Anatomical imaging at 7 T using 2D GRASE – A Comparison with 2D TSE

R. Trampel[1], R. M. Heidemann[1], and R. Turner[1]
[1]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

Introduction: GRASE (Gradient-and Spin-Echo) [1] imaging has recently been used successfully for perfusion measurements [2] and functional MRI [3]. However, due to known blurring and ringing artifacts [4] GRASE still awaits a breakthrough in structural imaging [5-7]. At high field strengths such as 7 T, many imaging sequences are limited in their spatial coverage per unit time, due to their high specific absorption rate (SAR). This is recognized as a severe issue for sequences with many high power RF pulses such as Turbo Spin-Echo (TSE). A reduction of RF power without losing the superior features of a TSE sequence would therefore be highly advantageous. GRASE imaging offers a solution for this problem by replacing most of the refocusing pulses with segmented EPI readouts [1]. By keeping the EPI factor low (e.g., 3 gradient echoes per refocusing pulse) and, hence the EPI readouts short, high resolution imaging is possible. The goal of this study was the careful comparison of TSE and GRASE for structural imaging at 7 T.

Method: All experiments were performed on a 7 T whole-body MR scanner (MAGNETOM 7T, Siemens Healthcare Sector, Erlangen, Germany) using a 24 channel phased array head coil (Nova Medical Inc, Wilmington MA, USA). The study was approved by the ethics committee of the local university and informed consent was obtained. 30 axial slices at identical positions were acquired using a GRASE and a TSE sequence. Identical parameters were chosen for both sequences: TR = 6 s; TE = 45 ms; refocusing flip angle = 180°; bandwidth = 325 Hz/Px; voxel = 0.5 x 0.5 x 0.7 mm³; turbo factor = 3; EPI factor = 3 (GRASE); scan time: 3:43 min (GRASE) / 10:48 min (TSE). No intensity correction was applied to the images. The signal-to-noise ratio (SNR) was determined for both images. Furthermore, images were acquired perpendicular to the calcarine sulcus to visualize the Gennari stripe. Finally, the point-spread-function (PSF) was assessed by imaging a resolution phantom containing sharp edges (enhanced section see Fig. 5B). A profile along those edges (dotted line in Fig. 5B) was determined for the TSE and GRASE, respectively.

Results: Figures 1 and 2 show axial slices obtained with the GRASE and the TSE sequence, respectively. Vascular structures as well as the cingulum bundle (arrows) are visible in both images. However, mild ringing artifacts and a subtle blurring decrease slightly the quality of the GRASE image. The SNR values are similar, namely 20.4 for the GRASE and 19.0 for the TSE image, respectively. The difference between the two images is displayed in Fig. 3. Due to subject motion, but also because of the blurring artifacts in the GRASE image, remaining signal can be seen mainly at the tissue-CSF boundary and in the skull. Figure 4 shows a GRASE image acquired perpendicular to the calcarine sulcus. The stria of Gennari is clearly visible (arrows). The very slightly inferior PSF of GRASE compared to TSE is depicted in Fig. 5A.

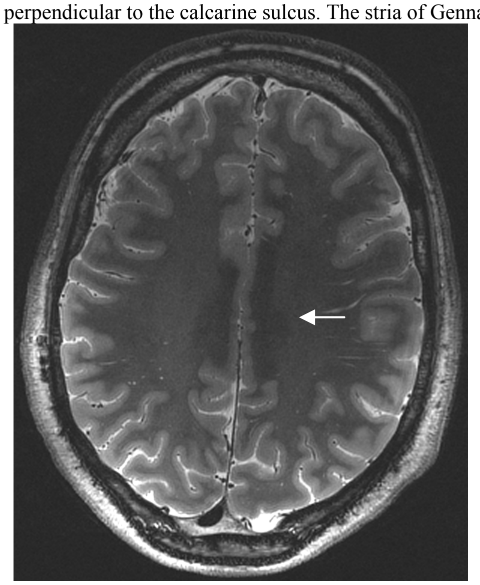

Fig 1. Axial GRASE image.

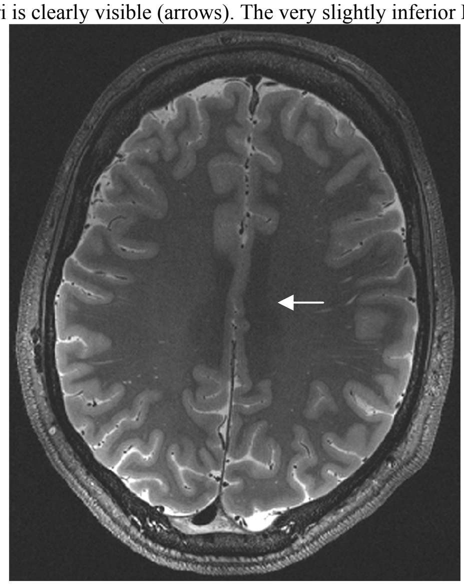

Fig 2. Axial TSE image (identical parameter set).

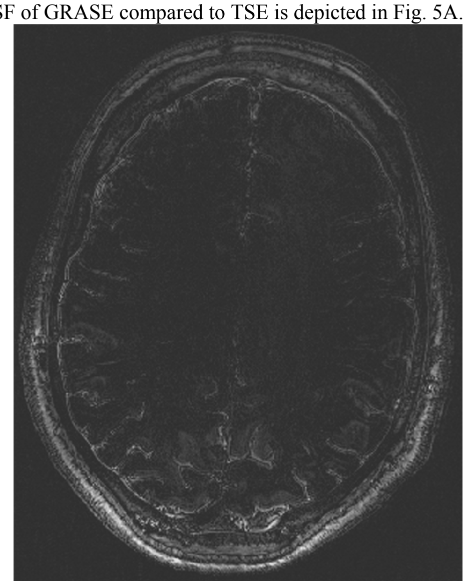

Fig 3. Difference image of GRASE and TSE.

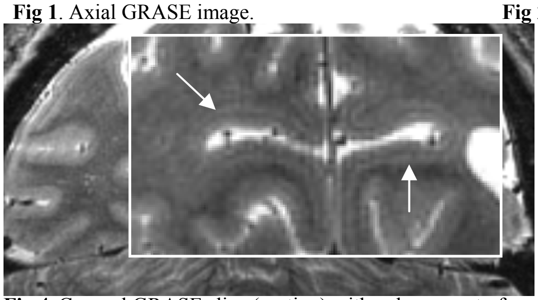

Fig 4. Coronal GRASE slice (section) with enlargement of calcarine fissure, showing the stria of Gennari.

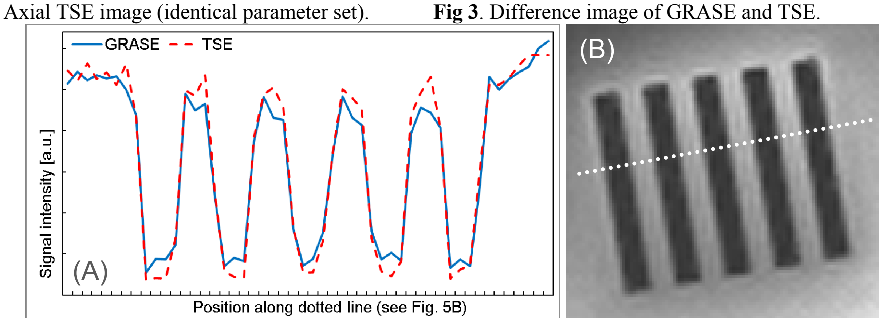

Fig 5. **A**: Profiles across resolution phantom: TSE (red/dashed); GRASE (blue/solid). **B**: Phantom section.

Discussion and Conclusion: GRASE is shown to be an alternative for the widely used TSE sequence for high resolution anatomical imaging. Similar contrast and SNR are achievable with both sequences. It must be mentioned, however, that the SNR of the TSE sequence can be slightly increased (to 22.8 in this study) by decreasing the echo time and the bandwidth to values shorter then the minimum possible values of a corresponding GRASE readout (which depends on the EPI factor). The slightly higher sensitivity to blurring and ringing artifacts of the GRASE sequence are counterbalanced by a substantially reduced SAR, making it advantageous for imaging at higher field strengths. At 7 T, the reduced SAR combined with the intrinsic shorter scan time of the GRASE sequences allows either approximately tripling the number of slices acquired per unit time, and therefore the brain coverage, or decreasing the scan time to roughly a third of the TSE scan time. SAR-reduction approaches such as hyperechoes [8] can be implemented for TSE and GRASE in a similar way. Both sequences enable reliable visualization of cortical layers such as the Gennari stripe.

References: [1] Feinberg DA and Oshio K. Radiology 1991;181:597-604. [2] Günther M et al. Magn Reson Med 2005;54:491-8. [3] Feinberg DA et al. ISMRM 2008;16:2373. [4] Umek W et al. Eur Radiol 1998;8:409-15. [5] Patel MR et al. AJR Am J Roentgenol 1995;165:963-6. [6] Fellner F et al. AJNR Am J Neuroradiol 1997;18:1617-25. [7] Brunereau L et al. Neuroradiology 2001;43:973-9. [8] Hennig J and Scheffler K. Magn Reson Med 2001;46:6-12.