Two Approaches to Water/Fat Selective Whole-Body Continuously Moving Table 3D Imaging

P. Börnert[1], B. Aldefeld[1], J. Keupp[1], H. Eggers[1]

[1]Philips Research Laboratories, Hamburg, Germany

Introduction

Non-invasive measurement of the fat distribution using MRI may be of interest for future whole-body screening procedures. For example, the perilesional fat sparing can serve as an indicator for tumors or their metastases. Furthermore, the amount of body fat and its local bio-distribution shows a relationship with a number of obesity-related diseases. Continuously moving table imaging [1], currently mainly used for contrast-enhanced peripheral angiography, has the potential to be used in water/fat selective whole-body imaging [2] at high patient comfort. For water/fat measurements, two different basic methodological approaches can be employed, i.e. chemical shift selective or chemical shift encoding techniques. Previous work [2] has shown the problems associated with spectral-spatial RF excitation [3] and two-point-Dixon [4] encoding in continuously moving table imaging. To overcome these difficulties, a more robust magnetization prepared (chemical shift selective) approach [5] and a three-point-Dixon technique [6] were studied in the present work and compared with respect to performance and image quality.

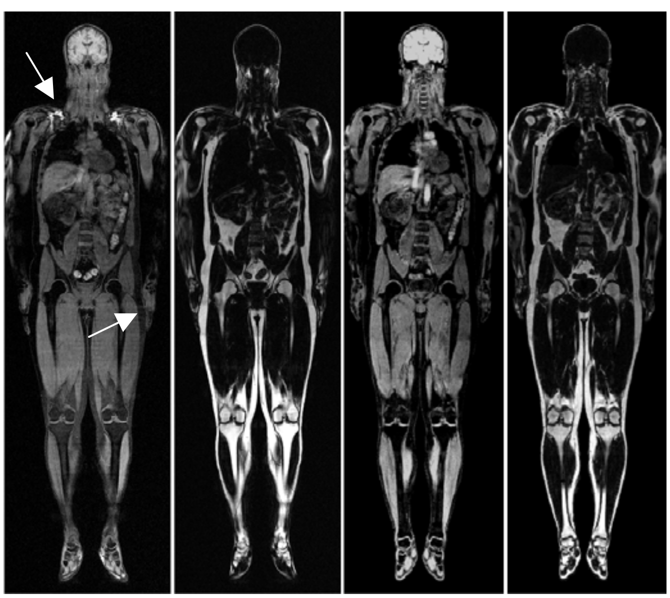
Methods

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. During data acquisition, the patient table was moved at constant velocity controlled by an external PC. Continuously moving table data acquisition was performed using a 3D gradient-echo pulse sequence employing lateral frequency encoding [7]. This approach allows fast *k*-space scanning in a FOV_z with short extent along the direction of motion (z), which is essential for reducing adverse effects due to B_0 and B_1 inhomogeneity. The slab-selective RF pulse of the 3D sequence was applied in the z-direction, and slight oversampling served to suppress effects of non-ideal slab selection and to allow sufficient time for the spin system to establish steady state. A virtual FOV of $512 \times 2000 \times 256$ mm³ (voxel size: $2.0 \times 2.0 \times 6.1$ mm³) was covered, using an elementary FOV_z of 110 mm in motion direction. Sampling was performed using a pixel bandwidth of 500 Hz. During reconstruction, all data were corrected for the table motion and Fourier transformed [7].

Two basic water/fat selective approaches were investigated. In the first approach, a spectral pre-saturation RF pulse (110°) was employed, tuned to suppress either the fat or the water signal. Each RF pulse was followed by an appropriate gradient spoiler and a segmented gradient-echo acquisition (4 dummies and 16 sampled echoes) using a low-high *k*-space sampling scheme and TR/TE of 4.5/2.2 ms. No relaxation delay was employed prior to the subsequent fat suppression pulse. These parameters required a matched table velocity of 5.7 mm/s and a total scan time just below 6 minutes. To cope with body-susceptibility induced effects, which shift the Larmor frequency as a function of the patient's z-position [8], approximately volunteer-invariant frequency off-sets were determined in a pre-study and used to adjust the chemical shift selective excitation. In the second approach, three-point Dixon sampling was employed using a fly-back EPI-type read-out to sample three echoes at the same gradient polarity, thus avoiding eddy-current related phase problems. A linear 3D *k*-space sampling scheme was employed, with a first TE of 2.2 ms, an increment of 2.0 ms and TR of 8.7 ms. Using a matched table velocity of 4.35 mm/s, the total scan time was below 8 minutes. After image reconstruction for each of the individual echoes, iterative water/fat separation was performed by fitting the local B_0 inhomogeneity as an additional parameter [6]. To stabilize this reconstruction, spatial smoothing of the field map was performed between the individual iterative steps.

Results and Discussion

Figure 1 shows one slice from 3D data sets for one selected volunteer and the two methods under study (magnetization prepared: Fig. 1a, three-point Dixon: Fig. 1b), illustrating the achieved image quality in water/fat selective 3D continuously moving table imaging. Negligible moving-table artifacts are visible although no correction was applied for gradient non-linearity or other system imperfections. However, the performance of the water/fat suppression was found to be better in the three-point Dixon approach. Especially, the water-selective images show some areas of incomplete fat suppression (e.g. arrows in Fig. 1) due to local off-resonance not reflected by the simple resonance offset model used. The fat-selective data are robust in that respect. The iterative three-point Dixon approach proved to be more robust against the local off-resonance effects. It is also more SNR-efficient, corresponding to NSA=2.75 for the maximum encoding time [9], whereas the chemical shift selective approach corresponds to NSA=1, and it acquires both data sets (fat and water) in a single run.



(a) (b)

Fig. 1. Water and fat images (from 3D data sets) acquired using spectral pre-saturation (a) and three-point Dixon sampling (b).

Conclusion

Whole body water/fat sensitive imaging can be performed with high quality using continuously moving table technology. The 3-point Dixon approach turned out to be the more robust and more efficient approach in terms of SNR per total scan time. Its higher SNR and its single-run scan feature offer improved diagnostic quality and patient's comfort.

References

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