Multiple Narrow-Band Excitations Spiral Imaging

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Introduction

Spiral trajectories are used for fast imaging. However, in the presence of off-resonance a typical blurring of the image occurs especially when using long readout times. A few methods have been proposed to correct for off-resonance in the reconstruction [1,2]. Here, an excitation approach is proposed. Multiple narrow band pulses are used to excite only on-resonance spins thus avoiding off-resonance .The full range of frequencies in the image is obtained by multiple acquisitions shifting the center frequency from one acquisition to the other. A super-field of view (sFOV) approach [3,4] (sensitivity encoding type reconstruction [5]) is used to reduce the scan time overhead associated with the multiple acquisitions. A spiral phantom scan is demonstrated

Theory

ting a narrowband of frequencies, the effect of off resonance within the excited spins in minimal. However, the can time is increased by the number of acquisitions. The narrow-band pulse is imposing a sensitivity profile that depends on the off-resonance. By changing the center frequency the sensitivity will shift. Since in general, off-resonance is slow varying [6], and the spectral profile of the pulse is known, the sensitivity can be estimated with little or no overhead (for example from a low-res frequency map). Therefore, instead of acquiring multiple full k-space images one can sub-sample k-space and reconstruct using a SENSE type reconstruction incorporating the excitation profiles information in the reconstruction.

Methods:

As a proof of concept we designed a narrow-band spectral spatial RF pulse. The pulse duration was set to 20ms, which achieves a band-width of a 100hz with a slice thickness of 7mm. We tested our method on a 1.5T GE Signa scanner with gradients capable of 40mT/m and 150mT/m/ms maximum slew-rate using a 25 interleaves GRE spiral sequence with 16ms readout (FOV=16cm, res=0.75mm). To simulate off resonance we applied a linear shim across the image, creating off resonance of 30hz/cm. We acquired 7 images each time shifting the center frequency by 50hz. The k-space data was sub sampled by a factor of four for each of the images -- only 1.75 increase in scan time compared to a full single wide-band excitation acquisition. The sensitivity maps were calculated using frequency maps and the pulse profile. The image was reconstructed using SENSE type iterative conjugate-gradient method [4,5]. The result was compared to a full FOV multiple acquisition and to a wide-band single acquisition.

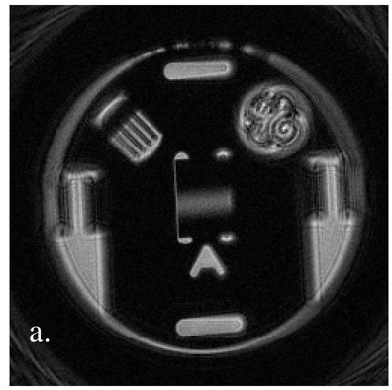
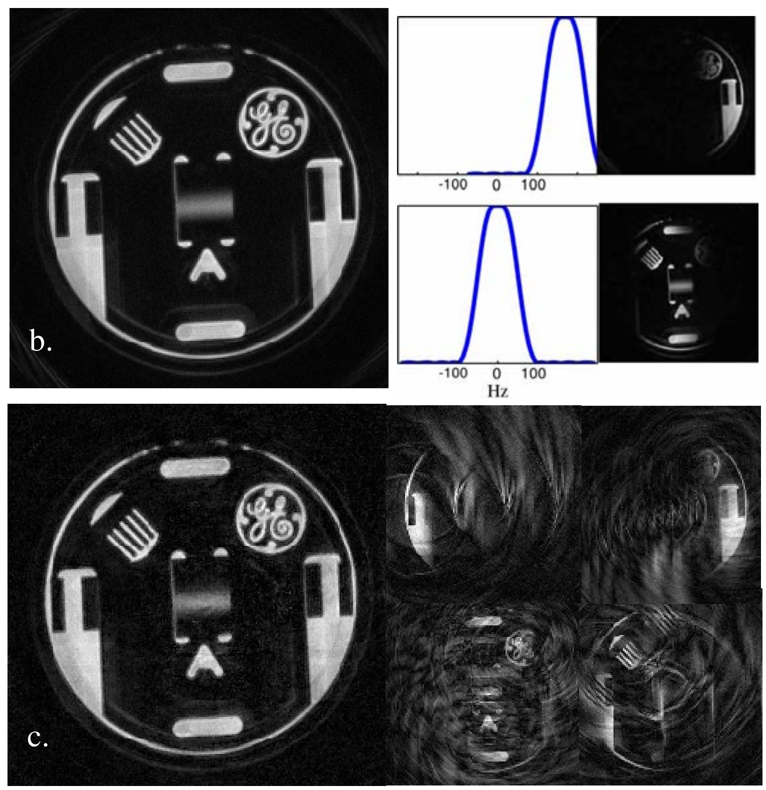


Figure 1: a) Wide band excitation, single acquisition. The result experiences image blurring due to off resonance. b) Multiple acquisitions of narrow-band excitations. Two of the acquisitions and the corresponding spectral profile of their pulses are shown on the right. c) Multiple undersampled acquisitions of narrow-band excitations with sFOV reconstruction. The undersampled narrow-band images used in the sFOV reconstruction are shown on the right.



Results and Conclusions

Fig. 1 outlines the results of the experiment. The images acquired with the narrow-band multiple acquisition are free of off-resonance artifacts. The sFOV reconstruction exhibits similar sharpness as the full multi narrow-band acquisition. In conclusion, by using multiple narrow-band spiral acquisitions one can avoid off-resonance artifacts. Using an sFOV approach can significantly reduce the scan time overhead. It is also possible to further speed up the acquisition by using interleaved multi-frequency excitations as in multi-slice FSE imaging.

References

[1] Man et al, MRM;37(5):785-92(1997) [2] Man et al, MRM;37(6):906-13(1997) [3] Lustig et al, US Patent 7,132,828. [4] Lustig et al, Proc ISMRM;p. 504 (2005) [5] Pruesmann et al. MRM 2001,46:638-651 [6] McGibney et al. MRM 1993, 30:51-59