

Contrast Manipulation in 3D Whole-Body Continuously Moving Table MRI using Magnetization Preparation and k-Space Segmentation

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Introduction

The ability to create clinically relevant image contrasts in continuously moving table (CMT) imaging [1] is a pre-requisite to enable applications such as metastases screening in cancer patients. Contrast variation can be achieved using appropriate magnetization preparations, interlaced in the pulse sequence using segmented k-space acquisition schemes. So far, this type of CMT imaging has only been shown for sequences with 2D-oriented data acquisition in transversal slices [2,3]. In this paper, feasibility of contrast manipulations for 3D CMT imaging is studied, which requires special attention with respect to the timing of the preparation pulses and the type of segmentation, so as to avoid image artifacts caused by the table motion and non-perfect B_0 and B_1 field conditions [4]. Different magnetization preparations and k-space segmentations were studied in experiments on healthy volunteers.

Methods

In-vivo experiments were performed on healthy volunteers, using a 1.5 T whole-body scanner (Achieva, Philips Medical Systems). The body coil was used for RF transmission and signal reception, and the patient table was moved at constant velocity during data acquisition. The CMT method used in this work is based on a 3D gradient-echo pulse sequence with lateral (left/right) frequency-encoding direction [5]. Selective RF excitation is used to restrict the data reception to a 3D slab of extension L_z in z-direction (feet/head). The slab is moved along with the table while phase encoding (PE) steps are applied in the z-direction including some over-sampling. The second PE is chosen along the y-direction (anterior/posterior). For each PE step in y-direction, the RF slab is reset to its initial position. Segmentation is applied in z-direction, and magnetization preparation (P) is inserted (c.f. Fig.1). Two different schemes, low-high and linear, have been studied in detail. To show feasibility, selected magnetization preparation schemes have been employed: inversion-recovery and chemical shift selective signal suppression. 3D head-to-toe signal sampling was performed using $L_z = 100\text{mm}$, a virtual FOV of $512 \times 2000 \times 256 \text{ mm}^3$ (voxel size: $2 \times 2 \times 6 \text{ mm}^3$), TR/TE = 4.6/2.2 ms and a flip angle of 15° . For the inversion recovery measurement (180° -preparation pulse), 64 phase encoding steps were acquired after each preparation pulse in a linear acquisition order (Fig.1 top) to accommodate a long recovery time. The table velocity of 7.5 mm/s is matched such that the table travels the distance L_z during one full traversal of k-space, resulting in a total scanning time of 4 1/2 min. To test the low-high k-space sampling order (Fig.1 bottom) in combination with CMT imaging, water/fat selective imaging was performed. Here, contrast-relevant encoding steps near $k_z = 0$ are scanned directly after the preparation pulses. 16 encoding steps were sampled after a chemical-shift selective pre-saturation (110° RF-pulse, tuned to the water or fat resonance) and 4 dummy profiles were introduced to approach transient steady state. The sampling interval after spin preparation lasted for 92 ms, which is less than the typical lifetime of the prepared magnetization. Using a matched table velocity of 5.4 mm/s the total scan time was about 6 min. During reconstruction, the duration of the preparation P and the timing of data acquisition was considered for proper correction of the table motion.

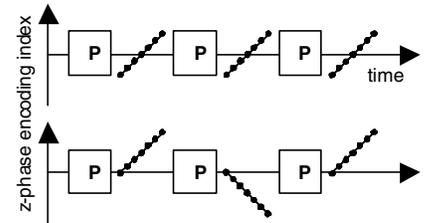


Figure 1: Linear (top) or high-low (bottom) ordered k-space segmentation applied after magnetization preparation (P).



Figure 2: Selected slices from magnetization prepared segmented 3D CMT data. (a) inversion pre-pulse (b) water suppressing pre-pulse (c) fat suppressing pre-pulse.

Results and Discussion

Figure 2 shows selected slices from a 3D magnetization-prepared data set, illustrating the feasibility of k-space segmentation and contrast manipulation in CMT imaging. Images measured for different volunteers were free of table-motion induced artifacts without using additional corrections for field- or gradient- heterogeneity. As the FOV exceeds 51 cm in the lateral direction, B_0 inhomogeneity distorts the outer border of the arms. In these areas the performance of the magnetization preparation as well as the signal sampling process is affected. However, such distortions might be of low clinical relevance and are observable as well in conventional imaging with the table at rest. The water selective image reveals a specific difficulty in CMT imaging. Due to body susceptibility induced resonance frequency (f_0) or main field distortions, the quality of the fat suppression varies slightly over the anatomy (c.f. Fig. 2c: bone marrow signal in the neck/shoulder region). Such shortcomings could be addressed by patient-position dependent f_0 -setting or receiver calibrations.

Conclusion

The presented studies show that different k-space segmentation and contrast preparation schemes can be used in combination with 3D CMT imaging, increasing the diagnostic flexibility of this head-to-toe imaging approach.

References

1. Kruger DG et al., *Mag Reson Med.* 47:224-231 (2002)
2. Ghanem et al., *Proc. ISMRM* 13:796 (2005)
3. Sommer et al., *Proc. ISMRM* 13:1966 (2005)
4. Aldefeld B et al., *Proc. ISMRM* 12:102 (2004)
5. Aldefeld B et al., *Proc. ISMRM* 13:2367 (2005)