GAGCEST imaging of Knee at 7T a Reproducibility Study

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Introduction

Osteoarthritis (OA) is one of the most common forms of arthritis affecting millions of people around the world. It is believed that the initiation of OA is predominantly due to the loss of proteoglycans from the cartilage. Glycosaminoglycan (GAG) are side chains attached to protein core of Proteoglycans. Multiple studies have reported Chemical Exchange Saturation Transfer (CEST) imaging using Glycosaminoglycan (GAG) as the endogenous agent at 7T in the Knee (1-2). In the current work we have looked at GAGCEST imaging of Knee cartilage at 7T in controls and performed a reproducibility study.

Methods

The GAGCEST sequence used in this study was developed using 3D segmented SPGR sequence. The CEST prep consisted of a series of 5 Gaussian RF pulses, each pulse having a duration of 80ms and B1=2uT. Gradients were played between the RF pulses to suppress any residual transverse magnetization (Figure 1). B0 correction was performed using the WASSR (3) technique, using the same sequence as CEST but with a lower RF saturation power B1=0.08uT. For the reproducibility study, 2 male volunteers aged between 30 to 35 were scanned twice each.

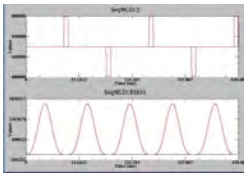

Figure 1: CEST Prep

CEST imaging was performed on volunteers with IRB approval and informed consent. All the scans were done on the Discovery MR 950w scanner (GE Healthcare) using a 28-channel T/R knee coil (QED, Mayfield, OH). The protocol consisted of a 3-plane localizer, 3D SPGR IDEAL (3-point Dixon), WASSR for B0 correction and the CEST scan. CEST Magnetization Transfer Ratio (MTR) analysis was done the patella and trochlea. The IDEAL, WASSR and CEST scans were done in the sagittal plane covering these two compartments. A shim volume of 8mm^3 was placed covering the knee cartilage for the 3D SPGR IDEAL. Linear shimming was applied for the scan. The shim setting from the IDEAL scan was used for the WASSR and CEST scans. The acquisition parameters for 3D SPGR IDEAL sequence were: FOV 140*140mm^2; Nx*Ny = 256*128; slice thickness 4mm; no of slices 10; TR 5ms; scan time 1:00 minute. The acquisition parameters for WASSR sequence were: FOV 140*140mm^2; Nx*Ny = 256*128; slice thickness 4mm; no of slices 10; TR 6ms; Frequency Range for saturation -2 PPM to +2 PPM in increments of 0.1 PPM; ARC (self accelerating technique) 2*1; segment length 64; scan time 7:00 minutes. The acquisition parameters for CEST sequence were: FOV 140*140mm^2; Nx*Ny = 256*128; slice thickness 4mm; no of slices 10; TR 6ms; Frequency Range for saturation -3 PPM to +3 PPM in increments of 0.1 PPM; ARC 2*1; segment length 64; scan time 10:00 minutes. One set of images in the CEST scan were acquired by turning off the CEST prep RF pulses for generating the images without saturation.

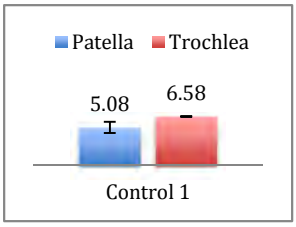

Figure 2: Control 1 Average MTR_{asym}

MTR analysis was done using Matlab with custom software developed inhouse. MTR analysis involved the following steps: manual segmentation of the cartilage on the IDEAL water only images, spline interpolation of the WASSR data to 0.01 resolution, generating B0 field map using WASSR data, spline interpolation of the CEST data to 0.01 resolution, correction of CEST data for B0 inhomogeneity, and finally generation of the z-spectrum MTR plots and CEST maps. The resonance frequency of GAG is between 0.9 to 1.9 PPM (4), for the MTR plots the MTR_{asym} was integrated from 1 to 1.5 PPM. MTR_{asym} is computed as follows: MTR_{asym} (Δω) = (S(-Δω) - S(Δω))/S0

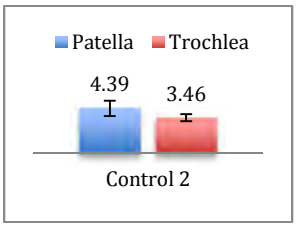

Figure 3: Control 2 Average MTR_{asym}

Results

In control 1, the average MTR_{asym} over the two scans was 5.08% and 6.58% in patella and trochlea compartments (Figure 2). In patella compartment the absolute difference between the two scans was 1.52% and in trochlea compartment it was 0.14%. The Maximum MTR_{asym} recorded were 5.84% and 6.65% in the respective compartments. In control 2 the average MTR_{asym} over the two scans was 4.39% and 3.46% in patella and trochlea compartments (Figure 3). In patella compartment the absolute difference between the two scans was 1.52% and in trochlea compartment it was 0.69%. The Maximum MTR_{asym} recorded were 5.15% and 3.8% in the respective compartments.

Discussion/Conclusion

In the trochlea compartment the absolute difference in the MTR_{asym} between the two scans is less than 0.7% across the two controls (Figure 4-5). The absolute difference was higher in the patellar compartment where with a maximum difference of 1.52% (Figure 6-7). The Transmit Gain (TG) between both the scans was identical ruling out differences in B1. The MTR_{asym} measured in the cartilage is in agreement with literature (1-5).

This is the first time some group has looked at scan rescan impact on GAGCEST results. These are preliminary results and we will be extending this study to look at more controls and also looking at patients with different levels of OA.

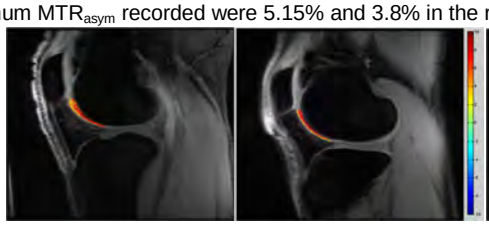

Figure 4: MTR_{asym} maps in trochlea compartment in control 1 between two scans

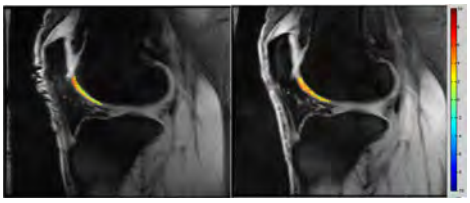

Figure 5: MTR_{asym} maps in trochlea compartment in control 2 between two scans

Figure 7: MTR_{asym} maps in patella compartment in control 1 between two scans

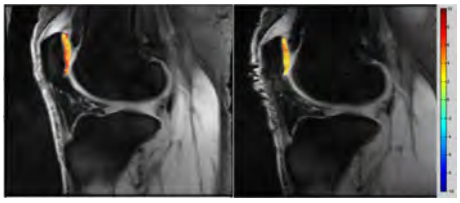

Figure 8: MTR_{asym} maps in patella compartment in control 2 between two scans

References

1) Anup Singh et al, MRM 68:588-594 (2012); 2) B. Schmitt et al, Osteoarthritis and Cartilage 20:5:357-363 (2012); 3) Mina Kim et al, MRM 61:6: 1441-1450; 4) Wen Ling et al, PNAS 105:7:2266-2270; 5) Jae-Seung Lee et al, Scientific REPORTS 3: 1701.