Minimizing Spiral Image Blurring on Whole-Body 7T Scanner with Multi-Shots and UTE Acquisitions

Y. Qian[1], T. Zhao[2], Y-K. Hue[1], T. S. Ibrahim[1], and F. E. Boada[1]
[1]Department of Radiology, University of Pittsburgh, Pittsburgh, PA, United States, [2]R&D, Siemens Medical Solutions USA, Pittsburgh, PA, United States

INTRODUCTION

High resolution brain images, such as 0.22mm, are usually acquired at matrix size of 1024×1024 on whole-body 7T scanners albeit at the expense of long scan times (e.g., ~12 min for a 3D T_1-weighted image) even parallel imaging and partial Fourier samplings are used. Spiral imaging has an acquisition speed advantage over rectangular sampling, but its implementations are limited due to large image blurring from strong off-resonance effects at 7T. This abstract presents a new approach to minimize image blurring through a combined use of multi-shot spiral and ultra-short echo time (UTE) acquisitions. The performance of the proposed technique is demonstrated here using high-resolution T_1-weighted brain images of healthy volunteers acquired on a whole-body 7T scanner.

METHODS AND MATERIALS

Methods: To minimize spiral image blurring two steps were taken in this study. First, multi-shot spirals were used to shorten readout time of individual spiral interleaves, as image blurring decreases for the shorter spiral readout (1). Second, ultra-short echo time (UTE) was used to minimize signal dephasing caused by through-plane off-resonance before the spiral acquisitions (2). A customer-developed pulse sequence, acquisition-weighted stack of spirals (AWSOS) (3), was employed to implement the 3D UTE spiral acquisitions. *Experiments*: Healthy human subjects were scanned on a whole-body 7T MRI scanner (Magnetom TIM 7T, Siemens Medical Solutions, Erlangen, Germany) with an 8-channel head array coil (Rapid Biomedical GmbH, Rimpar, Germany). The human experiments were approved by the Institutional Review Board (IRB) of the University of Pittsburgh. The scan parameters were sinc RF pulse of duration=2ms and cycle=1.5, flip angle=50°, TR/TE=100/1.18ms, FOV=220×220 mm^2, matrix size=1024×1024, partitions=60 at 2mm in thickness, in-plane spiral interleaves=128, readout time=20.32ms, and total acquisition time=12.8 min without use of parallel imaging and partial Fourier samplings. Two resolutions (low and high) were implemented. The low-resolution images were acquired with matrix size=256×256 and interleaves=64 at a short TE (1.18ms) and long TE (11.2ms), respectively. The high-resolution images were acquired only at short TE (1.18ms). The image reconstruction was implemented with the gridding algorithm (4).

RESULTS AND DISCUSSION

Figure 1 demonstrates the low-resolution (0.86mm) images showing the effectiveness of UTE acquisitions in the minimization of signal loss due to off-resonance induced dephasing. In the long TE image (11.20ms, Fig. 1a), signal intensity in the frontal cortex (arrows) are significantly decreased due to the strong off-resonance that is typically present at that anatomical location. When a UTE (1.18ms, Fig. 1b) was applied, the signal intensity from the frontal cortex is restored (Fig. 1b). Figure 2 presents high-resolution (0.22mm in-plane) images that demonstrated much reduced blurring despite the relative long readout time (20.32ms). The bright arteries in the images (Fig. 2) were produced by the fresh blood flowing from outside of the imaging volume. The total acquisition time for the high-resolution imaging was 12.8 min without use of parallel imaging and partial Fourier samplings. The disadvantage of the UTE acquisition on spiral imaging was that T_2- or T_2*-weighted contrast was not able to produce. This limits uses of UTE spiral imaging. *In conclusion*, we have demonstrated an approach for reliably obtaining high-resolution spiral images of human brain on the 7T scanner. Our results demonstrate decreased image blurring from the use of both multi-shot spiral and UTE acquisitions. The efficiency of the multi-shot spiral acquisitions in the high-resolution experiment was maintained at eight-folds compared with rectangular sampling, even without use of parallel imaging and partial Fourier samplings.

REFERENCES [1] Noll D, etc. MRM 1992; 25:319-333. [2]. Pauly JM, etc. U.S. patent 5025216, 1991. [3] Qian Y, etc. MRM 2008; 60:135-145. [4] Jackson JI, etc. IEEE Trans Med Imaging 1991; 10:473-478.

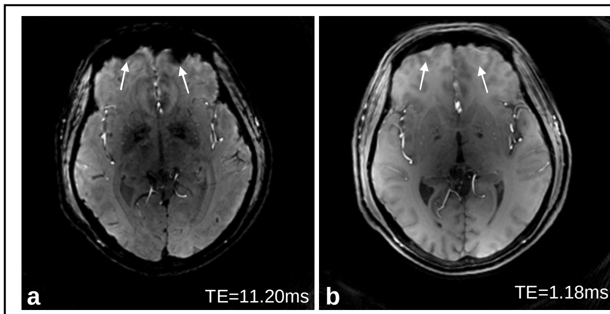

Fig. 1. Spiral images of a healthy volunteer's brain at 7T (TR= 100ms, θ=50°, FOV=220mm, matrixSize=256, and spiral Ts= 3.52ms, AWSOS sequence). The signal decays (arrows) due to off-resonance at long TE in a) were minimized at UTE in b).

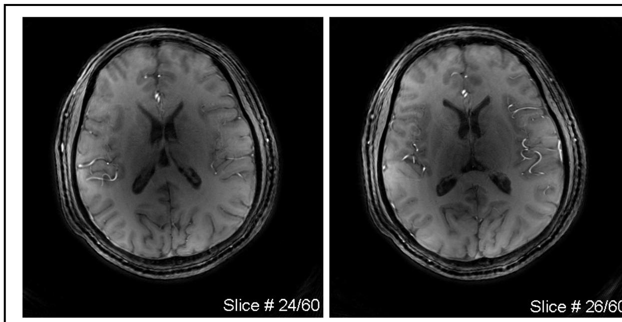

Fig. 2. High-resolution spiral images of a healthy subject at 7T (TR/TE=100/1.18ms, θ=50°, FOV=220mm, matrixSize=1024, slice thickness=2mm, spiral Ts= 20.32ms, AWSOS sequence). The image blurring is smaller than the expected.