Motion Corrected T1-Weighted PROPELLER FSE

J. G. Pipe[1]
[1]Barrow Neurological Institute, Phoenix, Arizona, United States

Introduction: PROPELLER FSE imaging has been shown to be effective for T2 imaging with motion correction[1,2]. This method of data collection collects phase encoding lines in groups centered about k-space (blades), which are subsequently rotated in k-space each TR. The fact that each blade intersects the center of k-space allows one to compare data for motion correction – at the same time, in means that all phase-encoded lines lie near the center of k-space, and therefore contribute substantially to image contrast (Fig. 1a). Reordering lines within the blade has little effect on image contrast, with the effective TE roughly equal to the average TE (1/2 the total echo train duration). For T1 imaging, one needs to keep the echo train duration short to mitigate T2 weighting. However, the short ETL diminishes the blade width, making motion correction less robust. Also, the relatively long duration of the echo train allows only a few slices to be interleaved in the short TR required for T1 weighting, making the sequence less efficient.

Method: To make T1-weighted PROPELLER clinically feasible, three approaches were taken together:

1. Turboprop FSE was used in order to keep the echo-train as short as possible. Typical parameters were ETL 4, 5 lines per echo, TE 24 msec, FOV 24 cm, 256 matrix, scan time 3' for 20 slices. Resulting images are shown in Fig. 1c,d.
2. By adding an extra 180˚ pulse followed by a second 90˚ rf pulse at the end of the sequence (Fig. 1b), the remaining signal after the echo train was refocused and inverted, adding T1 contrast. This is similar to the "Forced Recovery" FSE approach of restoring signal to the +z axis, except the sign of the second 90˚ rf pulse restores magnetization to the -z axis. This gives a greater CNR than achievable with conventional FSE for multi-pass studies, and at a longer optimal TR, allowing more slices to be interleaved within a given pass.
3. For this method, the T2 weighting is much greater in the later echoes than for the first ones. Since the prescribed phase encoding places the echoes contiguously across each blade, one side of each blade is more T2-weighed than the other. The data across the blade were weighted nonuniformly[3] during the gridding process, weighting early TE data more than late TE data wherever the blades overlapped in k-space. A matched filter design to this weighting, approximating the decay of brain signal, can moderately increase SNR and reduce T2 weighting simultaneously.

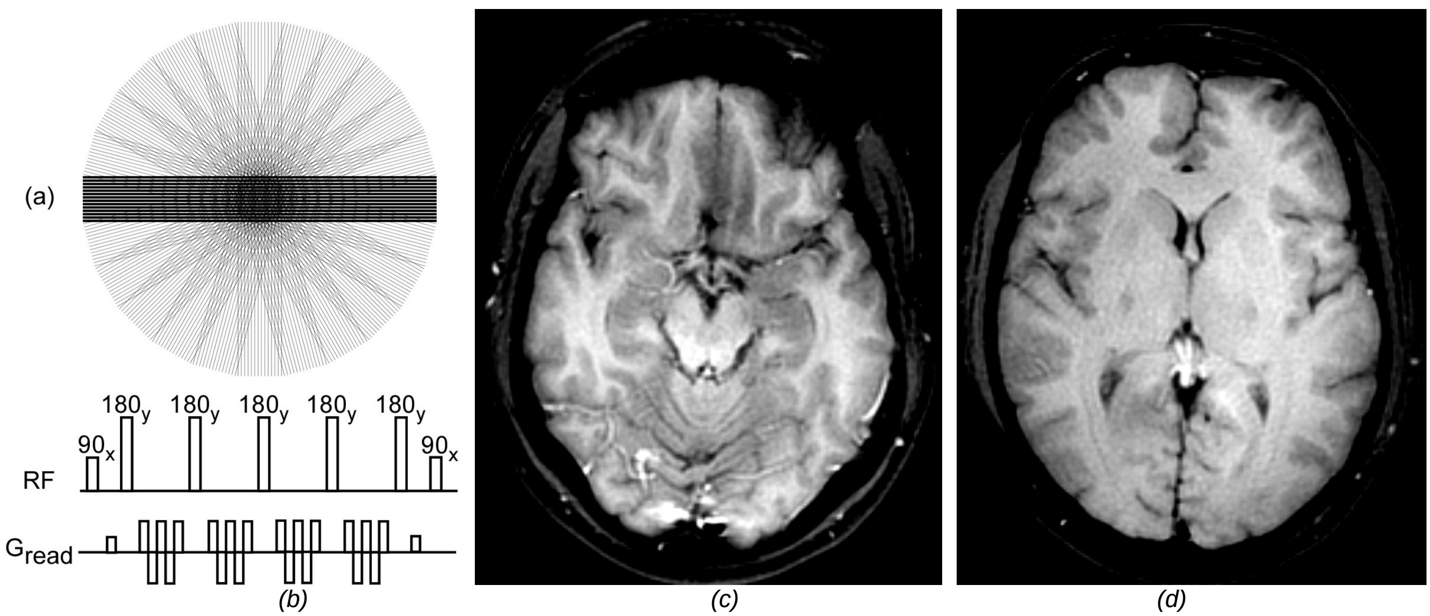

Fig. 1. Illustration of (a) a single blade (bold lines) and rotated blades from subsequent TR's (thin lines), (b) the PSD employed using with a turboprop readout and a 90˚ "inversion" pulse at the end of the echo train, and (c,d) the resulting images of a volunteer.

Discussion: At the time of this abstract, this sequence is running, but has not been tested in patients. The performance of motion correction appears to be good with the proposed parameters. We have also run this sequence using ASSET (factor of 2) (not shown) along with an 8-channel head coil, which doubles the blade width, if the data are collected with an appropriate phased array coil. This greatly enhances the robustness of motion correction, or alternatively, can be used to reduce the echo train length and the effective TE, if desired.

References: 1. Mag Res Med 42(5), 963. 2. JMRI 14(3), 215. 3. Mag Res Med 41(1), 179.

Acknowledgements: This work funded in part by GE Healthcare.