Evaluation of MT Asymmetry under Spin-Lock condition in Rabbit Disc and Bovine Cartilage
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Target Audience: Musculoskeletal radiologists/researchers.

Purpose: To evaluate MT$_{asym}$ (magnetic transfer asymmetry) in cartilaginous tissue, e.g. intervertebral disc, articular cartilage, as a function of RF amplitude/RF duration in a 9.4T scanner.

Theory: gagCEST (Evaluate glycosaminoglycan via Chemical Exchange Saturation Transfer) has been applied in cartilaginous tissue. Its successful application clinically requires accurate knowledge of MT$_{asym}$ in such tissue of interest. Recently, CEST has been conducted through spin-lock (SL) T$_1$ρ technique. Its MT$_{asym}$ can also be accessed in PTR (proton transfer ratio):

$$PTR(\delta) = \frac{M(-\delta) - M(\delta)}{M(\delta)}$$

where $M(\delta)$ is the bulk magnetization when irradiated at chemical shift $\delta$.

Since MT$_{asym}$ originates from interaction with short correlation time, it usually can be accessed in much wider spectral width. In this study, a spectral width of ±30ppm has been evaluated for both disc and cartilage. Since molecular integrity plays essential role in MT$_{asym}$, evaluation of individual component separately will not help address such problem.

Method: Rabbit disc (n=3) and bovine articular cartilage (n=2) were scanned on a 9.4 T Varian scanner equipped with Agilent VNMRJ 3.2 software. The SL approach with Various $\omega_1$/duration pairs (Fig.1a,1b) were applied on rabbit disc and bovine articular cartilage. The saturation offsets varies from -30 ppm to 30ppm with a step of 0.5 ppm. Thk = 1mm, TR/TE = 3000ms/7ms.

Results & Discussion:
Several pair ($\omega_1$/duration) of commonly applied CEST parameters have been tested on both rabbit disc and bovine cartilage. In disc, the most visual MT$_{asym}$ appears at 0.47μT/2000ms. As power increases and duration shortens, MT$_{asym}$ stabilizes at less than -1% (Fig.1a, blue line: 4.22μT/300ms), and it stretch beyond 30ppm. For cartilage, MT$_{asym}$ does not appear at 0.47μT/2000ms. At 3.75μT/300ms, it also stabilize at less than -1% around 30ppm (Fig.1b, blue line). The slight different behavior may come from the different collagen type I (predominantly in nulcous pulposus of disc) and type II (predominantly in cartilage). Our results of cartilage is consistent with the previous report from Lee JS et al, which is also ~1% with RF amplitude of ~2μT at 11.2T machine.

Conclusion: The MT$_{asym}$ effect in both cartilage and disc tends to be stabilized at less than 1% in both bovine cartilage and rabbit disc as RF amplitude reaches at ~4μT. Whether or not he progression of disease has any effect on MT$_{asym}$ should be further evaluated.

Reference: