Restoration of large slice profile distortions near metallic implants by frequency mapping

Viktor P Morin[1], Gunilla M Müller[2], and Sven Månsson[3]

[1]*Electrical measurements, Lund University, Lund, Sweden,* [2]*Radiology, Lund University, Malmö, Sweden,* [3]*Medical Radiation Physics, Lund University, Malmö, Sweden*

Target audience

The results of this work are of interest to those working with methods for orthopedic imaging near metallic implants.

Purpose

The interest to apply MRI examinations near metallic implants is growing, triggered not least by the failures of Articular Surface Replacement implants[1]. Accordingly, acquisition techniques to reduce image artifacts have been developed. View angle tilting (VAT) reduced in-plane distortions[2], and field mapping was previously used to correct through-plane distortions when the frequency offset was moderate[3]. More recently, Slice Encoding for Metal Artifact Correction (SEMAC) was developed for correction of much larger frequency offsets[4]. However, despite the use of acceleration techniques (parallel imaging, partial Fourier), SEMAC is still time consuming (>10 min) when the slice profile is heavily distorted.

The purpose of this work is to investigate the use of field mapping to restore the slice profile of a rapid VAT sequence without SEAMC encoding, when the frequency offset is very large.

Methods

A stainless steel hip prosthesis (Stryker Exeter) was embedded into agarose gel together with a rectilinear Perspex grid. Coronal MR images aligned with the grid were acquired on a 1.5-T Siemens scanner. Four VAT spin echo sequences with 0, 15, 25, and 50 µs offsets between the *k*-space center and the spin echo position were acquired for calculation of a 3D field map (TR/TE = 600/5 ms, matrix = 128×96, bandwidth = 977 Hz/px, 32 slices with 3 mm thickness). To improve the SNR of the field map, the field map based on the shortest offset was used to unwrap the maps based on longer offsets. The slices of the acquisition with 0 µs offset were transformed to a 3D k-space and a phase shift corresponding to the slice displacement determined from the field map was applied to all voxels, before inverse FFT along the z-direction.

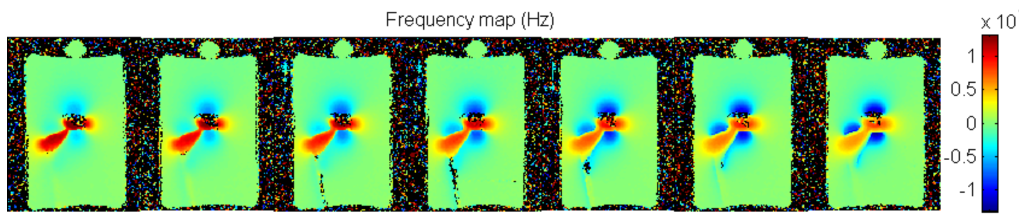

Fig. 1. Fieldmap showing the frequency offset near the stainless steel hip implant. The range of frequencies was roughly ±15 kHz, corresponding to a maximum z-displacement of nearly 10 slices.

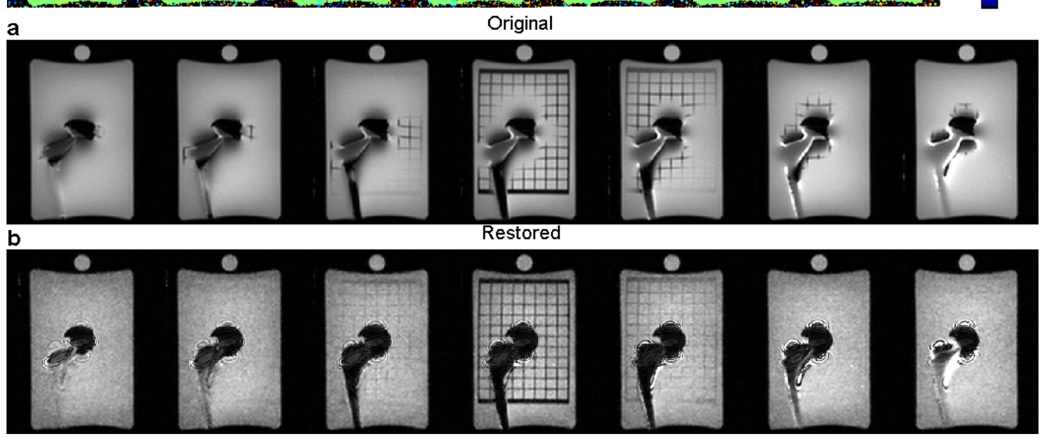

Fig. 2. Spin echo images with VAT before (a) and after (b) restoration of the slice profile using the fieldmap shown in Fig, 1.
Before restoration, the gridlines are visible ±three slices away from the center slice. After restoration, the grid is correctly displayed in the center slice.

Results

The measured fieldmap is shown in Fig. 1. The frequency range was approximately ±15 kHz. Fig. 2 shows the corresponding images before and after restoration of the slice profile. After restoration, the grid is correctly displayed in the centre slice. However, the SNR is clearly reduced in the restored images.

Discussion

The results show that field map correction can restore the slice profile even near implants causing very large frequency offsets. The SNR were substantially reduced in the restored images, however neither the field map acquisition nor the reconstruction algorithm was fully optimized in this pilot study.

Conclusion

Field mapping can restore the slice profile even when the frequency offset caused by the metallic implant is very large. This method, when applied to conventional spin echo sequences with VAT, may therefore be an alternative to the more time consuming SEMAC encoding.

References

1. Hug KT, *et al.,* Clin Orthop Relat Res, Aug 2012.
2. Cho Zh, *et al.* Med Phys, 15;1988.
3. Butts K, *et al.*, Proc. ISMRM, p2380; 2006.
4. Lu W, *et al.*, Magn Reson Med, 62; 2009.