Image Acquisition & Reconstruction / Echotrain Pulse Sequences: EPI, RARE & Beyond

David C. Alsop, Ph.D. dalsop@bidmc.harvard.edu
Dept. of Radiology, Beth Israel Deaconess Med Ctr and Harvard Med School, Boston MA USA

Highlights

- Echotrain imaging greatly accelerates imaging with T2 and related contrasts
- EPI imaging suffers from spatial distortion but can be improved with parallel imaging
- 2D RARE sequences with long echotrains can be single shot, but with some blurring
- 3D RARE has become practical with parallel imaging and variable refocusing flip angle trains

Target Audience: Scientists and Engineers interested in implementing, using, or improving fast MRI methods and Clinicians who may use fast MRI in applications.

Introduction: The lecture will begin with an overview of the image encoding process in MRI. The concept of k-space and the echo as a line in k-space will be presented to provide context for the echo-train sequences covered.

Echoplanar Imaging (EPI): Echo train sequences using purely gradient echoes will be described. These sequences are widely used in functional MRI, Dynamic Susceptibility Contrast, and Diffusion Imaging. The k-space trajectory and the unavoidable sensitivity to off-resonance effects will be covered. Improvements to echoplanar image quality with parallel imaging will be explained. The option for interleaved echoplanar will be described and the trade-offs with respect to 2D RARE sequences will be considered.

2D RARE: Echo train sequences using only spin echo refocusing will be described. Originally named RARE, these sequences are often referred to by vendor names such as Fast Spin Echo or Turbo Spin Echo. These clinical workhorse sequences are frequently used in interleaved, multi-shot acquisitions, though single-shot acquisitions are also commonly performed. The basic sequence and the effect of sequence parameters on speed, resolution, and T2 contrast will be emphasized. Strategies for reducing RF power and blurring by lowering and tailoring refocusing flip angles will be reviewed.

3D Strategies: The previous 2D echo train strategies can readily be applied to 3D acquisitions. Though echoplanar can be used as the basis for 3D sequences, this approach is generally confined to specialized applications. 3D sequences based on RARE are becoming widely used. While 3D RARE sequences originally used a multi-slab approach, artifacts from boundaries between slabs made this undesirable. The combination of long echo train sequences, tailored flip angles to minimize power and blurring, and parallel imaging have made 3D single slab sequences practical.

References

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