High resolution reduced-FOV single-shot FSE imaging using 2DRF pulses with less blurring and low SAR

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Introduction: Single shot fast spin echo (SS-FSE) is an important fast sequence, which collects all k_y lines in one shot to produce T2-weighted images rapidly. However, the extremely long echo train length (ETL) in SS-FSE brings side effects such as blurring, low spatial resolution, ghosting, and high SAR. Reduced FOV (RFOV) imaging could be employed to reduce k_y lines and hence reduce the ETL without sacrificing spatial resolution for applications in which fractional FOV may be of clinical interest. The purpose of this work is to develop RFOV imaging using 2DRF pulse in a SS-FSE sequence to benefit fast imaging applications. High spatial resolution RFOV imaging by 2DRF in SS-FSE results in a shorter acquisition time with significantly reduced blurring artifacts and lower SAR.

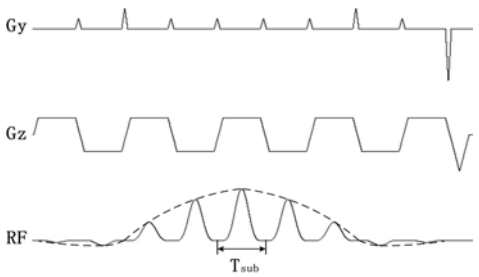

Fig.1. Waveforms of an echo-planar 2DRF pulse

Methods and Results: The echo-planar 2DRF pulse [1] was implemented using a 2DRF pulse library developed by National Center for Image-Guided Therapy (www.ncigt.org). The waveforms for a 2DRF pulse with 9 sub-pulses are shown in Fig.1. Imaging experiments were performed on a 1.5T GE Signa MR scanner. FOV reduction factors (R) from 2 to 5 were demonstrated in phantom imaging (Fig. 2) with a 7*688μs 2DRF pulse. Fig. 3 shows the comparison in spatial resolution between full FOV and RFOV brain images. Matrix sizes of 128*128 and 192*192 were acquired for Fig. 3(a) and (b), respectively. A matrix size of 320*320 with RFOV factors of 2 and 3 are shown in Fig. 3(c) and (d), respectively. The total acquisition times for Fig. 3(a-d) are 0.74s, 1.22s, 0.94s and 0.69s, respectively. Fig. 4 demonstrates blurring reduction in the RFOV image compared to a full FOV image with the same nominal spatial resolution of 320*320. In Fig. 4(a), the septum pellucidum and fornix (white arrow) and internal cerebral veins (yellow arrow), blur due to the T_2 decay within the extremely long echo train length. The fine structures in Fig. 4(b) are better visualized when the ETL is halved.

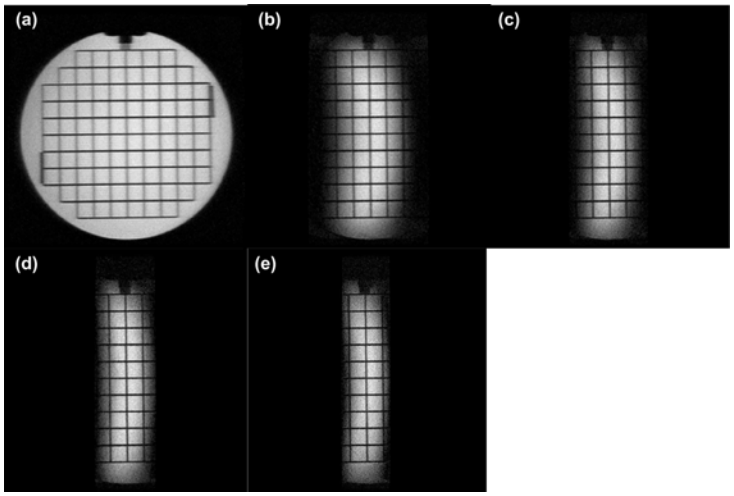

Fig.2. (a) full FOV; (b-e) RFOV with R from 2 to 5, respectively. Imaging parameters: FOV = 22 cm, matrix = 256*256, thickness = 8 mm, bandwidth = 83.33 KHz.

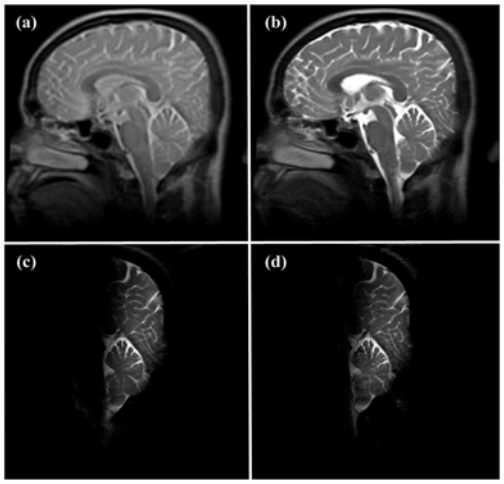

Fig.3. (a) full FOV: 128*128, ETL=70; (b) full FOV 192*192, ETL=102; (c) RFOV: 320*320, ETL=86, R=2; (d) RFOV: 320*320, ETL=66, R=3; FOV=22cm, thickness: 5mm; bandwidth: 20.83KHz

Discussion: Unlike spatial pre-saturation and orthogonal RF excitation, RFOV imaging by 2DRF is insensitive to B_1 inhomogeneity, experiences no T_1 recovery within the saturation band, and is compatible with multi-slice scans. It is promising for various fast imaging applications in image guided therapy. However, a problem with 2DRF echo-planar pulses is its sensitivity to B_0 inhomogeneity and the timing delay between RF gradient waveforms [2]. Susceptibility and B_0 inhomogeneity could be compensated by a careful shimming. Fly-back 2DRF excitation addresses the timing mismatch problem, but at the cost of double the pulse duration. Phase-calibrated bipolar 2DRF pulses [2, 3] can also be employed but require increased complexity of 2DRF design. In conclusion, high resolution RFOV SS-FSE imaging has been achieved using echo-planar 2DRF pulses with less blurring and low SAR to benefit fast imaging applications.

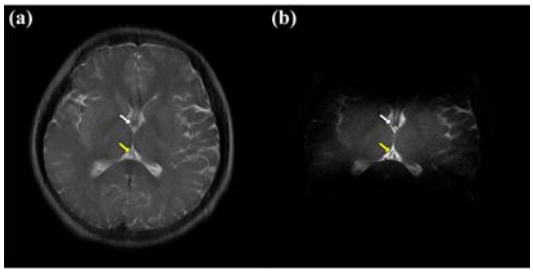

Fig. 4. (a) full FOV: ETL=166, *TR*=2.2 s; (b) RFOV: ETL=86, *TR*=1.0 s; Both 320*320 and bandwidth of 20.83 *KHz*.

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References: [1] J. Pauly et al, JMR 81:43-56 (1989); [2] Y. Zur MRM 43:410-420(2000); [3] M. Oelhafen et al, MRM 52:1136-1145(2004);