Dual-Resolution Multi-shot Partial k-Space EPI Acquisition

Y. Mazaheri[1], E. C. Wong[1], T. T. Liu[1]

[1]Center for Functional Magnetic Resonance Imaging, UCSD, La Jolla, CA, United States

INTRODUCTION: Single-shot partial *k*-space EPI acquisitions for high resolution imaging reduce artifacts due to T_2* decay as reported by Jesmanowicz *et al.* [1]. It has also been shown that multi-shot interleaved EPI reduces T_2* artifacts, particularly at high field strengths [2]. Recently, a method which combines partial *k*-space and multi-shot EPI was reported by Lu [3]. The results demonstrate improved image quality due to further narrowing of the T_2* point spread function. Here we present a dual-resolution technique that acquires an additional data set prior to the echo time, during multi-shot interleaved partial *k*-space EPI acquisition. For data acquired after the first RF pulse, the echo time of both the additional data set and interleaved data are shifted by a time equal to half the duration of the acquisition window. For the interleaved data, this echo shift reduces ghosting artifacts. The phase difference between the reconstructed low resolution complex data sets, brought about by the echo shift, can be measured and used to generate real-time field maps as suggested by Roopchansingh *et al.* [4]. The field maps can be used to reduce geometric distortions due to B_0 inhomogeneity, chemical shifts, and eddy currents that distort the high resolution multi-shot image. Furthermore, since they are acquired in real-time, the need for a separate acquisition is eliminated.

METHODS: A schematic diagram of the *k*-space trajectory is shown in Figure 1. Prior to acquiring each interleave, low spatial frequency data are sampled at intervals of Δk_y. Subsequently, *k*-space data are sampled (in the opposite k_y direction) at intervals of $2\Delta k_y$ in an interleaved fashion (see Fig. 1a). The acquired data are divided into two sets (Fig. 1b and Fig. 1c) and reconstructed separately. The first set consists of fully sampled low spatial frequencies acquired at echo times of: TE_1, and $TE_2 = TE_1 + \Delta TE$, (see Fig. 1b) and zero-filled prior to reconstruction. The echo shift ΔTE, is 1 ms. The second set consists of partial *k*-space interleaved data, with higher spatial resolution acquired at echo time of TE_h. For this data set, complex conjugation and phase correction are performed during reconstruction. We have acquired gradient-recalled two-shot EPI images of a resolution phantom on a Varian 4 Tesla imaging system. The acquisition parameters were: $\theta = 90°$, FOV = 24.0 cm, TR = 2000 ms, 1 slice, slice thickness = 4.0 mm. The acquisition matrix for the low spatial resolution image was 64×16 zero-filled to 64×64. The acquisition matrix for the interleaved data set was = 64×40 with 8 over-scan lines.

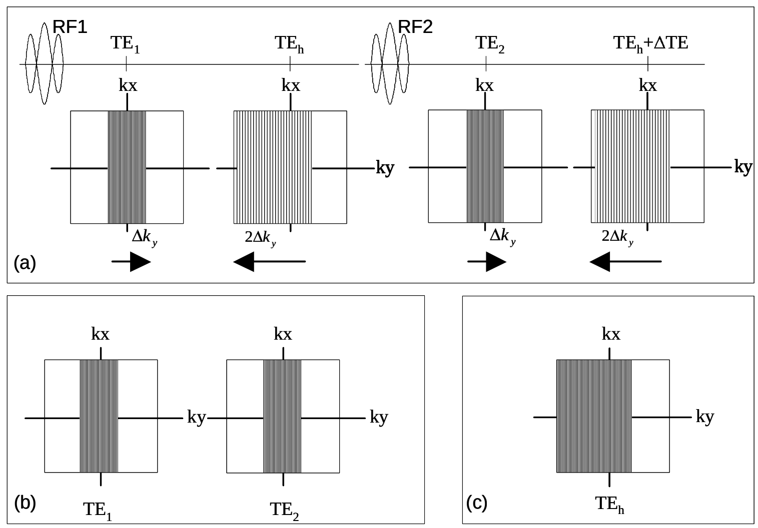

Figure 1: Interleaved (two-shot) dual-resolution partial k-space EPI acquisition.

RESULTS: Figure 2 shows (a) a two-shot EPI image of a phantom and (b) a low spatial resolution image of the same object acquired using the dual-resolution acquisition strategy. With a bandwidth of 125 kHz, the echo times were 9.1 ms (9.2 ms for the second RF pulse) for the first set of data and 21.9 ms for the interleaved data set. These echo time values compare to 26.2 ms for single-shot full *k*-space, 14.8 ms for two-shot full *k*-space, and 9.1 ms for two-shot partial *k*-space (8 over-scan lines) acquisitions. Hence, the acquisition of the low spatial resolution image at short echo times increases the echo time of the interleaved set from 9.1 to 21.9 ms but does not affect the overall temporal resolution of the image.

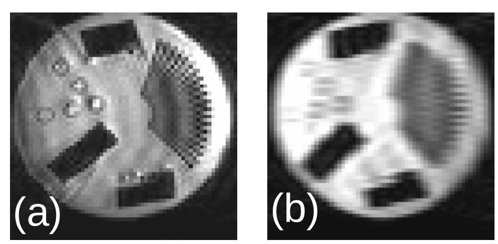

Figure 2:Dual Resolution Image

DISCUSSION: We have presented a method that acquires EPI images with multiple shots and partial sampling of *k*-space, while monitoring the imaging region at twice the sampling rate with low spatial resolution images acquired at each RF pulse. The acquisition of a high temporal resolution image can be beneficial in reducing artifacts. A low spatial resolution field map is useful for real-time off-resonance phase correction due to B_0 inhomogeneity. Currently we are investigating applications of this acquisition sequence for high resolution fMRI experiments.

REFERENCES

[1] Jesmanowicz A., *et al*., *MRM* 40, 754-762, 1998.
[2] Yacoub, E., *et al*., *MRM* 45, 588-594, 2001.
[3] Lu, H., *et al*., *Proc. ISMRM*, p. 2372, 2002.
[4] Roopchansingh, V., *et al*., *MRM* 50, 839-843, 2003.