A Comparison of Continuously Moving Table and Multi–Station 3D Whole-Body Water-Fat Separation

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Introduction

The distribution and the amount of body fat are of increasing interest in diagnosis. Obesity and in particular visceral adiposity are significant contributing factors to a variety of health problems, such as diabetes, psychological dysfunctions and cardiovascular diseases [1]. Whole-body isotropic 3D water/fat selective MR imaging could be an appropriate and very accurate tool for this kind of analysis. Since moderate spatial resolution would be sufficient, the required scan time can be in the order of a few minutes. For whole-body water/fat separation, three-point chemical-shift encoding was found to be advantageous because of its insensitivity to local resonance frequency variations [2]. In this study, a continuously moving table technique (CMT) [3,4] and a traditional multi-station approach (MST) were studied for whole-body water/fat imaging and compared with respect to image quality, patient comfort and overall scan time.

Methods

In-vivo experiments were performed on 10 healthy adults (1 female, 9 male, 25-47 years), using a 1.5T clinical whole body scanner (Achieva, Philips Medical Systems) equipped with a modified patient table, allowing continuous table movement during data acquisition. The body coil was used for RF transmission and signal reception. Two whole-body-scanning approaches were investigated. Both approaches used a fly-back-EPI-type gradient-echo pulse sequence with linear 3D *k*-space sampling and lateral frequency encoding. This allowed fast *k*-space sampling in a volume with a short extent along the *z*-direction, which reduces artifacts due to B_0 and B_1 inhomogeneity. A slab selective RF pulse was applied along the *z*-direction, and slight oversampling served to suppress effects of non-ideal slab selection. After one RF excitation, three gradient echoes were acquired with identical phase encoding and at the same read-out gradient polarity to avoid eddy-current related phase differences. The first TE was adjusted to 1.3 ms, the TE increment to 1.7 ms and TR to 6.5 ms. The flip angle was 15°, the virtual FOV covered $518 \times 295 \times 1944$ mm^3 in all approaches, and the voxel size was $5.4 \times 5.4 \times 5.4$ mm^3. In the CMT approach, the patient table was moved during data acquisition with the matched, constant velocity of 11.45 mm/s. The excited volume had an extension of 108 mm in the motion direction. During reconstruction, all data were corrected for the table motion and Fourier transformed for all three echoes separately [4]. After image reconstruction, an iterative water/fat separation was performed using a region-growing algorithm for local B_0 inhomogeneity estimation, similar to the method described by Yu et al. [5]. In the MST approach, data were acquired at several stations. The successive sub-volumes to be excited were moved to the iso-center of the scanner at the highest table velocity. Two versions of this second approach were investigated, one with the same FOV length in the *z*-direction as for the CMT scan (108 mm, i.e.18 stations, MST-18), and one with a FOV length in the *z*-direction twice as large (216 mm, i.e. 9 stations, MST-9). The same water/fat separation was performed as for the CMT method, but each sub-volume was processed separately. The final water and fat images were obtained by concatenation of all sub-volumes, using a smooth transition function. All volunteers were examined with all three methods (CMT, MST-18, MST-9). The SNR of the final 3D water images was analyzed. Visual scoring (test by three observers, from 1 (best) to 5 (barely acceptable)) was subsequently performed for all 3D images. Furthermore, the volunteers were asked to grade the three different methods, with respect to acoustical noise and patient comfort (from 1 (best) over 4 (neutral) to 7 (worst)).

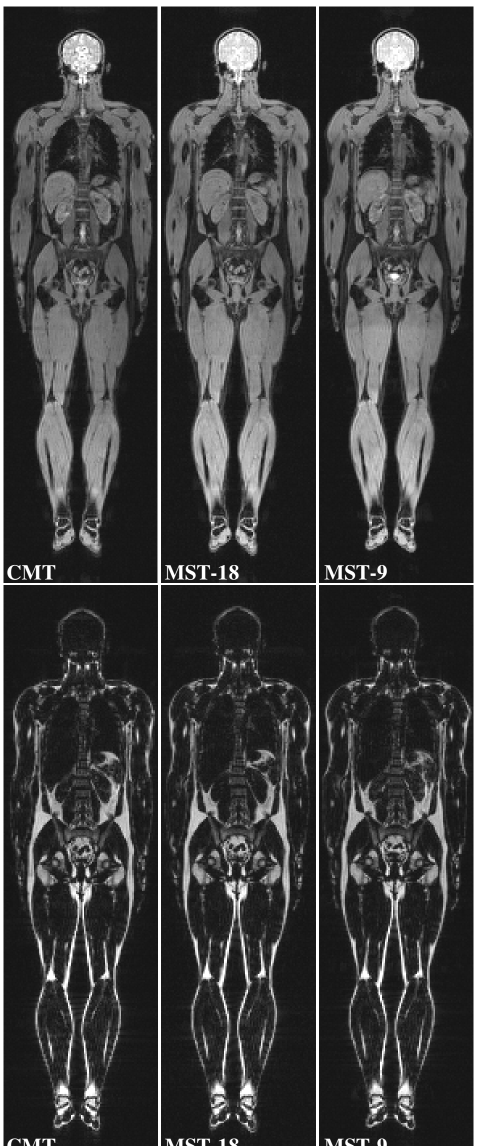

Figure 1: Selected coronal view of the 3D water/fat data of one volunteer. From left to right: CMT, MST-18, MST-9. Top: water image, bottom: fat image.

Results

Figure 1 shows one slice from the 3D data of each method studied and one selected volunteer, illustrating the image quality achieved. All methods show very good water/fat separation within the complete FOV. Transition artifacts between neighboring stations are most dominant in the MST-9 method, visible especially in the water images. Since the flip angle was not adjusted for the different body regions, all methods show some small contrast variation along the *z*-direction. Further results of the comparison are summarized in the table below. The CMT method required the shortest scan time and was graded best by the volunteers, but at a wide variance. The MST-18 method was scored to have a slightly better image quality compared to the other methods, but it shows a little smaller SNR.

method	**scan-time**	**SNR**	**image quality** (ranking,1 - 5)	**noise exposure** (ranking, 1 - 7)	**patient comfort** (ranking, 1 - 7)
CMT	2:45 min	104.7 ± 6.7	1.7 ± 0.6	3.2 ± 0.8	2.4 ± 0.9
MST-18	3:30 min	94.5 ± 8.9	1.3 ± 0.4	3.7 ± 0.9	3.7 ± 1.3
MST-9	3:10 min	118.0 ± 12.4	1.8 ± 0.5	3.6 ± 0.9	4 ± 0.8

Discussion and Conclusion

3D isotopic whole body water/fat MR imaging using three-point chemical-shift encoding can be performed with all studied methods. CMT data acquisition has the advantage of a shorter scan time (up to 20% compared to MST-18) and turned out to be more pleasant for the person under examination. The MST-18 method shows slightly better image quality. CMT and MST-18 both benefit from a small extent along the *z*-direction of the RF-excited volume. With the MST methods, it is possible to instruct the patient to breath only during the table travel sections. This could improve the image quality in the abdominal body section. Whole body water/fat scoring can be performed at high quality with either a continuously moving table technique or a multi-station procedure. When shortest scan time is important, CMT should be considered.

References

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