Efficient Volumetric Brain MR Imaging with Ultrashort Echo Times

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INTRODUCTION

Ultrashort echo time (UTE) fast imaging has recently gained interest because of its relevance on imaging applications such as stroke and muscular skeletal imaging [1]. The requirement of ultrashort echo time, however, usually confines the sequence design within non-selective excitations and radial data collections and thus leads to time-consuming scanning or low-resolution imaging [2-5]. In order to efficiently acquire 3D UTE data with high spatial resolutions, we recently introduced a new design strategy and developed a new UTE pulse sequence called acquisition-weighted stack of spirals (AWSOS) (Fig. 1), which employs selective spin excitation, variable-duration phase encoding, and spiral data collection [6]. This abstract will demonstrate high-resolution MR images of human brain obtained from the UTE data acquired with the AWSOS pulse sequence.

METHODS AND MATERIALS

Experiments were performed on a clinical 3T whole-body MRI scanner (Signa VH3, GE Milwaukee, WI, USA) using the standard birdcage head coil. The scanner has a maximum gradient amplitude of 40 mT/m and a maximum slew rate of 150 T/m/s. Adult healthy volunteers were scanned under an IRB approved protocol using the AWSOS pulse sequence with a selective rf pulse (sinc pulse of duration=0.4 ms and flip angle=30^0) and imaging parameters of: FOV=22×22×15 cm^3, slice thickness=5 mm, phase-encoding steps=30, in-plane spiral leaves=24, total excitations=720, matrix size=256×256×30, spatial resolution=0.86×0.86×5 mm^3, TE/TR=0.408/1000 ms, and readout time=7.112 ms. The point spread function (PSF) of the AWSOS sampling was calculated under T2=3 ms to illustrate the potential image blurring caused by the variable acquisition delay.

RESULTS AND DISCUSSION

Fig. 2 presents selected partitions from a 3D UTE acquisition on the brain of a normal human volunteer. The in-plane spatial resolution is 0.86mm. Note the lack of large variations in signal intensity due to the predominantly proton-density weighted nature of the images. The data acquisition efficiency in the proposed technique is also clearly documented in this example as the entire 3D data set was obtained with a total of only 720 excitations (or 3600 for 1mm slice thickness), this compares favorably with the 160,000 projections that are required for an equivalent projection reconstruction acquisition. To investigate the potential deterioration of the spatial resolution due to the variable echo time delay, the point-spread-function (PSF) of the data acquisition technique was calculated. Fig. 3 presents a comparison between the PSF for projection imaging (PI), stack of spirals and AWSOS. As can be seen, the AWSOS technique exhibits a PSF with a comparable width to that of the PI data acquisition but definitely narrower extent than the conventional stack of spirals.

CONCLUSIONS

We have demonstrated that AWSOS is an effective approach for the acquisition of high-resolution ultra-short TE MR images. The AWSOS technique can achieve high levels of data acquisition speed without a significant penalty on the shape of the PSF making it an attractive technique for volumetric data acquisition at high spatial resolution.

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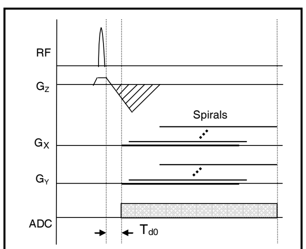

Fig.1. AWSOS sequence.

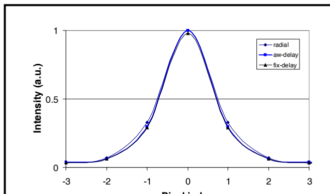

Fig.3. Point spread functions of radial, stack of spirals and awsos.

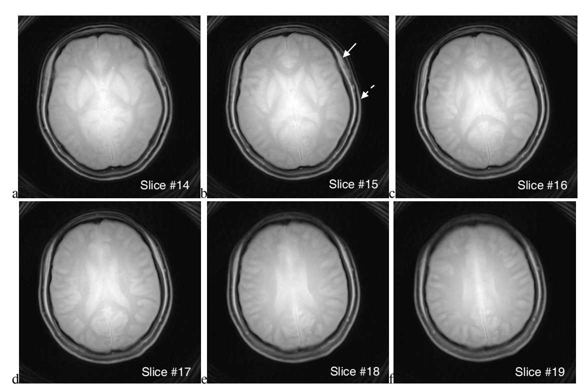

Fig. 2. Human brain images (consecutive central slices) acquired using AWSOS pulse sequence. High in-plane resolution makes the structures of white/gray matter clearly visible. Due to the ultrashort TE=0.408 ms, the signal from the meninges (solid arrow) is as strong as the one from the scalp (dashed arrow).