RASER: A New Ultra Fast Magnetic Resonance Imaging Method

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Introduction

A new pulse sequence is described in which multiple echoes per excitation are acquired in such a way that all of the echoes have the same echo time, and all of the echoes are T_2-weighted, (as opposed to spin-echo EPI in which all echoes except one are T_2^* weighted). The method is based on rapid acquisition by sequential excitation and refocusing, and thus is called RASER.

Theory

The RASER pulse sequence is shown in Fig. 1. The chirp excitation pulse is used to time-encode one dimension of the image [1]. This pulse creates a phase profile that is a quadratic function of position along the direction of the time-encoding gradient [2]. This profile is preserved throughout the two 180° pulses by the time-encoding gradient between them. At the vertex of this profile, the derivative of the magnetization phase is zero. Hence, only isochromats near the vertex have similar phase, and data acquired from the slab will be dominated by isochromats near the vertex of this quadratic phase profile. When the acquisition window begins the vertex of the quadratic phase is at the edge of the slab that was excited first. Continued application of the time-encoding gradient moves the vertex across the slab while the echoes are being acquired, so the signal originates in sequential locations as the acquisition proceeds. The timing is such that the isochromats near the vertex are the same isochromats having their local rephasing time, so the signal is originating from a small set of isochromats that have had their variations in magnetic susceptibility, static field homogeneity, and other frequency shifts refocused. This effectively creates a train of spin echoes with a constant echo time. The echo train can be used to produce a multislice image set, or they can be used as one dimension of a single-shot two-dimensional image. RASER offers the capability to restrict the field-of-view in the time-encoded direction (i.e., zoom), while avoiding some of the image artifacts that often plague such techniques (e.g., aliased signals).

Methods

Multislice and single-shot images of saline-filled phantoms, water-filled resolution phantoms and normal human brain were acquired with RASER. Standard spin echo and gradient echo sequences were used to acquire comparison images. The image shown was acquired with a matrix of 128x56, and with TE = 143 ms. The thickness of the slice was 5 mm, and the total acquisition time was 203 ms.

Results and Discussion

Figure 2 shows a zoomed single-shot image of a resolution phantom acquired with RASER. Although all encoding was performed in one shot, signal averaging was performed to increase SNR (N_{ex} = 9). These first results provide convincing evidence of the potential usefulness of RASER for T_2-weighted imaging, using one of two possible modes (multislice and single shot). RASER is the first sequence the authors know of that acquires multiple echoes per excitation where all of the echoes are T_2 weighted, and all of the echoes have the same echo time. This results in a fast image that is free of susceptibility and ghosting artifacts and avoids resolution degradation.

References

[1] M.E. Meyerand, E.C. Wong, Magn. Reson. Med. 34, 618-622 (1995). [2] J. G. Pipe, Magn. Reson. Med. 33, 24-33 (1995).

Acknowledgements

Supported by Keck Foundation, MIND Institute, and NIH P41 RR008079.

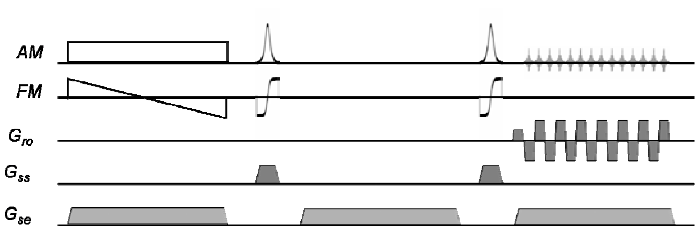

Fig. 1. Single-shot RASER pulse sequence

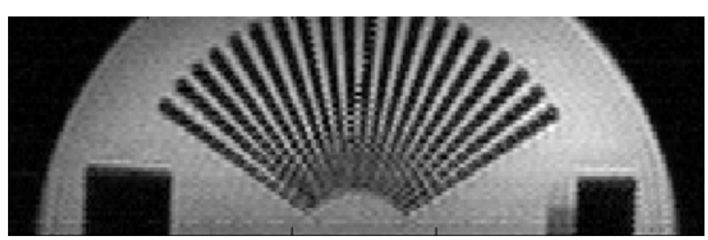

Fig. 2. Single-shot RASER image