Field probe based shot-to-shot B_0 correction for multi-shot breast-DWI at 7T

Tijl A. van der Velden[1], Vincent O. Boer[1], Peter R. Luijten[1], and Dennis W.J. Klomp[1]
[1]*Radiology, University Medical Center Utrecht, Utrecht, Utrecht, Netherlands*

Introduction

Diffusion-Weighed Imaging (DWI) is an effective parameter to distinguish between malignant and benign breast tumours [1]. However, the inherent spatial resolution of DWI in clinical MRI is low, thereby reducing sensitivity in tumour detection, particularly from small lesions. With regularly used single-shot EPI acquisition the resolution of the image is limited and EPI-distortions can be severe, especially close to water/lipid boundaries inside the breast, which becomes worse at higher fields. By moving to multi shot imaging, higher resolutions can be obtained and EPI-distortions are reduced. However, inter-shot variability in the B_0 field causes severe ghosting artefacts. Physiological effects, e.g. motion of the respiratory system, can cause these non-local B_0 fluctuations [2] (fig 1). Recently, field probes have been used to measure these fluctuations [2,3]. This data can be used to correct the variation between shots in a multi-shot acquisition, thereby removing ghost artefacts and improving image quality. With the increased SNR at 7T, high resolution DWI of the human breast is now feasible with minimal distortions using field probe corrected multi-shot EPI.

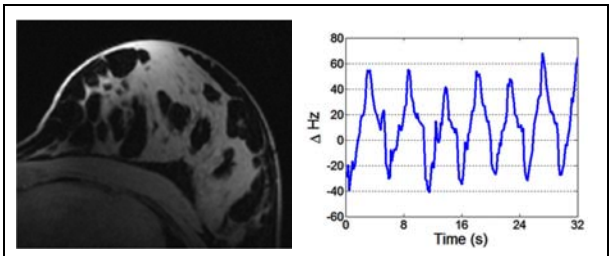

Figure 1: Local B_0 fluctuations measured in the breast from a dynamic B_0 map

Figure 2: Home-built T/R field probe tuned at ^{19}F, and interfaced directly to the Philips MR system.

Methods

A healthy volunteer was scanned on a 7T MRI (Achieve, Philips Healthcare, Cleveland, USA). The system was equipped with a home-built quadrature, unilateral, breast-coil. Four home-built field probes (fig 2), small T/R-coils tuned at ^{19}F, were placed around the breast coil. Both single shot (TE=60ms, 60% halfscan) and multi-shot DWI (TE=94ms, full kspace, 2 shots) were acquired with a B-value of 0 and 500mm2/s (TR 4s, 1x1mm2, FOV 150x150mm^2, SPAIR and slice-selection gradient reversal lipid suppression). Just before every shot a short (1ms) pulse-acquire B_0 field measurement was performed. The field information was stored and used for calibrated retrospective shot-to-shot B_0 correction of the data.

Results

The standard single shot spin echo EPI leads to severe distortions in the human breast (fig 3B). Multi-shot imaging is less prone to susceptibility distortions, however, suffers from severe ghosting due to B_0 field instability in the breast (fig 3C). K-space phase correction with B_0 field information from the field probes leads to improved coherence between the shots, and reduces the ghosting (fig 3D) from which an ADC map can be calculated (fig 3E).

Discussion and Conclusion

B_0 field monitoring was used to reduce ghosting artefacts in multi shot EPI images. This information had been obtained by using B_0 field probes. While real time correction and higher order dynamic field monitoring have not yet been applied, we already demonstrated that multi-shot imaging in combination with the field probes, substantially reduced ghosting artefacts when considering zero order dynamic B0 fluctuations only. Therefore high resolution DWI was feasible in the human breast at 7T.

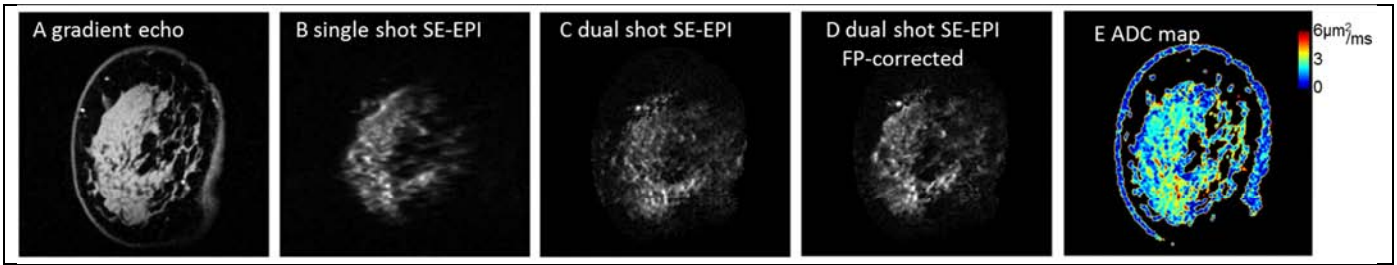

Figure 3: gradient echo image (a), single shot spin echo (SE) -EPI shows severe distortions and blurring (b). Dual shot imaging is less prone to distortions, but suffers from ghosting (c) which can be restored by B_0 correction, showing a high resolution (d). From this corrected image an ADC map can be calculated (e).

References

[1] Guo et al. JMRI 2002 [2] Boer et al. MRM 2012 [3] De Zanche, MRM 2008