 1mm×1.46mm in-plane resolution, TR=2000ms/TE=10ms, BW 555Hz/pixel) sequences were compared to SEMAC images with the same orientations and weightings (axial PDW SEMAC, 48 slices of 4mm, 11 slice encoding steps, 1mm×1.3mm in-plane resolution, TR=2400ms/TE=18ms and coronal STIR SEMAC, 24 slices of 4mm, 9 slice encoding steps, 1mm×1.46mm in-plane resolution, TR=2200ms/TE=30ms) with Off-Resonance Suppression [3] to avoid through-plane back-folding. Two experienced radiologists (C.S. and J.S.) evaluated the image quality and artifact extension independently. The analysis included the measurement of the artifact area (mm^2) in the coronal STIR sequences which was calculated from total artifact area (Fig. 2a and b) minus the acetabular component area from CT scanning (Fig. 2c). Just cranial of the acetabular component of the prosthesis the total artifact area in the axial PDW sequences were measured (Fig. 2d and e). Additionally, the number of slices with artifacts was counted for the STIR images.

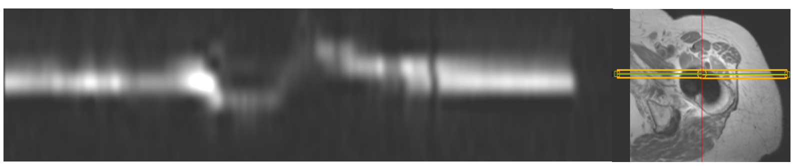

Figure 1. Example of single axial slice (right) and through-plane slice distortion in coronal plane (left), resolved by slice encoding

Figure 2. Evaluation of artifact size by manually defining the total area of the artifact in the coronal STIR (a) and STIR SEMAC (b) and subtracting the acetabular component area obtained by CT (c). Total artifact extent was also delineated in axial PDW (d) and PDW SEMAC (e).

Results

The area of the artifact in STIR SEMAC was significantly less than in conventional STIR ($422\pm90mm^2$ vs. $1601\pm244mm^2$, respectively), $P<10^{-10}$. Likewise, the total artifact of PDW sequences was significantly larger for conventional TSE ($1163\pm192mm^2$) than for SEMAC ($471\pm196mm^2$), $P<10^{-10}$. The number of slices affected by artifacts was lower in the SEMAC (15±1.9) than in the conventional (18±1.4) series of coronal STIR images, $P<10^{-6}$.

Image quality was in general considered superior in the SEMAC images compared to the conventional images except for noise in the PDW series. The radiologists judged SEMAC images to be superior to conventional images for delineation of tissue structures.

Discussion and conclusion

We observed a large difference between the SEMAC and corresponding conventional sequences in terms of artifact size and how artifacts interfere with the clinical assessment. As the data presented herein is part of the larger study we did not yet perform an exact delineation and measurement of osteolysis and inflammatory pseudotumor. However, preliminary review indicates that SEMAC was essential to be able to observe osteolysis and inflammatory pseudotumor near the implant at all in this patient group. PDW is not an appropriate sequence for evaluation of edema, but in general edema is an important marker for pathology. Future work will also include other weightings and a T2W SEMAC sequence will be evaluated in the coming setup.

In conclusion, SEMAC enables tissue evaluation very close to the metal implant, thus significantly improving the quality of the diagnosis when imaging near hip implants.

References

[1] W. Lu et al., MRM 62:66 (2009) **[2] Z.H. Cho et al., Med Phys, 15:7 (1988)** **[3] C.J. den Harder et al., ISMRM2011, p3170**