Single session whole body T2-weighted and T1-weighted MRI (both with and without fat suppression)

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Introduction:

An MRI study is commonly used for examining the local extent of a disease and often consists of acquiring images of the same region with different image contrasts. Using a moving tabletop and without re-positioning the patient, MRI has also been shown to be a feasible tool for whole body screening or staging of a disease [1-3]. In this regard, whole body MRI is potentially more advantageous than some other imaging modalities: it does not involve the use of ionizing radiation (as in CT) and is more patient-accessible, less costly and of higher spatial resolution (than PET).

The large anatomical coverage required in whole body MRI and the limited magnetic field homogeneity attainable within the large FOV, however, pose some special technical challenges. For example, fat suppression, which is often useful for lesion detection, cannot be reliably achieved with the conventional chemical shift saturation method. Acquiring images of a whole body with different image contrasts, which is essential for more accurate lesion detection, may lead to prohibitively long scan time. Due to these limitations, the most widely used and perhaps also the most reliable approach for whole body MRI has so far been the turbo-STIR (short tau inversion recovery) technique [1]. As an alternative, we demonstrated that a fast spin echo (FSE) two-point Dixon method can be used for whole body T2-weighted MRI with better SNR and contrast [4]. In this work, we show that a fast spin echo triple echo Dixon (fTED) technique can be used to further improve the image quality in whole body T2-weighted imaging and reduce the scan time. Further, we show that a 3D fast spoiled gradient echo dual-echo Dixon technique can be included to acquire whole-body T1-weighted images (suitable for contrast agent enhancement studies). A protocol comprising these two techniques is shown to be capable of providing whole body T2-weighted and T1-weighted (pre and post contrast agent injection) images, both with and without fat suppression, in a total acquisition time of less than 15 minutes.

Experiments and Method:

Both the fTED technique for T2-weighted imaging [5] and the 3D fast spoiled gradient echo dual-echo Dixon technique for T1-weighted imaging [6] used in the study are Dixon-based [7]. The fTED technique is modified from the conventional FSE technique by replacing the single readout gradient between each successive refocusing RF pulse pair with three consecutive readout gradients. The three readout gradients are of alternating gradient polarity and are timed to provide three echoes with a relative water and fat signal phase shift of -180°, 0, 180°, respectively. Post-processing of the images from the three echoes permits generation of T2-weighted images with and without fat suppression with a scan time efficiency equivalent to that of the conventional FSE. The 3D fast spoiled gradient echo dual-echo Dixon technique is modified from the conventional 3D fast spoiled gradient echo technique by replacing the single readout gradient after each RF excitation pulse with a dual echo readout. The two echoes have a relative water and fat signal phase shift of 180° and 0, respectively, and post-processing of the corresponding two images generate T1-weighted images with and without fat suppression and with a scan time efficiency equivalent to that of the conventional 3D fast spoiled gradient echo sequence with fat suppression.

The two techniques were implemented on 1.5T GE whole body MRI scanners (GE Healthcare). The data were acquired of a patient lying on a moving tabletop and in four different stations (the 1st station covering head and shoulders, the 2nd station covering abdomen/pelvis, the 3rd station covering the upper legs, and the 4th station covering the lower legs and feet). Both T1 and T2-weighted images were acquired in (oblique) coronal planes. The 2nd station was acquired with an 8-channel torso phased-array coil and in breath holds (for both T1 and T2). All other stations were acquired with the built-in body RF coil and with free breathing.

Results


Fig. 1a)


Fig. 1b)

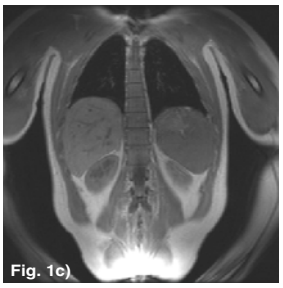
Fig. 1c)

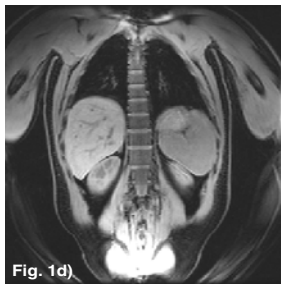
Fig. 1d)

For the 2nd station, the imaging parameters for the fTED T2-weighted images were TR/TE = 2500/68ms, ETL (echo train length) = 21, acquisition matrix = 256x160, FOV = 48, slice thickness/gap = 6/1mm. In all, a total of 33 slices were acquired in three separate breath holds of 25 seconds each. For all the other stations, a longer TR and free-breathing were used for the fTED T2-acquisition. Depending on the total number of slices needed (typically < 30), the acquisition time for fTED T2 was typically less than 2:30 minutes per station. For the T1-weighted images by the 3D fast spoiled gradient echo dual-echo Dixon technique, the scanning parameters were: acquisition matrix = 256x160, FOV = 48cm, slice thickness = 5mm, flip angle = 12°, and a total of 38 slices in 29 seconds. The acquisition time for T1-weighted imaging was typically 25-30 seconds per station. Thus, the total acquisition time for both T2 and T1-weighted images (including pre and post contrast injection) and for all the stations can be less than 15 minutes. Including the time for overhead (e.g. patient setup, contrast agent injection, table movement), the entire exam of the whole body can be completed within a single imaging session (typically 45-60 minutes).

Fig. 1a) and b) show a representative slice of the fTED T2-weighted images from the 2nd station without and with fat suppression, respectively. Fig. 1c) and d) show a slice of the similar location for T1-weighted images by the 3D fast spoiled gradient echo dual-echo Dixon technique without and with fat suppression, respectively. Both T1 and T2-weighted images demonstrate excellent image quality with no noticeable motion artifacts. Fat suppression is uniform in both sets of images despite the very large FOV used. Similar image quality was observed for other slices or other stations.

Discussions and Conclusion:

By using the fTED and the 3D dual echo Dixon techniques, we demonstrate that high-quality T1-weighted (including pre and post contrast agent injection) and T2-weighted images, both with and without fat suppression, can be acquired in a single MR session (with a total data acquisition time of less than 15 minutes). The acquisition time can be further reduced with the use of a parallel imaging technique. These images typically form the basis for the interpretation of most of the routine MR exams. When compared to other approaches using a single sequence, our techniques can therefore be expected to help enhance the diagnostic accuracy and the use of the whole body MRI [8].

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References:

[1] Eustace S et. al. AJR 1997; 169:1655-1661. [2] Johnson KM et. al. Radiology 1997; 202 :262-267. [3] Horvath LJ et. al. Radiology 1999; 211:119-128. [4] Ma J, 13th ISMRM, 2005; p. 1965. [5] Ma J et. al., 14th ISMRM, 2006; p. 3025. [6] Ma J, et. al., JMRI, 2006; 23 :36. [7] Dixon WT, Radiology 1984; 153:189. [8] Lauenstein TC et. al. JMRI 2006; 24:489-498.