Biochemical MRI with gagCEST (Glycosaminoglycan Chemical Exchange Saturation Transfer Imaging) of finger joint cartilage in rheumatoid arthritis

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Target Audience: People interested in biochemical imaging of cartilage and in CEST imaging

Purpose: MRI plays an increasing role in the diagnosis and treatment monitoring of arthritis. Next to synovitis, erosions and osteoedema, cartilage composition is of increasing importance in the research of arthritis. gagCEST has recently been demonstrated to be sensitive to alterations in the biochemical composition of cartilage in the knee in patients following cartilage repair surgery as well as in vertebral disks[1,2]. The purpose of our study was to test the feasibility of gagCEST imaging in finger joint cartilage in healthy volunteers and patients with rheumatoid arthritis (RA).

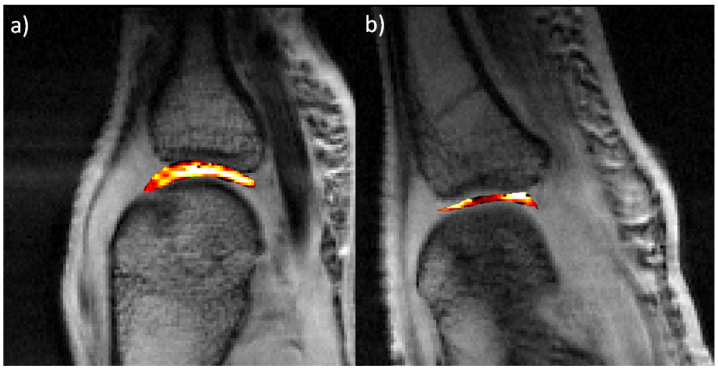

Fig. 1. Gradient echo image used as anatomical reference with ST ROI evaluated from CEST imaging of (a) a healthy volunteer and (b) a patient with arthritis.

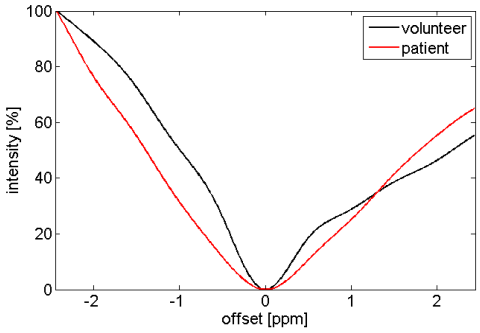

Fig. 2. CEST curves of one volunteer and one patient. The CEST effect is decreased in the patient compared to the volunteer.

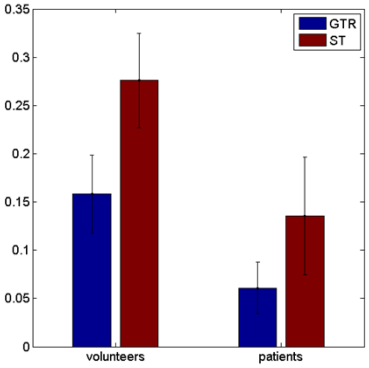

Fig. 4. GTR (blue) and ST (red) for both volunteers and patients.

Methods: Six volunteers (age 33 ± 12 years) and four patients (age 58 ± 6 years) were investigated at a 3T MR scanner (Siemens Magnetom Trio) with two loop coils (4 cm diameter), one fixed on the palmar, the other on the dorsal side of the MPC2. For gagCEST imaging, CEST effects were prepared by a train of Gaussian RF pulses followed by signal readout with a 3D RF spoiled GRE sequence. The saturation parameters were: B1-CWAE (continuous-wave amplitude equivalent) = 0.6 µT, pulse duration PD = 99 ms, interpulse delay IPD = 100 ms, number of CEST pulses = 8. The GRE imaging parameters were: FOV = 35mm x 35 mm, slice thickness = 2 mm, TR/TE = 11 ms /4.07 ms, spatial resolution = 0.3 mm x 0.3 mm, flip angle = 12°, acquisition duration (min:sec) = 17:54. The CEST curves were calculated for each pixel and were shifted for the water resonance to appear at 0 ppm of the Z-Spectrum. The MTR_{asym} curves were determined. Afterwards, a region of interest (ROI) was placed at the area of the cartilage and the CEST effect of this region was calculated by determination of the glycosaminoglycan transfer ratio (GTR = MTR_{asym}(1.3 ppm) / ((1-Average(MTR_{asym}(0 ppm – 2.35 ppm)) / Average(MTR_{asym}(0 ppm – 2.35 ppm)) and saturation transfer (ST = (CEST(+1.3 ppm) – CEST(-1.3 ppm))/CEST(+1.3 ppm)). Joint space width (JSW) was determined as a conventional measure of cartilage integrity in RA.

Results: Fig. 1 shows the anatomical reference with ST ROIs exemplary for one volunteer and one patient. Visually, lower ST values can be recognized in the patient compared to volunteers. Fig. 2 shows cartilage CEST curves exemplary for one volunteer and one patient. A decrease of CEST effects is visible between 1.2 and 2.2 ppm, which corresponds coarsely to the resonance frequency of hydroxyl protons of glycosaminoglycans. Fig. 3 shows the mean and standard deviation of ST and GTR for the volunteer and patient cohort. Lower values were obtained in patients compared to volunteers. There was no significant difference in JSW between healthy volunteers and RA patients.

Discussion: CEST imaging revealed differences in the finger cartilage of RA patients compared with healthy controls in the absence of cartilage thinning indicating biochemical alterations. As shown by Schmitt et al.[1], diseased cartilage presents with decreased CEST effect in the spectral range of glycosaminoglycan resonances, possibly representing a depletion of glycosaminoglycans.

Conclusion: Biochemical MRI of cartilage composition with gagCEST imaging is feasible at finger joints in RA. gagCEST may be a possible tool in the research of cartilage damage in RA.

References

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