Rapid T2 and lipid-water imaging of the liver with radial IDEAL GRASE

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Introduction: The information yielded by T2-weighted and the in- and out-of phase images is important in the characterization of liver pathologies [1]. The difference in signal intensity between moderately and heavily T2-weighted images is used to discriminate benign from malignant lesions. Differences between the in and out-of-phase images are used to evaluate the presence of fat in focal lesions or in conditions leading to fatty liver. Currently, data for T2-weighted and in-and out-of-phase images are acquired in different scans. Also, the information yielded by the methods currently used in the clinic can only be analyzed in a qualitative manner.

Recently, a radial fast spin-echo method has been developed for liver imaging [2,3]. The method provides high spatial resolution, motion insensitivity, and T2 mapping based on a fast single data set acquisition. The method has been successfully used to discriminate malignant from benign liver lesions [2,4]. An extension of the method is the radial Gradient and Spin-Echo (GRASE) method, where several gradient echoes are collected within a spin-echo (SE) period [5]. With radial GRASE both T2 and quantitative lipid-water information is obtained from only one scan.

In this work we describe the technique and demonstrate its utility for the characterization of liver pathologies.

Methods: As shown in Fig. 1A in the GRASE pulse sequence four gradient echoes ($E_{n,m}$, n=gradient echo index, m=SE echo index) are collected at different echo shifts from the SE point. The images generated from the four gradient echoes are used in the iterative algorithm described in [6,7] to obtain lipid and water images without the effects of field inhomogeneities. Since data are collected with a radial k-space trajectory, the oversampling in the center of k-space allows us to obtain images at various effective TEs from a single data set by using the echoes that are closest to the SE point ($E_{0,m}$) and the TE sharing technique described in [3]. This is illustrated in Fig. 1B for the 1st and 2nd SE points. From these data TE images are generated and a T2 map is calculated.

The radial GRASE method was implemented on a 1.5T GE Signa NV-CV/i scanner. Data for lipid-water and T2 imaging were acquired on a single breath hold with echo shifts of ($-5\pi/2$, $-\pi/6$, $\pi/2$, $7\pi/6$), BW=±125 kHz, ETL=10, matrix size=256×192, TR=1s, NEX=1.

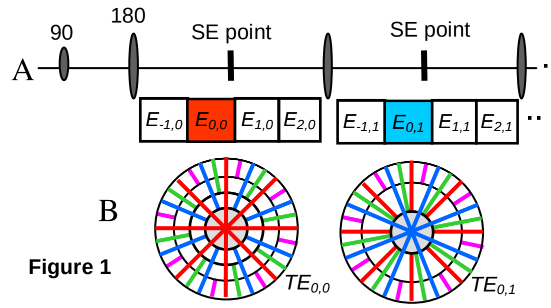

Figure 1

Results: Figure 2 shows the water and fat images obtained from radial GRASE data on two different subjects. The *top* images correspond to a normal subject and the *bottom* images to a subject diagnosed with a fatty liver. Figure 2 also shows the %fat image, generated from the lipid and water images. The %fat image is insensitive to the coil's sensitivity profile thus can be used for quantitative analysis. Note that the patient with a fatty liver has a significantly higher lipid content in the organ compared to the healthy volunteer.

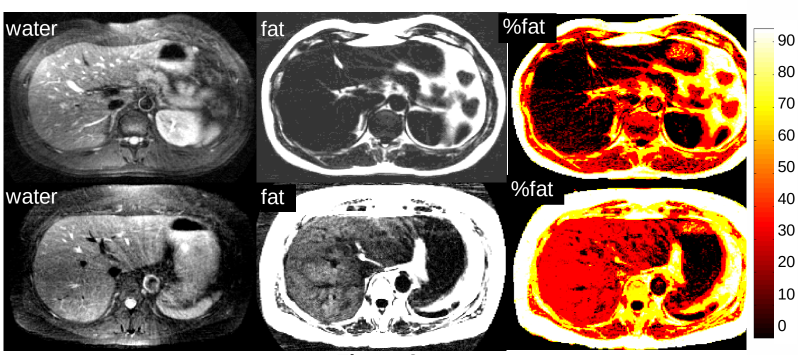

Figure 2

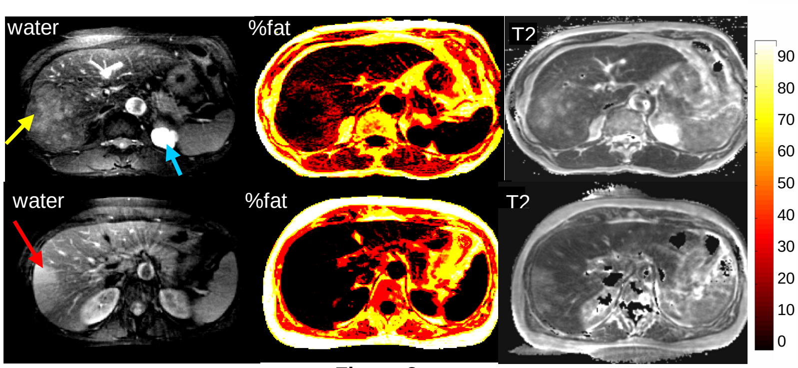

Figure 3

The usefulness of the combined %fat and T2 information in terms of lesion characterization is illustrated in Fig. 3. The figure shows the water, %fat, and the T2 images obtained from radial GRASE data for two patients with abdominal lesions. The lesion indicated by the *blue arrow* in the (*top*) water image is a cyst and has a long T2 value (324±34 ms). As expected there is no lipid signal associated with the cyst in the corresponding %fat image. This patient has also a large lesion on the right side of the liver indicated in the water image by the *yellow arrow*. The lesion has a necrotic core with high T2 values (98.6±9.2 ms) and a non-necrotic area surrounding the core with a T2 =71.4±7.2 ms. There is a small amount of lipid in the lesion in the corresponding %fat image. The low T2 value in the non-necrotic area of the lesion and the presence of lipid are consistent with the diagnosis of a hepatocellular carcinoma. The second patient (*bottom*) has a metastatic liver lesion indicated in the water image by the *red arrow*. As with the cyst the metastatic lesion does not have lipid. But the T2=70.6±11.7 ms of the metastatic lesions is significantly lower than the cyst.

Conclusion: A radial GRASE technique was developed for obtaining lipid-water and T2 information from data acquired in a single scan (during a single breath hold). The method was demonstrated for the characterization of liver pathologies such as fatty infiltration in the liver and for the characterization of focal liver lesions. This novel method is fast and may prove to be a valuable tool the characterization of liver pathologies in the clinic.

Acknowledgement: Work supported by NIH grants CA099074 and HL085385.

References: [1] Ichikawa T et al, Eur J Radiol 29:186, 1999. [2] Altbach MI et al *JMRI*. 16:179, 2002. [3] Altbach MI et al, *MRM* 54:549, 2005. [4] Knowles N, ISMRM 15, 2715, 2007. [5] Li Z, ISMRM 14, 625, 2006. [6] Reeder SB et al MRM 51:35, 2004, [7] Li Z et al, MRM 57:1047, 2007.