MR Spectroscopic Imaging of Short T2 Tissue Using Complex Division (CD) HYPR-LR Reconstruction

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INTRODUCTION

Spatially resolved MR spectroscopic imaging can be achieved by acquiring a series of images at a number of different echo times (TE) to form a time-resolved series of images. The spatially resolved spectra can then be obtained by Fourier transforming the time-resolved series along the time dimension [1]. The disadvantage of this approach, however, is the long scan time required to obtain images at a sufficient number of TEs to provide an accurate representation of the spectra. Undersampled projection reconstruction techniques have been explored previously in conjunction with Highly Constrained Back-Projection (HYPR) [2] and HYPR with Local Reconstruction (HYPR-LR) [3] to shorten scan time for time-resolved MR applications using magnitude data. These reconstructions exploit spatio-temporal correlation in the time-resolved data to constrain reconstruction of each undersampled time-frame. Extension of these techniques to spectroscopic imaging applications requires treatment of complex valued data. A novel complex-valued implementation is proposed and applied to spectroscopic MR data of pig tibia. This may provide new approaches for the study of metabolic bone disease in humans [4].

MATERIALS AND METHODS

Data were acquired by using an ultrashort TE (UTE) spectroscopic imaging sequence with a long adiabatic inversion pulse (16ms) to suppress long T2 signals from muscle and fat [5]. All projections were interleaved into multiple groups and each group covered the k-space sparsely and uniformly. Images at different TEs were reconstructed by using Complex Division (CD) HYPR-LR algorithm (Fig. 1). The magnitude and phase of the final complex HYPR-LR images are calculated as

$$abs(H) = abs(C) \cdot abs(B_t) / abs(B_c),$$

$$angle(H) = angle(C) + angle(B_t) - angle(B_c),$$

where H is the HYPR-LR image, C is the composite image, B_t and B_c are the blurred fbp and composite images, respectively. All images are allowed to be complex valued. Acquisition parameters were: single slice radial acquisition, TR=300 ms, TI=110 ms, BW=±62.5 kHz, FOV=10 cm, slice thickness=4 mm, xres=256, total number of half echoes=1350 (half echoes that were 180° apart were combined into a full projection echo, 15 full projections per interleaf in 45 groups) with a minimal TE of 12 μs and a TE delay of 80 μs, total scan time=14 min. The CD HYPR-LR reconstruction parameters were: sliding composite window length=15 interleaves, Gaussian blurring kernel with filter size=10 pixels and σ =7 pixels. To generate the spectroscopic images, zero-padding to 512 was followed by Fourier transform in the time domain.

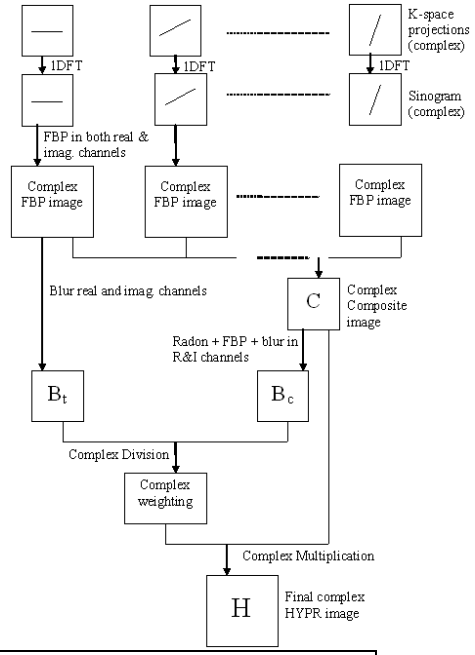

Figure 1. *Block diagram of CD HYPR LR*

RESULTS AND DISCUSSION

Fig. 2 shows the TE images and the corresponding spectroscopic images. The intensity vs TE curve and spectra are displayed in Fig. 3. T2* of bone can be estimated by fitting the exponential decay of signal intensity. The water peak and fat peak can be clearly identified in both bone and marrow spectra.

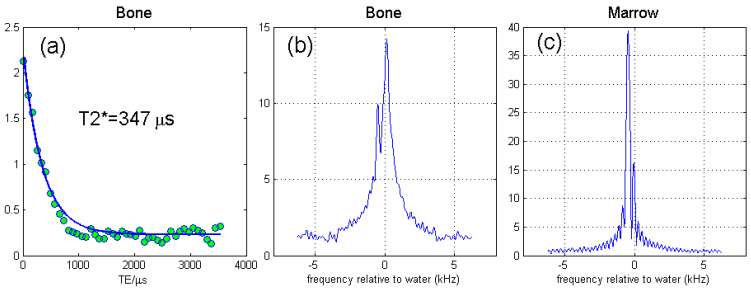

Figure 3. *T2* decay of a 25 pixel region of interest (ROI) from tibia (a) and the corresponding spectrum (b). The tail in (a) is mainly due to non-zero background noise in magnitude images, and the fitting is modeled as* $signal = c \cdot \exp(-TE / T2^*) + n_{bg}$ *where* n_{bg} *accounts for background noise . The central water peak in (b) is slightly off-resonance due to bulk susceptibility in bone. The spectrum of a 100 pixel ROI from marrow (c) shows a small water peak at zero frequency and a large fat peak located at -440 Hz. The widths of these peaks are narrower than tibia because T2* is longer in marrow.*

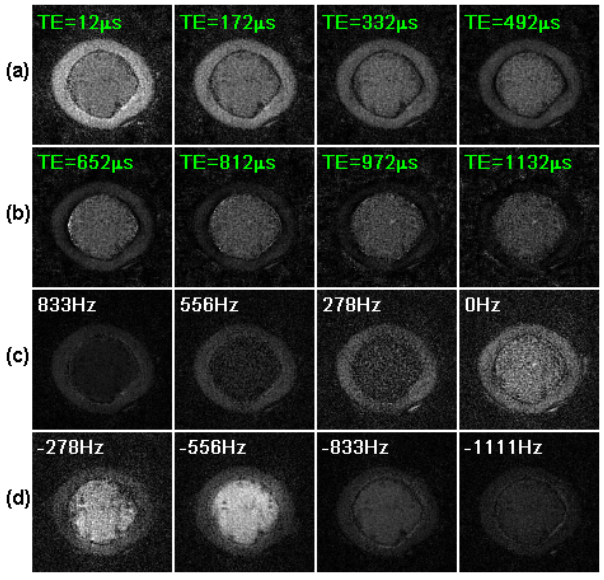

Figure 2. *Selected TE images (a,b) and spectroscopic images at different frequencies relative to water (c,d) with high resolution (0.39×0.39×4 mm³) under a total scan time of 14 min.*

CONCLUSIONS

The CD HYPR-LR reconstruction combined with UTE acquisition provides a fast and efficient way to image short T2 tissues, such as cortical bone with high spatial resolution under clinically acceptable scan time. It also provides quantitative information such as T2* mapping, chemical shift and bulk susceptibility effect, which may have high potential for clinical evaluation of osteoporosis.

ACKNOWLEDGEMENTS

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