

Multi-Slab SPACE

G. Li¹, D. Paul², W. Zhang¹, T. Mamisch³, Q. He¹, M. Beckmann¹, and L. Lauer²

¹Siemens Mindit Magnetic Resonance Ltd., Shenzhen, Guang Dong, China, People's Republic of, ²Siemens Medical Solutions, Erlangen, Germany, ³Department of Orthopaedic Surgery, Inselspital, University of Berne, Bern, Switzerland

Introduction Single Slab 3D turbo spin echo sequence with variable refocusing flip angles (aka SPACE) [1, 2, and 3] has been optimized for PDw, T2w and T1w contrast imaging. In order to obtain 3D high resolution and reduce the acquisition time to the clinical acceptable range, the TR has to be shortened dramatically compared to conventional TSE imaging. Moreover, a relative low echo train has to be used also for the time reduction. However, these features will compromise the contrast purity and SNR. The sampling efficiency of Single Slab 3D acquisition is relatively low, especially in PDw and T1w imaging, because echo trains are short and hence the data acquisition duration is just a small portion of each TR and the other time is only for tissue relaxation. There will be more flexibility to improve the contrast and SNR when the sampling efficiency can be further increased. In this abstract, a Multi-Slab SPACE technique (MS-SPACE) is proposed to dramatically improve the time efficiency of 3D acquisitions, to reduce acquisition time and/or improve the contrast purity and SNR.

Methods Like in interleaved multi-slice acquisition, in MS-SPACE, a single volume is split into several thin slabs, which are excited in an interleaved manner. Beside the selective excitation pulse, all the refocusing pulses in MS-SPACE are selective, instead of the non-selective refocusing pulses in Single Slab SPACE. To avoid the cross-talk in adjacent slabs due to imperfect RF pulse profile, the odd number slabs and even number slabs are acquired in two different TRs. In image reconstruction, after the inverse Fourier transform in slice direction, the slab boundary artifacts (SBA) from suboptimal RF pulse profile are corrected by a modified histogram matching algorithm [4]. As shown in Fig1, each slab can be divided into 3 kinds of areas: green, yellow and red. In the green area, the RF flip angle is accurate, and generates the correct contrast and signal intensity. In the yellow area, the actual flip angle deviates slightly from the nominal value, and hence causes visible signal intensity change, however change in contrast can be neglected. A scaling factor can be calculated by histogram matching algorithm in [4] to recover the signal intensity. This correction is done slice by slice from inner to outer slices in the yellow area. The adjacent slice at the inner side is taken as reference in histogram matching. In the red area, since both contrast and signal intensity may be dramatically changed, and hence the simple scaling method can not recover the information any more. Usually, only a very small number of slices are in this area, especially in thin slab acquisition, so these slices can be replaced by 3D interpolation of adjacent slices in the yellow area without significant information loss.

Results This MS-SPACE has been implemented and tested on a 1.5T MR scanner (MAGNETOM ESSENZA, SIEMENS Mindit Magnetic Resonance Ltd, Shenzhen). Fig2 shows an example of this technique to speed up the acquisition in PDw ankle imaging. The images in the first row are acquired by Single Slab SPACE, with the parameters: image matrix [PE x RO x SL] = [320 x 320 x 120], spatial resolution [0.58mm x 0.5mm x 0.6mm], TR = 1100 ms, TE = 34ms, turbo factor = 54 (echo train duration = 252ms), total acquisition time = 6min22sec. The images in second row are acquired by MS-SPACE with the parameters: the identical image matrix, spatial resolution, TR and TE as in single slab acquisition. Turbo factor = 26 (echo train duration = 149ms), 10 slabs (12 slices in each slab), total acquisition time = 4min15sec. As shown in Fig2, both acquisitions show the same contrast. However, MS-SPACE has reduced the acquisition time by 2 minutes, and further shortened the echo train duration by 100ms, which resulted in less blurring and higher signal intensity in Multi-Slab images (e.g. about 1.4 times higher bone signal compared Single-Slab SPACE).

Conclusion and Discussion

The MS-SPACE is very promising for accelerating high resolution 3D turbo spin echo imaging and improving the contrast in long echo train acquisition.

Due to the suboptimal RF pulse profile, a big slice oversampling factor is needed to suppress the aliasing artifacts. The RF pulses with more side lobes would provide better profile, but at the cost of longer pulse duration, which results in bigger echo spacing and longer echo train duration. In this context, a new technique, min. time VERSE [5] has been presented, which may be a promising technique to provide good profile with compressed the pulse duration.

References

- [1] Jaeseok Park, MRM, 2007, p982.
- [2] Mugler, MRM, 1990;
- [3] Mugler, ISMRM 2006, p2429
- [4] Eugene KHOLMOVSKI, ISMRM 2001, p738
- [5] Brian A. Hargreaves, MRM, 2004, p590-597

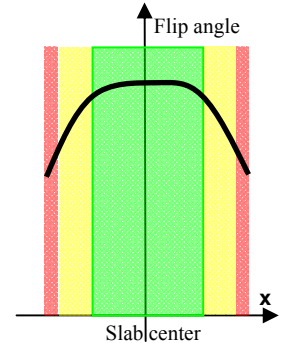


Fig1. The actual profile of the selective RF pulse

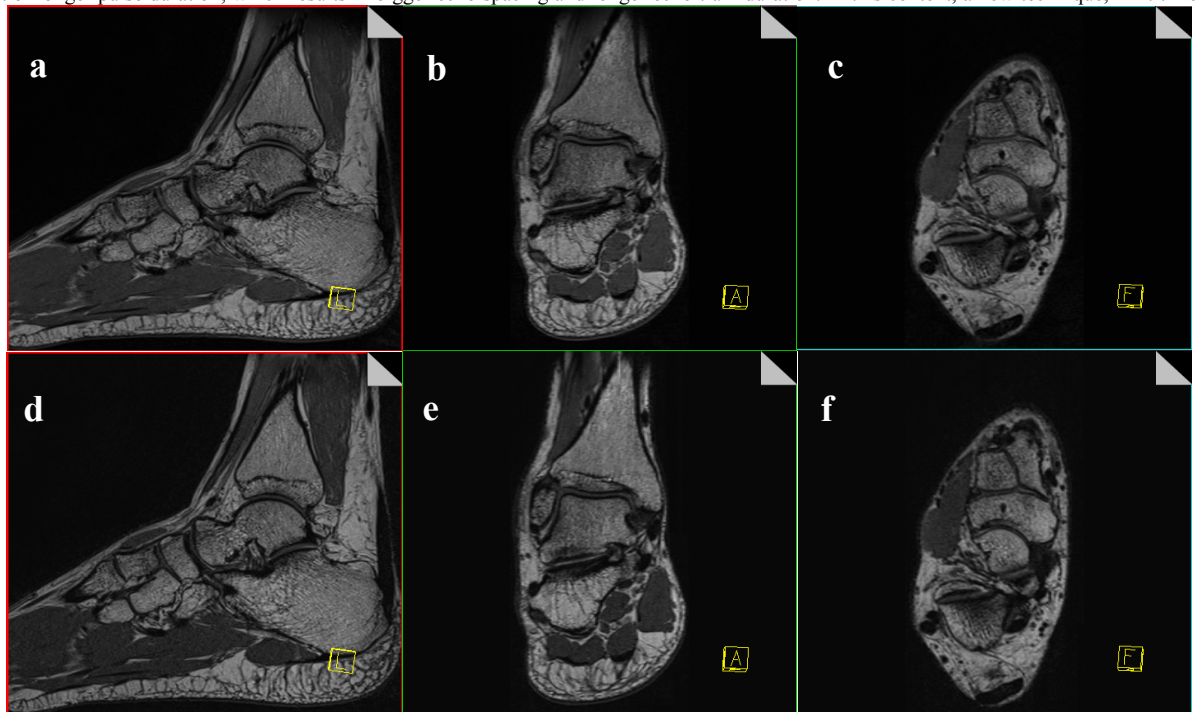


Fig2. The a), b) and c) are acquired by Single Slab SPACE in 6min22seconds, and d), e) and f) are acquired by MS-SPACE. The a) and d) are original images; the b), c), e) and f) are the reformatted images by MPR reconstruction.