Initial experience with artefact reduction sequences and MR conditional cochlear implants

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Introduction

A growing number of MR conditional cochlear implants can now be scanned safely without requiring temporary surgical removal of the internal magnet. However, scanning with the magnet *in situ* represents perhaps the worst case scenario for metal artifact with large areas of signal drop-out and distortion around the device which may obscure nearby structures of interest, even with spin echo sequences and large receiver bandwidths. The aim of this work was to evaluate two new options available on a clinical MRI scanner for reducing metal artefacts, View Angle Tilting (VAT) [1] and Slice Encoding for Metal Artifact Correction (SEMAC) [2].

Methods

A uniform phantom was imaged on a 1.5 T MR system (MAGNETOM Aera, Siemens Healthcare, Germany) with an MR conditional cochlear implant fixed to the side. Images were obtained with a repeated TSE sequence with different options including: standard TSE (receiver bandwidth 190 Hz/pixel) VAT, SEMAC (prototype sequence provided via a works-in-progress package) and standard TSE with maximum receiver bandwidth (610 Hz/pixel). SEMAC was applied with a varying number of phase-encodings per slice ranging from 0-32. Other parameters were kept approximately the same (TR≈5.6s, TE≈97ms). The phantom images were thresholded to include only voxels within 60% -180% of the mean signal intensity (chosen from a region not affected by the implant). Voxels outside this range were considered to be within the artefact and set to zero. The signal void fraction was calculated from the ratio of the phantom volume removed through thresholding to the total phantom volume. Additionally a volunteer was imaged with the implant firmly bandaged to side of the head (at the typical implant location) and the same sequences were acquired

Results

The signal void fractions measured in a phantom for the VAT and SEMAC sequences are shown in fig 1. Volunteer results showed reduction of the artefact extent with VAT (fig 2(a-c)). SEMAC result for 6 phase encoding steps does not display any qualitative reduction in artefact extent, however, structures were visible through the artefact "penumbra" (fig 2(d)). SEMAC result from a different imaging session with 14 phase encoding steps does show marked reduction in the artefact extent and image distortion (fig 2(e-f))

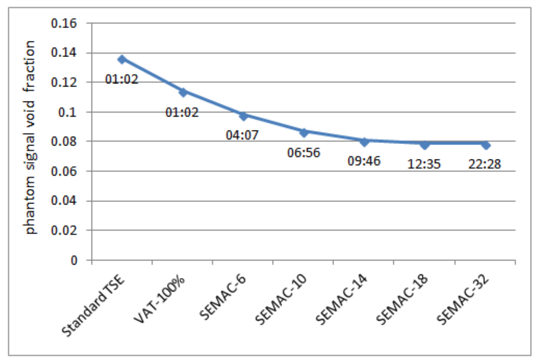

Figure 1. Signal void fraction for the phantom for w/o VAT and various SEMAC phase encodings per slice. The numbers on each data point represents the acquisition time for that sequence

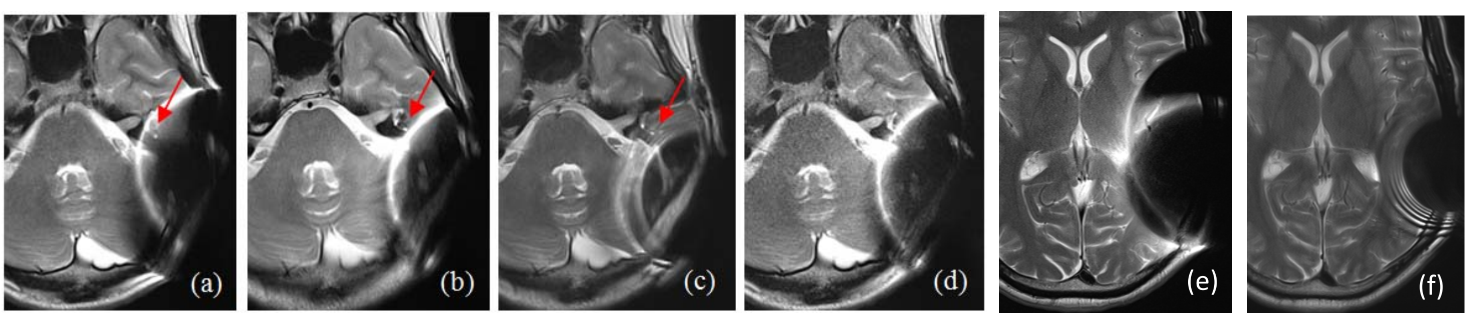

Figure 2. Artefact in regular TSE sequence (a) extends medially to obscure the inner ear structures, in particular the high signal of the posterior semicircular canal (arrow). The artefact is less extensive with the posterior semicircular canal clearly displayed with VAT (b). The addition of SEMAC factor 6 with VAT (c) gives rise to a "penumbra" to the artefact, which although extends as far as that seen in the regular TSE sequence, is of reduced severity with less distortion of surrounding structures and the posterior semicircular canal remains visible. Only a slight reduction in artefact compared to regular sequence is demonstrated by the conventional approach of maximising receiver bandwidth from 190 to 610 Hz/pixel (d) with an apparent reduction in SNR. (e) Imaging results for a different imaging session with regular TSE sequence and (f) results for SEMAC factor 14.

Conclusion. VAT and SEMAC appear promising for artefact reduction when scanning MR conditional cochlear implants where the internal magnet is left *in situ*. Our results can help to inform which parameters to choose to optimize artefact reduction whilst keeping imaging time at a minimum.

References

[1] Cho, Z.H. et.al. Med. Phys: **15**, 7 (1988). [2] Lu, W. et.al. Magn. Reson. Med: **62**, 66 (2009).