# Evaluation of the applicability of iGagCESL and gagCEST on both cartilage and disc at 3T

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***Target Audience***: MSK researchers / clinicians; cartilage / spine disc researchers; Researchers interested in CEST / $T_{1\rho}$ / NMR relaxation.

***Purpose***: Evaluation the applicability of iGagCESL[3] / gagCESL[3] / gagCEST[1] on 3T clinical platform (GAG stands for Glycosaminoglycan; CESL stands for CEST by spin-lock method[2]; iGagCESL differs from gagCESL by additional inversion pulse prior CESL preparation[2,3]).

***Methods***: The SI (signal intensity) and MTR (magnetic transfer ratio) of iGagCESL / gagCESL / gagCEST were compared by 3-pool Bloch simulation.

The MTR and SNR (signal-to-noise ratio) of both iGagCESL and gagCEST were extracted from in vivo human patellar cartilage and intervertebral disc at 3T.

Both results are listed in the Table. SI is reported as the ratio between [signal@-1ppm+signal@+1ppm]/2 and signal @-300ppm (ref). MTR is defined as [M(-1 ppm)-M(+1 ppm)] / M(-300ppm).

Both the simulation and measurement parameters were chosen according to published results[3,4].

| | Cartilage | | Disc | |
|---|---|---|---|---|
| Simulation | | | | |
| iGagCESL MTR /% | 0.99 | | 4.6 | |
| gagCESL MTR /% | 0.76 | | 4.1 | |
| gagCEST MTR /% | 1.2 | | 5.9 | |
| | | | | |
| iGagCESL SI /% | 11.1 | | 17.5 | |
| gagCESL SI /% | 6.9 | | 14.0 | |
| gagCEST SI /% | 1.2 | | 1.3 | |
| Measurement (averages = 10, TR/TE = 2000ms/0.5ms) | | | | |
| iGagCESL MTR /% | 1.1±0.2 | n=3 | 5.2±0.7 | n=3 |
| gagCEST MTR /% | 1.4±0.6 | n=3 | 5.6±1.5 | n=3 |
| | | | | |
| iGagCESL SNR | 26.5±2.3 | n=3 | 18.5±2.9 | n=3 |
| gagCEST SNR | 2.4±1.0 | n=3 | 1.9±0.8 | n=3 |

Human data was acquired on 3T trio Siemens scanner. Both iGagCESL and gagCEST data were acquired on healthy human subjects (n = 3) for both intervertebral disc and patellar cartilage. Radial GRE readout was used.

***Results***: Both simulation and 3T measurement data are shown in the Table. In simulation, all the three methods demonstrate similar MTR, ~1% for cartilage and ~4~5% for disc. However, large difference exists for SI. gagCEST only preserves ~1% of original SI before saturation while iGagCESL preserves over 10% of SI before spin-lock. The experiment data of both cartilage and intervertebral disc confirms the simulation data in the Table. The image before processing was shown in Fig.1.

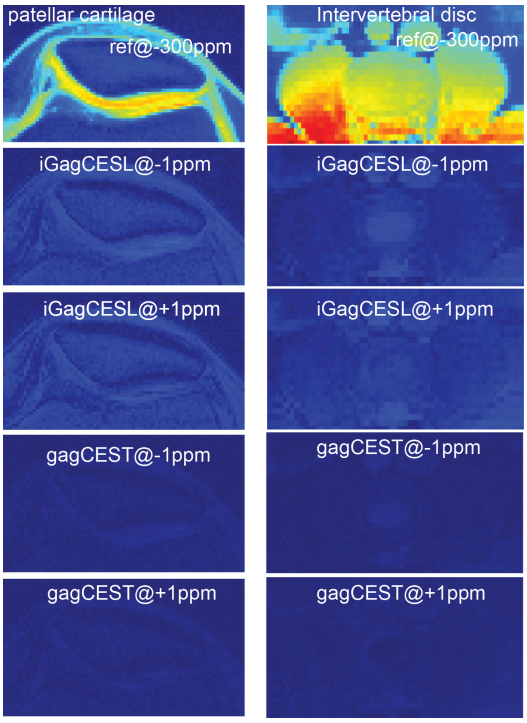


Fig.1 Comparison of SI of raw image between iGagCESL and gagCEST.

***Discussion***: $k_{GAG}$ falls into intermediate exchange regime at 3T, which designates the low MTR of both iGagCESL and gagCEST. However, the much higher SI/SNR by iGagCESL means that reliable iGagCESL contrast can be readily extracted from 3T images with reasonably short scanning time (3~5 mins). The reasons of high SNR are: i) iGagCESL utilize high magnetic transfer rate due to intermediate exchange efficiently; ii) spin-lock method can recover more magnetization back to z-axis compared to the crusher gradient used in gagCEST; iii) the removal non-zero steady state magnetization by additional on/off inversion pulse further increase SI/SNR and MTR.

***Conclusion***: Compared to original gagCEST, iGagCESL preserves over 10 times higher of SI/SNR, and but produce similar MTR ratio at 3T scanners. The additional advantage of iGagCESL is that pure chemical exchange specific $R_{1\rho,asym}$ can be extracted and is linearly proportional to GAG content, and has minimal influence from collagen content, $T_1/T_2$ value of water. Hence, iGagCESL is superior than gagCEST for in vivo quantitative imaging of proteoglycan matrix at 3T scanners.

***References***: 1. Ling W et al, PNAS 2008(105):2266-2270. 2. Jin T et al, *MRM.* 2012(68):1056-1064. 3. Ling W et al. proceedings of ISMRM 2014 (p3324) 4. Stanisz GJ et al, *MRM.* 2005(54):507-512.