Whole Body MRI at 3 Tesla Using a Moving Tabletop and a Fast Spin Echo Dixon Technique

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Introduction

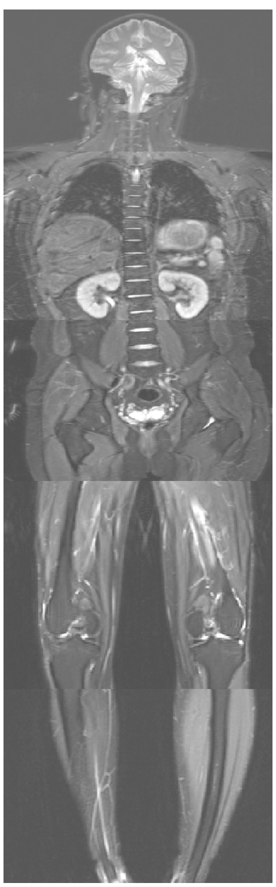
Imaging procedures for staging of cancer patients often consist of using multiple modalities such as ultrasound, X-ray, CT, MRI and nuclear medicine (scintigraphy, SPECT, PET). Recently, whole body MRI has been proposed as a potentially viable "one-stop shop" for determining the local extent and distant metastases of a confirmed or suspected primary malignancy [1-3]. As in regular MRI, the most useful techniques advocated for whole body MRI include T2 weighted imaging (either fast spin echo or EPI) with fat suppression [1-2] and T1-weighted imaging with contrast agent injection [4].

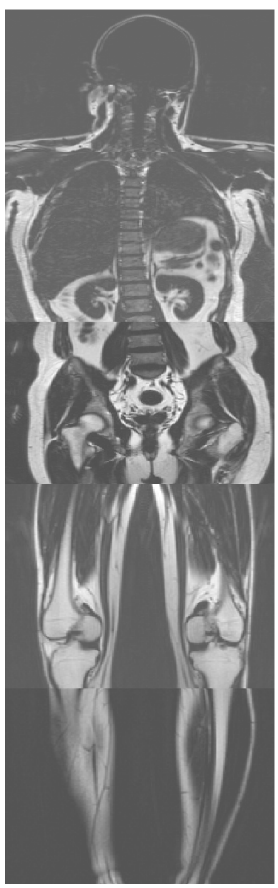
Due to the large field of view involved, fat suppression in whole body MRI is achieved with short-tau inversion recovery (STIR) instead of the conventional chemical shift selective saturation (CHESS). Despite its insensitivity to magnetic field inhomogeneity, STIR is known to exact reduced scan efficiency, lower signal-to-noise ratio (SNR), and altered image contrast. In this work, we present a fast spin echo two-point Dixon technique for whole body T2-weighted imaging. Using a 3-Tesla scanner and body RF coil, we demonstrate that excellent water-only and fat-only images of an entire body can be obtained in less than 15 minutes.

Methods and experiments

Imaging was performed on a GE Signa 3 Tesla whole body MR scanner (GE Healthcare, Waukesha, WI). A conventional fast spin echo sequence was modified to allow interleaved collection of a water and fat in-phase image and a water and fat opposed phase image. Rawdata of a healthy volunteer were acquired using a body coil in five separate stations and in the coronal plane (obliqued along the axis of spine when necessary). The subject was supine on a moving tabletop without being repositioned throughout the exam. The imaging parameters used were: FOV = 48cm, TE = 68 ms, ETL = 16, RBW = ±32 kHz, acquisition matrix = 256x192, slice thickness/gap = 6/1 mm. A TR of 6000 ms was used to allow for a maximum of 31 slices in 2:30 minutes per station. For the second station, which encompasses chest and abdomen, respiratory triggering was used to minimize the motion artifacts. As a result, the imaging time for the second station was 3:45 minutes. The total imaging time for all the five stations was thus less than 15 minutes.

Separate water and fat images were reconstructed using an algorithm similar to that described in Ref. [5]. The phase correction part of the algorithm uses a region-growing scheme that is guided by weighted boxcar averaging and pre-calculated phase gradients. As such, the algorithm is efficient and robust with respect to local phase variations. No user input was required in the entire image reconstruction process.





Results

The figure on the left shows a representative water-only image combined from all five stations at a given slice level. Overlapping regions in the images from individual stations were cropped off. Note that despite the large FOV used, clean and uniform fat separation was achieved over the entire image, including regions of sinuses, shoulders, spine, femur and knees. The accompanying fat-only image of the same locations, which is available as a by-product of the technique at no additional scan time, is shown in the right figure. Such images could provide complementary information and thus aid the detection and diagnosis based on water-only images. Conversely, the fat-only images provide the fat distribution throughout the body, which may be valuable in diagnosing certain diseases (such as obesity and diabetes) and in monitoring the progression of the diseases. In the image presented, the different fat amounts within the appendicular and axial bone marrow (for example, between vertebral bodies and femurs) are clearly appreciable.

Discussions and Conclusions

If completed within a reasonable amount of scan time, whole body MRI offers an appealing and cost-effective alternative for the initial workup and follow-up of cancer patients compared to other imaging modalities. It does not involve ionizing radiation and offers excellent soft tissue contrast. Our preliminary results indicate that T2-weighted images of excellent quality from head-to-toe can be acquired within 15 minutes. Even with additional whole body fast 3D T1-weighted imaging with contrast agent [4], the exam time could still be well below the current standard MR time slot (ca. 45 minutes).

The FSE based Dixon technique overcomes several previously mentioned limitations with the STIR-FSE technique. Nor does it suffer from the image distortion and artifacts sometimes encountered with EPI-based techniques. While our experiment was performed at 3T and using a body coil, the technique is certainly applicable at other field strengths and using phased array coils.

References

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