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[2]. Recently, CEST has been conduct through spin-lock (SL) $T_{1\rho}$ technique[3]. Its MT_{asym} can also be accessed in PTR (proton transfer ratio):

$$PTR(\delta) = \frac{M(-\delta)-M(\delta)}{M(\infty)} \quad [1],$$

where is M(δ) is the bulk magnetization when irradiated at chemical shift δ.

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 be 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 ω_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.

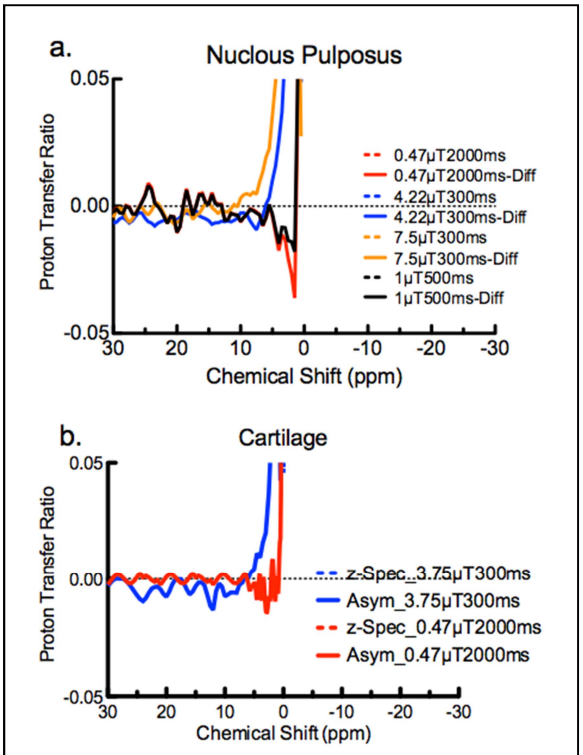

Fig.1 (a) PTR of nucleus pulposus in rabbit disc; (b) PTR of bovine cartilage. All the experiments were conducted at 35°C.

Results & Discussion:

Several pair (ω_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: 4.22uT/300ms), and it stretch beyond 30ppm. For cartilage, MTaym does not appears at 0.47μT/2000ms. At 3.75uT/300ms, it also stabilize at less than -1% arround 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 ~2uT at 11.2T machine[4].

Conclusion: The MTasym 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 ~4uT. Whether or not he progression of disease has any effect on MTasym should be further evaluated.

Reference:

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3.Jin T, Wang P, Zong X, & Kim S-G, *NeuroImage* 2012 (59):1218-1227.
3.Lee JS, Regatte RR, Jerschow A, JMR 2012(215): 56-63