Accelerated T2* measurements in human meniscus using projection reconstruction with data sharing from adjacent echo

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Introduction

The human meniscus consists primarily of collagen fibers that contribute to important mechanical functions of the knee, such as load distribution, but is also strongly correlated with the progression of osteoarthritis (OA) [1]. Quantitative measurements, such as T2 and T1rho, on meniscus contribute to early detection of the degeneration and the monitoring of its progression. Recently, several studies have demonstrated the ability of T2* mapping using ultra-short echo time (UTE) sequence to target the rapid decay signal from the meniscus due to short T2 of the water in this highly collagenous structure [2]. Moreover, T2* relaxation time could reflect spin-spin interactions of protons bound to collagen and the degree of collagen fibril alignment [3]. Although one previous report indicated that the dual-echo radial sequence with minimal phase excitation pulse is helpful in meniscal T2* mapping in vivo [4], relative long acquisition time of four repeat scans for the high resolution imaging restricts its clinical application. Fortunately, the radial MR k-space data consists of oversampled low frequency component in all projections, which may provide some possibility for contrast manipulation with more efficient acquisition. As a result, the purpose of this study is to take advantage of the projection reconstruction with data sharing from adjacent echo images for acceleration of quantitative T2* measurements.

Theory & Method

In projection reconstruction imaging, MR data are acquired radially to fill the k-space. For the reason, the central region which determines the image contrast is sampled more densely compared to the outer part of k-space, and will be redundant in the following reconstruction. Based on this concept, Song HK, et al indicated the ability of reconstructing multiple T2 weighted images as well as a T2 map from a single image data set using k-space weighted image contrast (KWIC) [5]. We extend the similar concept conjugated with the dual echo radial meniscus imaging sequence to speed up the T2* measurements (Figure 1). The proposed imaging method was performed on six asymptomatic volunteers without any known or suspected knee pathology in supine position at 3T (TIM TRIO, Siemens Medical Solutions, Erlangen, Germany) with an eight-channel knee coil. More specifically, the 2D dual echo radial imaging sequence were repeated 4 times with 8 different echo times 0.82/2/3/4/6.95/8.13/9.13/10.13 ms, flip angle = 60^0, TR = 700ms, number of slice = 8, slice thickness = 5mm, projection number = 512, readout per projection = 512, in-plane resolution = 0.24x0.24 mm^2, acquisition time per repeat = 5 min 58 sec. After that, 2- and 4- fold undersampled radial k-space data (256 and 128 projections, respectively) was extracted from this integral data set to test the acceleration ability of the contrast manipulation in our radial meniscus imaging.

Results

The demonstration of the first echo images of menisci reconstructed from 512, 256, and 128 projections were shown in Figure 2. Both images originally reconstructed from 2- and 4-fold underampled data with 256 and 128 projections, respectively, have relatively lower signal-to-noise ratio (SNR) due to insufficient data information. Significant streaking artifact was displayed in the 128 projections image in which menisci may be contaminated by adjacent tissues. In contrast, in the corresponding images reconstructed using the proposed method, significant improvement of image quality was achieved. Moreover, average T2* fittings from these three different projection data sets were derived, respectively (Figure 3). The derived T2* values were increased from 5.7578 ms to 5.8464 (1.5% error) with two-fold acceleration, and 6.3284 ms (9.9% error) with four-fold acceleration, respectively.

Discussion

This present study indicated the feasibility of accelerated T2* measurements in in vivo human meniscus imaging using undersampled projection reconstruction. Although the difference on cartilage borders was higher on the reconstructed image with 128 projections, both images reconstructed from 256 and 128 projections showed a similar signal distribution on the menisci with an improvement in image SNR. Less than 10% discrepancy of the T2* values were observed in the reconstructed images using the proposed method as compared to the T2* value from 512 projection data set, validating the ability to speed up the T2* measurements. In conclusion, our preliminary finding demonstrated that the proposed method provides an alternative to obtain multiple T2* weighted images and a reliable T2* measurement with a shorter acquisition time, which may be helpful in the implementation of in vivo meniscus T2* mapping in clinical application.

Reference

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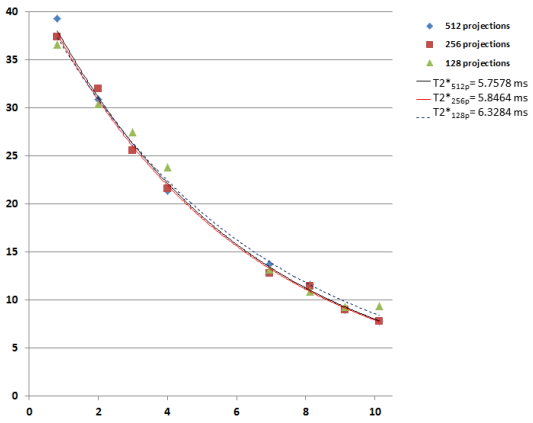

Figure 3 Average T2* fitting from 512, 256, 128 projections, respectively.

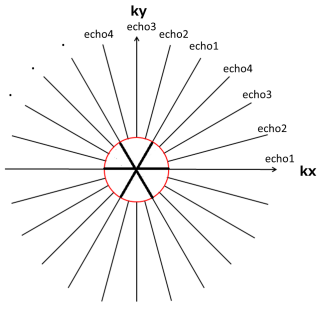

Figure 1 An illustration of pulse sequence used in this study.

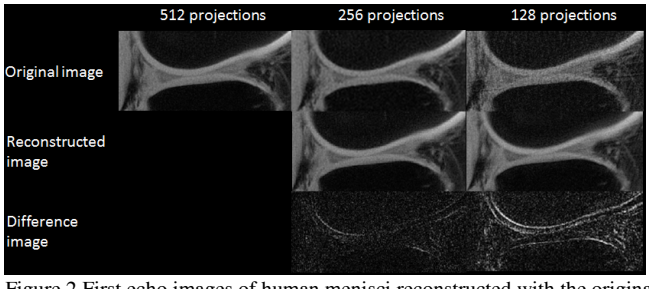

Figure 2 First echo images of human menisci reconstructed with the original and proposed method from 512, 256, 128 projections, respectively.