Examining the Accuracy of Dual Echo $B_0$ Map for Field Inhomogeneity Correction with the Application of gagCEST in Articular Cartilage at 3T

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INTRODUCTION:
Chemical Exchange Saturation Transfer (CEST) is a molecular MRI methodology which can detect the presence of endogenous macromolecules [1]. Recently, gagCEST was developed to quantitatively assess glycosaminoglycans (GAGs) that may indicate the presence of early cartilage degeneration [2]. This technique is based on asymmetry in the CEST spectrum around 1ppm where OH protons resonate. Because the OH resonance frequency is similar to that of water, it is very sensitive to $B_0$ field inhomogeneity [3], which can result in widely differing results with small shifts in the CEST spectrum. Conventionally, an entire CEST spectrum with high spectral resolution is sampled to match the actual minimum signal with the water frequency. This will give rise to a long acquisition time. To deal with this problem, a $B_0$ map is used to find the field inhomogeneity [4]. The purpose of this abstract is to compare the $B_0$ inhomogeneity determined by both the minimum point in CEST spectrum and $B_0$ map and their effects on gagCEST results.

MATERIALS AND METHODS:

Image Acquisition
Ten clinical knee patients (42±8 years) were scanned in a 3T MRI system (Achieva, Philips) using an 8-channel knee coil. A multi-shot turbo spin echo sequence with fat suppression was employed to achieve high resolution proton density weighted images (FOV=160x160mm², matrix size=256x256, slice thickness=4mm, TR/TE=1000/7ms, TSE factor=12, NSA=2). The pre-saturation pulse power was around 1.2µT with a total duration of 460ms. The CEST spectrum was acquired with 33 offsets from 4ppm to -4ppm in intervals of 0.25ppm. A $S_0$ image without pre-saturation pulse was acquired. Five dual echo $B_0$ maps with $\Delta$TE of 1ms, 2ms, 4ms, 8ms, 10ms (the largest $\Delta$TE available in the scanner) were also acquired.

Image Analysis
The CEST spectra were fitted with a 12th order polynomial through a least-squares approach, using the IDL programming environment (ITT, CO). Based on the generated coefficients, the CEST spectra were interpolated into 16001 points with a least-squares approach, using the IDL programming environment (ITT, CO). The magnetic transfer ratio asymmetry ($MTR_{ asym}$) was defined by $MTR_{ asym}(1.0ppm)=S_{sat}(-1.0ppm)/S_0=S_{sat}(+1.0ppm)/S_0$.

RESULTS AND DISCUSSION:
One patient with tricompartmental cartilage fibrillation (red arrow) and an abundance of hematopoietic marrow (white arrow) is shown (Fig. 1, Right knee). Fig. 2 examines the correspondence of the $B_0$ frequency shift map and the five dual echo $B_0$ maps. Fig. 2a shows the $B_0$ frequency shift map calculated from the minimum value of CEST spectra. For the gagCEST study, only the cartilage area (black arrow) is examined. The spectra were shifted using both the $B_0$ frequency shift map and the five $B_0$ maps to observe their effects on gagCEST analysis. The magnetic transfer ratio asymmetry ($MTR_{ asym}$) can be seen as artifacts because of low signals and thus noisy CEST spectra resulting in errors in detecting minimum values. $B_0$ maps with $\Delta$TE=1ms, 2ms, 4ms, 8ms, 10ms are shown in Fig. 2b, c, d, e, f respectively. As $\Delta$TE increases, the frequency shifts in cartilage area exhibit a closer pattern to the $B_0$ frequency shift map. The $B_0$ frequency shift map increases, the frequency shifts in the cartilage region (black arrow) exhibit a closer pattern to $B_0$ frequency shift map.

CONCLUSIONS:
In this study we demonstrated that with proper $\Delta$TE $B_0$ maps we are able to make reliable $B_0$ inhomogeneity corrections to CEST spectra. This can be used to calculate more accurate $MTR_{ asym}$ value in gagCEST experiments which are very sensitive to CEST spectra centering. With a better $B_0$ map acquisition, an entire CEST spectrum is not necessary and total scan time can be reduced which enables gagCEST to be more feasible for clinical use.

REFERENCES: