Comparison of Reduced FOV Techniques for High Resolution Imaging at 7T

C. J. Wargo[1], M. Jankiewicz[1], and J. C. Gore[1]
[1]Vanderbilt University Institute of Imaging Science, Nashville, TN, United States

Introduction

Improvements in the spatial resolution of human brain images are possible at ultra-high field strength (7T) because of the increased signal to noise ratio obtainable. However, very high resolution (≈ 100 microns) for a complete imaging field-of-view would require acquisition of a very large number of voxels, increasing the overall imaging time. Beyond the impracticality of long acquisitions, a number of artifacts are both time and field dependent, with temporal resolution for functional scans reduced for long durations. Improvements in resolution necessitate a proper balance of these effects and the intrinsic SNR loss. A variety of techniques are aimed at addressing constraints introduced by high-resolution studies. Parallel imaging methods such as SENSE typically achieve 2-4 fold improvements in resolution for a fixed duration. Reduced-FOV techniques constrain the imaging experiment to smaller regions of the overall object using selective excitation methods such as STEAM, PRESS, OVS, and spectral spatial pulses [1-5]. Each method introduces additional trade-offs between the achieved resolution, SNR, scan efficiency, established SAR, and production of artifacts. Here, we report a comparison between a subset of selective excitation approaches for resolution improvement at 7T in phantoms for future application in human brain imaging.

Methods

Techniques - The following approaches were implemented to perform reduced-FOV imaging prior to a gradient echo sequence:

STEAM Selective 90x – 90y – 90z with spoilers in between [1].
PRESS Selective 90x – 180y – 180z with spoilers in between [2].
OVS Slabs excited and suppressed left and right of FOV repeated three times using an FM pulse [3].
SE Selective 90x – 180z with spoilers around 180 [4].
SPOKE 50 pulse composite interleaved with gradients, RF pulse and gradient parameters determined by Matlab simulation to achieve a square excitation [5].

Imaging Tests - All experiments were performed on a Philips 7T Achieva system using a 16 channel SENSE head array and an FBIRN agar phantom. Images were collected with and without reduced-fov preparation as follows: TR/TE = 1200/32 ms, 128x128 points, 210x210x3 mm, 1 acquisition. The target FOV for each was a 42 mm thick slab (42x42 mm square for SPOKE). For each image, a central profile was taken to compare peak relative signal strength and suppression outside the target FOV, with SAR recorded.

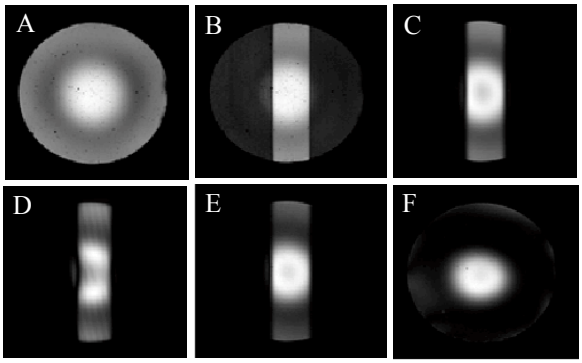

Figure 1 : A.) Original object, B.) OVS, C.) STEAM, D.) PRESS, E.) SE, and F.) SPOKE.

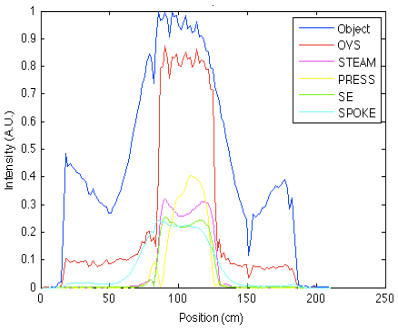

Figure 2 - Profile across central part of object for each reduced-fov preparation executed prior to a GE sequence.

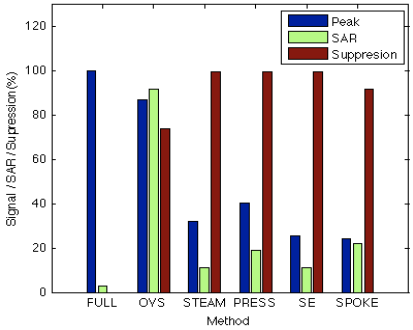

Figure 3 - Measured peak signal, suppression outside target FOV, and SAR for each preparation.

Results and Discussion

Outside the target FOV, all techniques had near 90-100% supression except OVS at 67% (fig 2 and 3). Likewise, these four approaches had similar SAR values from 11 to 22%, with OVS at 92%, lowest for STEAM at 11%. Peak signal, however, was best for OVS, at 87% of that measured with no preparation. STEAM, PRESS, and SE had similar peak signals at 24-40%, best for PRESS, with SPOKE the lowest at 24%. Qualitatively (fig 1), OVS images gave an excited region that best resembled the object, with STEAM, PRESS, SE, and SPOKE having notable artifacts in shape, width, and a dip in central signal. B1 inhomogeneity is believed to be the source of these artifacts. High OVS SAR is due to the large number of 90 pulses required. Future work will investigate other pulse types for better suppression, improved B1 in the target FOV, and to reduce artifacts.

References [1] Frahm J, et al, MRM, 9: 79-93 (1989) [2] Bottomley, US Patent 4,480,228 (1984) [3] Wilm BJ, et al, MRM, 57: 625-630 (2007) [4] Feinberg D, Radiology, 156: 743-747 (1985) [5] Hardy H, et al, J Magn Reson, 82: 647-654 (1989)