Distortion Scout in Metal Implants Imaging

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Introduction SEMAC [1] is a recently published technique, which combines the view angle tilting [2] (VAT) gradients with additional slice encoding steps to fully recover the geometric distortion induced by the metal implants in MRI examination. However, the use of extended slice encoding makes the kind of techniques suffer from very long acquisition time. In clinical evaluation, there are several types of metal implants, which introduce different degree of B0 inhomogeneity. Even in a single scan, the slice close to the implant needs more extended slice encoding, but the slice away from the implant may need much less. Based on the above facts, there are two ways to further reduce the acquisition time: 1) adjust the extended slice encoding steps for the specific type of implant; 2) use variable slice encoding steps for different slices. However, before these two schemes are implemented, the accurate distortion degree of each slice should be determined. In this abstract, a feasible method for the through-plane distortion scout in both SEMAC and the SEMAC-MAVRIC hybrid techniques [3] is presented.

Methods

Two running modes are designed in the acquisition: 'Image Mode' for acquiring the data for image reconstruction, and 'Scout Mode' for the through-plane distortion scout. 'Scout Mode' runs before the 'Image Mode'. Compared to the 'Image Mode', the readout gradients in the echo train are moved from read axis to slice axis in 'Scout Mode' (shown in Fig1). After the Fourier transform, the directly measured maximum distortion Δ in the slice direction actually includes two parts: a) the distortion Δ1 in the presence of slice-selection gradients during the procedure of signal excitation; b) the distortion Δ2 in the presence of readout gradients during the position encoding (shown in Fig2).

Since the distortion Δ1 and Δ2 has opposite sign in case of identical polarity between slice-selection gradients and readout gradients, and they are directly proportional to the amplitude of the gradients, the following formulas are obtained:

$$\Delta = \Delta 1 - \Delta 2$$

$$\frac{\Delta 1}{\Delta 2} = \frac{GS_{ro}}{GS_{ss}}$$

GSro is the amplitude of the readout gradient, and GSss represents the amplitude of the slice-selection gradient. Finally, the required extension factor *f* of the additional slice encoding can be calculated as:

$$f = \frac{\Delta 1}{TH} = \frac{\Delta}{(1 - \frac{GS_{ss}}{GS_{ro}}) \cdot TH}$$

TH is the nominal excitation thickness of a slice or slab.

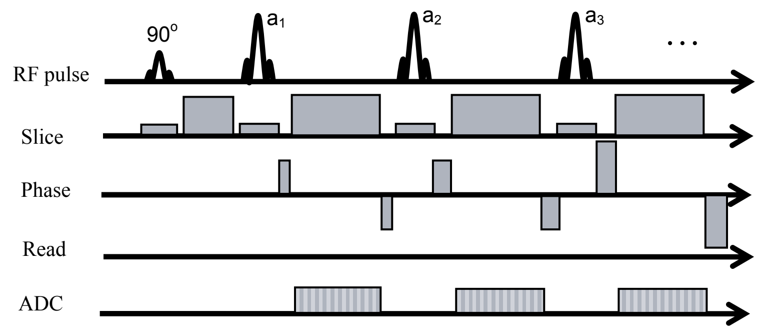

Fig1. The sequence diagram for the through-plane distortion scout, in which the readout gradients are moved from read axis to slice axis.

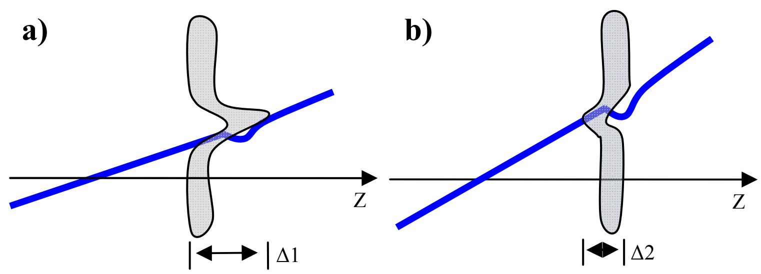

Fig2. a) Formation of the through-plane distortion in the presence of slice-selection gradients (blue arrow); b) formation of the distortion in the procedure of readout encoding (blue arrow).

Results

Phantom evaluation of the method was performed on a 1.5T MR scanner (MAGNETOM ESSENZA, SIEMENS Mindit Magnetic Resonance Ltd, Shenzhen). A cobalt-chromium femoral implant was attached onto a phantom. In Fig3, the induced through-plane distortion was measured by the 3D acquisition (Fig3 a) and 2D distortion scout method (Fig3 b) separately. The maximum distortion in 3D acquisition is 5.02cm, which is taken as 'Gold Standard'. The maximum distortion in 'Scout Mode' is 4.09cm. Considering the GSss (5.5 mT/m) and the GSro (21.74 mT/m) in this experiment, the calibrated distortion in 'Scout Mode' is 5.4cm, which is quite close to the 'Gold Standard' from the 3D acquisition. With a nominal excitation thickness of 1.3cm, the required extension factor of the slice encoding in this slice is about 4.2.

Conclusion and Discussion

.The phase encoding steps in the proposed distortion scout method can be turned off, which provides even faster speed. This method can be fully integrated into the SEMAC and the SEMAC-MAVRIC hybrid techniques, without separate sequence for the through-plane distortion scout.

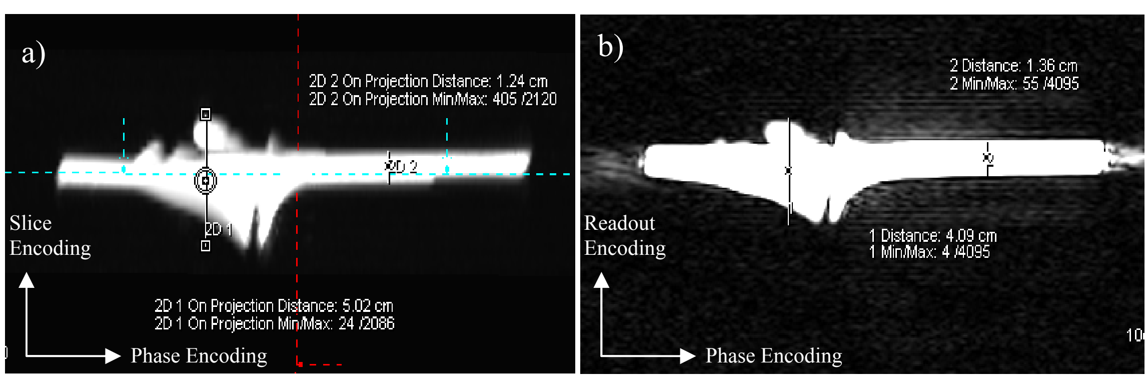

Fig3. a) The measurement of the through-plane distortion by 3D acquisition; b) the measurement of the through-plane distortion by 2D acquisition in the 'Scout Mode'

References

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[2] Koch KM et al., Magn Reson Med 2009;61(2):381-90.
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