3D Magnetization Prepared Elliptical Centric Fast Gradient Echo Imaging

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Introduction

Magnetization prepared fast gradient echo acquisition is an effective method for T1-weighted high resolution 3D MR imaging [1-3]. Examples such as MP-RAGE and IR-SPGR are widely used in clinical scans [4-5]. Although many variations of this method have been introduced [6-8], further improvements in terms of greater SNR, CNR, and data acquisition efficiency, as well as better artifact suppression are still possible. We have developed a novel acquisition strategy, MP-EFGRE, based on elliptical centric partial *k*-space sampling and recessed elliptical centric view ordering. Our initial study shows the advantages of this new method over a commonly used method, i.e., MP-RAGE, for brain imaging.

Methods

MP-EFGRE is mainly characterized by its elliptical centric view order, versus the linear or centric view order used in MP-RAGE or IR-SPGR, respectively. In MP-EFGRE, one segment of views is acquired after each magnetization preparation with fast gradient echo acquisitions similar to MP-RAGE and IR-SPGR as shown in fig. 1. However, the number of views in each segment and the number of segments is not constrained by the *ky*-*kz* matrix. Within each segment, recessed elliptical centric view order [9-10] allows the central views to be acquired at a specified delay time, i.e., TI. This is a generalization of the linear view order of MP-RAGE. A second feature of MP-EFGRE is the views in the corners of *k*-space are not acquired and are substituted with zeros during reconstruction. Usually, this ellipsoid is inscribed by the standard *ky*-*kz* rectangle to maintain the image resolution [11].

The initial comparison was made versus MP-RAGE, which has recently been chosen over other methods for high-resolution volumetric brain imaging in the ADNI study [12]. A healthy volunteer was scanned on a GE 3.0T EXCITE scanner using an 8-channel head coil with MP-RAGE and MP-EFGRE. For both methods, imaging parameters optimized for the ADNI study were used to acquire 170 sagittal slices with 26cm FOV, 256x256 matrix, 0.94 phase FOV, 1.2mm slice thickness, 8 deg flip angle, $\pm$31.25 KHz BW, 900ms TI, and 2300ms TR. A 2 KHz BW Silver-Hoult inversion RF pulse was used for magnetization preparation. However, internal parameters such as the number of views per segment were adjusted in MP-EFGRE for compromises between CNR, SNR and scan time. As the number of views per segment in MP-EFGRE increases, the delay time, TD, after the gradient echo train is reduced, if the repetition time is kept fixed. To quantify the CNR and SNR, signal intensities and standard deviations from the ROIs in gray matter (GM), white matter (WM) and background noise regions shown in fig. 2 are measured to calculate SNR and CNR.

Results & Discussion

As shown in fig. 2, MP-EFGRE produces 3D high-resolution T1-weighted images with good GM/WM contrast. Table 1 shows the comparison of CNR, SNR and scan time of different MP-EFGRE acquisitions with MP-RAGE. With the same number of views per segment, MP-EFGRE provides higher CNR and SNR within a shorter scan time. Increasing the number of views per segment further increases SNR and reduces scan time at the cost of CNR.

In MP-EFGRE, the *k*-space views are sampled in a pseudo-random fashion instead of line by line as in other methods. This effectively disperses structured artifacts as pseudo noise. Fig. 3 shows the axial images from the reformatted 3D data set of MP-RAGE and MP-EFGRE. The artifacts in the MP-RAGE image are due to an RF spoiling scheme in conjunction with reduced gradient area in the end-of-sequence spoiler gradient. The structured artifacts are absent in the corresponding MP-EFGRE image.

MP-EFGRE offers more flexible and optimized data acquisition than existing methods. While the initial study shows compromises between scan efficiency and image quality with a different number of views per segment, comprehensive optimization with other parameters has yet to be explored. MP-EFGRE is expected to benefit from phase-sensitive image reconstruction, which will eliminate tissue contrast reversal in magnitude reconstruction and allow more views to be acquired following each magnetization preparation to further improve efficiency, especially for short TI.

References

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Figures

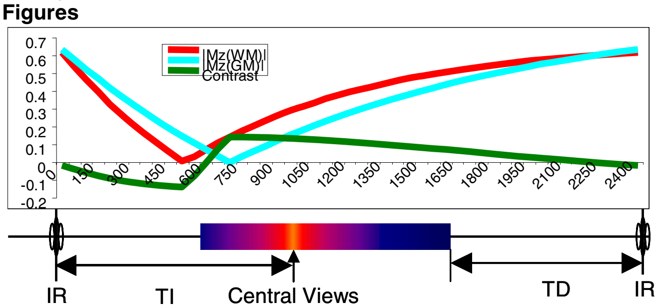

Figure 1. Red, blue and green curves are simulated WM signal, GM signal, and their contrast during inversion recovery. For each segment of views, recessed EC view order allows high CNR for more central views (orange) and higher SNR for outer views (dark blue).

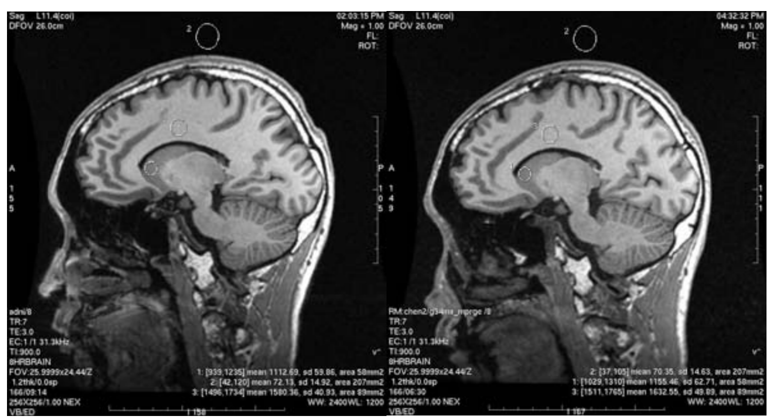

Figure 2. Images acquired with MP-RAGE (left) and MR-EFGRE (right) are shown with identical gray scale. The circles outline the ROIs where signal intensities and standard deviation are measured to calculated CNR and SNR.

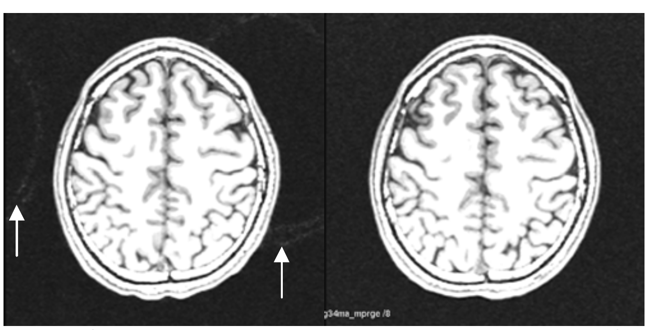

Figure 3. Structured artifacts marked by arrows in the 3D MP-RAGE image (left) are not observed in the MP-EFGRE image (right).

Tables

Type	Views/Seg.	SNR(GM)	SNR(WM)	CNR	Time
MP-RAGE	170	15.4 $\pm$ 3.3	21.9 $\pm$ 4.6	6.5 $\pm$ 1.7	9:14
MP-EFGRE	170	16.1 $\pm$ 3.4	23.1 $\pm$ 4.7	7.0 $\pm$ 1.8	7:16
MP-EFGRE	190	16.4 $\pm$ 3.5	23.2 $\pm$ 4.9	6.8 $\pm$ 1.8	6:30
MP-EFGRE	230	17.9 $\pm$ 3.7	23.9 $\pm$ 4.8	6.0 $\pm$ 1.7	5:23

Table 1. SNR and CNR of GM and WM are measured from the same slice of different MP-EFGRE acquisitions and compared with the values from MP-RAGE acquisition.