Double Inversion Recovery (DIR) MR Imaging to Improve a Contrast in Effusion Regions of the Knee

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Introduction

The use of two inversion delays with two inversion pulses allows signals with being suppressed two different tissues simultaneously, and is termed a double inversion recovery (DIR) sequence(1,2,3). Non-invasive characterizations of an effusion on the basis of imaging may obviate the need for joint aspirations with its associated patient morbidity. A fluid of the knee may consist of hemorrhage, hypertrophic synovium, and exudate from inflamed tissue shown a high signal intensity on the T2-weighted image and a low signal intensity on the T1-weighted image(4). Although the results of applications of the DIR technique have been quite promising, especially regarding pathologies in CNS legions, the DIR imaging was not systematically investigated on musculoskeletal (MSK) legions. This may be related to a relatively long scan time and low signal-to-noise ratio. Both of these problems can be overcome by using recent developments of coil techniques with a high field MR system. The objective of this study was to investigate an improved contrast using a DIR sequence for effusion imaging in knees with a dedicated 8-channel SENSE knee coil at a 3T MRI.

Materials and Methods

Simulations: The DIR sequence consists of two inversion pulses with two inversion times preceding a turbo spin echo sequence. The amount of the available z-magnetization Mz presented immediately prior to the 90 degree excitation pulse can be calculated from the Bloch equation. The first inversion time, TI1, is the time interval from the first to the second 180 degree inversion pulse. The second inversion time, TI2, is the time interval from the second 180 degree inversion pulse to the 90 degree excitation pulse. In order to calculate appropriate time intervals of TI1 and TI2, knowledge of the expected T1 values of the effusion fluids is required. In the simulation, we adjusted the TI1 and TI2 values to show the signal variations with keeping TR, TE, and τ constant value that was equal to the half of the echo spacing. In the effusion imaging, we were focused to suppress signals from the water fluid and fats and to enhance signals from other fluids(1)**.**

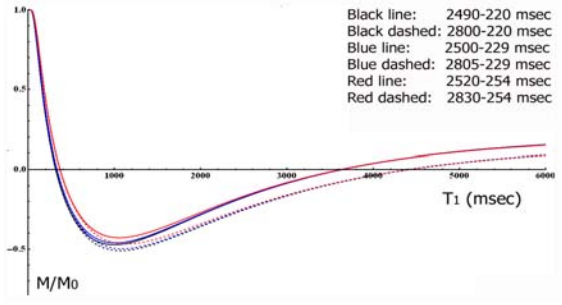
Effusion Imaging in Human Knee: The study protocol was applied on 5 patients and was approved by the local ethics committee and informed consents were obtained from patients. This study was performed on a 3 T whole-body MR scanner (Philips Achieva, Philips Medical Systems, Best, The Netherlands) using a dedicated eight-channel phased-array sensitivity-encoding (SENSE) knee coil. Two-dimensional DIR turbo spin-echo sequence was optimized for imaging in knee. Inversion timings were adjusted by changing the TI1 and TI2 values. The excitation radiofrequency pulse was preceded by a fat saturation pulse and an inferiorly placed saturation slab to minimize flow artifacts. Reconstruction was performed in magnitude mode. In addition to the DIR scan, a proton density (or intermediate)-weighted transverse images with suppression of fat signals and post-enhanced T1-weighted transverse images were acquired. First, we compared effusion signals with different inversion delay times. Second, DIR images run with the optimized two inversion times were compared with images obtained by fat-saturated proton-density weighted imaging sequence. Finally, DIR images were compared with images obtained with contrast-enhanced fat-saturated T1-weighted images. The scan time is 2 minutes 20 sec for each DIR sequences.

Results

Simulation: The timing to enhance signals from other fluid components was found to be TI1=2800msec and TI2=220msec for suppressing both the water fluid and the fat. Figure 1 shows the theoretical magnitude of the available magnetization Mz versus T1 values for values of TI1 and TI2 appropriate to null fluids and fats with being given TR, TE, and τ. The curves show the expected nulls at T1 values. These curves confirmed the validity of the graphical estimates of the inversion times.

*Effusion Imaging in Human Knee***:** Figure 2 shows selective DIR transverse images with different double inversion timings obtained from a patient with effusion legions. Fluids in effusion area are suppressed in the DIR images.

Fig1. Simulation result



Discussions

In this study, the improved contrast on the effusion lesions in knee is presented with the DIR sequence. Fluid signals which are relatively long T1 relaxation time can be selectively suppressed using proper inversion times. The clinical potential of the DIR sequence on effusion imaging can be immense in applications of MSK MR imaging. Currently, we have investigating the DIR sequence in patients with several pathological diseases in MSK areas. The DIR sequence may offer a method to segment synovium fluid from the water fluid in the effusion legion (5). The identification of a joint effusion with a marked suppression in a certain inversion time should thus prompt the interpreting radiologist to search for additional signs of an unsuspected inflammatory arthritis including synovitis and erosions.

In conclusion, we demonstrated improvements of imaging contrasts to differentiate fluid components on effusion legions in human knee. High-field MR imaging at 3T with the SENSE technique allows us the establishment of clinically routine protocol less than 5 minutes. The DIR sequence may be used to obtain synovial thickening without using contrast materials.

Acknowledges We thank Dr. Chang-Woo Ryu for valuable comments. This research was supported by the Program of Kyung Hee University for the Young Researcher of Medical Science in 2008 (20081229).

References

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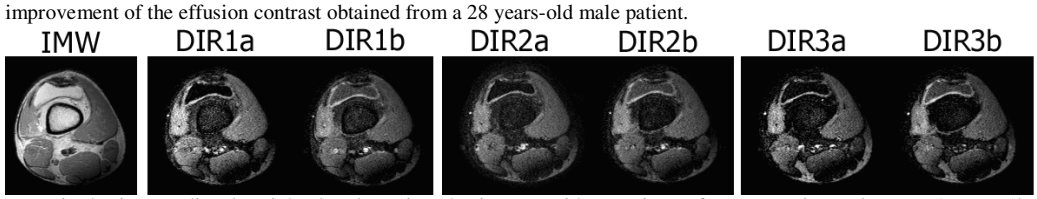
Fig2. DIR images with different double inversion times and without using a fat suppression pulse to demonstrate improvement of the effusion contrast obtained from a 28 years-old male patient.



IMW is the intermediated weighted turbo spin-echo images without using a fat suppression pulse. DIR1a, DIR1b, DIR2a, DIR2b, DIR3a, and DIR3b are images with the TI2-TI1 of 220-2490, 220-2800, 229-2500, 229-2805, 254-2520, and 254-2830 msec, respectively.