Multi-Contrast Continuously Moving Table 3D MR Imaging

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Introduction

The use of MRI for the screening of tumor patients has received an increasing interest during the last years. For example, perilesional fat sparing, an indicator for tumors or their metastases, gives important information, while T_1 and T_2 weighted imaging offers further tissue differentiation. MR screening covering the entire body has previously been shown using either the multi-station approach, in which the patient table is moved between acquisitions [1], or the continuously moving table method, in which data are acquired during table motion [2-4]. A continuously moving table method in which different contrasts are acquired *in one single run* would be an attractive screening method because of its shorter scan-time requirement. This direction has been pursued, so far, only for a 2D-oriented method [2]. In the present work, a single-run multi-contrast continuously moving table imaging method is described in which data are acquired from large 3D volumes, allowing improvements in SNR.

Methods

In-vivo experiments were performed on healthy adults, using a 1.5T whole-body scanner (Achieva, Philips Medical Systems) equipped with 32 receive channels. The body coil was used for RF transmission and a 16-channel phased array coil for signal reception. The receive coil, arranged as a 4×4 array, was fixed to the inner bore of the magnet and bent closely around the anterior site of the volunteer to be examined. The patient table was moved during data acquisition at constant velocity controlled by an external PC. The hybrid-space approach [4] was used for the timing of the acquisition and for reconstruction. However, to modify image contrast, essential sequence parameters were modified from one complete k-space scan (3D block) to the next, and the table speed was chosen such that the table moved through one elementary FOV during three k-space scans (Fig. 1). The cycle was repeated until the entire virtual FOV was covered. In this implementation, the sequence core was a 3D true FISP (balanced FFE) gradient echo acquisition using a linear phase encoding scheme applied during continuous table motion. The gradient regime, the RF spoil regime and the RF excitation angle were changed in real-time to manipulate image contrast of the corresponding 3D blocks, while TR was kept constant. The different contrasts used were a balanced FFE scan with a 60° flip angle and two spoiled gradient-echo (FFE) scans with excitation angles of 30 and 10 degrees, respectively. Other parameters were e.g. TR/TE 4.4/2.2 ms, elementary FOV in motion direction 180 mm, virtual FOV $460 \times 2000 \times 80$ mm³, voxel size $1.8 \times 1.8 \times 10$ mm³, table velocity 6.6 mm/s and total scan time just below 6 minutes. During reconstruction, all coil data were corrected for the table motion [4], Fourier transformed and combined using an approach similar to ref. [5], including local and global sensitivity corrections.

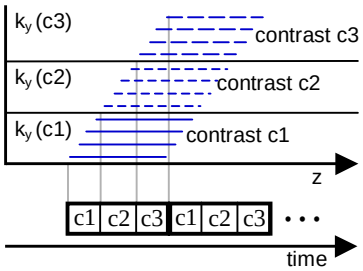
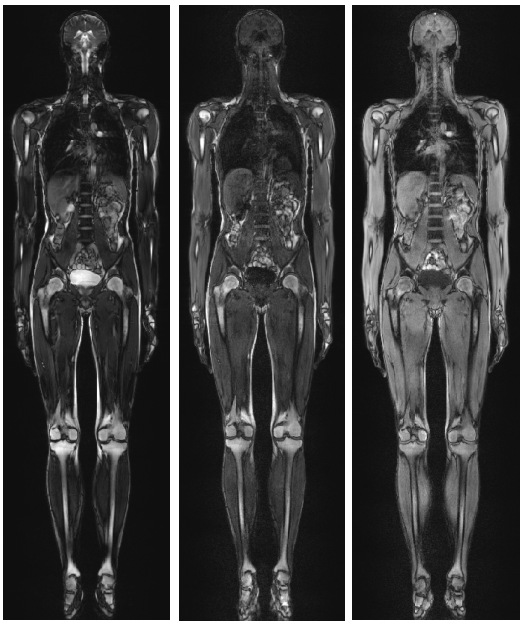


Fig. 1. Multi-contrast sequence in hybrid space

Results and Discussion

Figure 2 shows images of one selected volunteer, illustrating the basic feasibility of multi-contrast 3D continuously moving table imaging performed in a single run. Different image contrasts (T_2/T_1, T_1, and spin-density weighted, c.f. Fig.2a-c, respectively) are obtained for the different imaging methods. The use of the 16-channel array resulted in a high SNR. Only very small moving-table imaging artifacts are visible although no correction was applied for gradient non-linearity or other system imperfections. Gradient correction was not necessary due to the high linearity of the gradient coil employed. Magnetic-field inhomogeneities (ΔB_0 and ΔB_1) are serious sources of image artifacts in continuously moving table imaging. They act as an additional, adverse encoding of the signal of each voxel while it is moved through the FOV during k-space sampling. In the present multi-contrast approach, the effective traveling length for each voxel is reduced by a factor of three, resulting in a reduced artifact level caused by inhomogeneity effects. In some of the balanced FFE images, however, slight black banding artifacts caused by local susceptibility gradients are visible, especially near air-tissue interfaces. These could be reduced by further reduction of TR or by use of anatomy dependent f_0-adjustment to dynamically shift the dark bands away from the sensitive region. The latter measure would have to be studied further. For all gradient-echo sequences employed in this feasibility study, the same TR was chosen. At shorter TR, which would be advantageous for the balanced FFE scan, however, contrast would be lost in the spoiled FFE images. Thus, in the future, a concatenation of individually optimized sequences is mandatory to allow for T_1, T_2/T_1 or spin-density weighted or fat selective imaging [1]. However, the generation of a pure T_2 contrast in 3D continuously moving table imaging remains still challenging.



a) balanced FFE **b)** FFE 30^0 **c)** FFE 10^0

Fig. 2. Example showing three contrasts of images acquired in a single continuously moving table scan.

Conclusion

Whole-body single-run 3D multi-contrast continuously moving table imaging according to the approach presented is feasible and may be an interesting concept for screening patients. The high SNR and the single-run scan feature offer potential to increase the diagnostic quality and patient's comfort.

References

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