

Cartilage evaluation by gagCEST at 3 Tesla after arthroscopic partial meniscectomy

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Target Audience: Musculoskeletal radiologists and physicists interested in CEST imaging.

Purpose: Arthroscopic partial meniscectomy (PMA) is one of the most common orthopedic procedures for patients with degenerative meniscal tear. Nevertheless, rigorous evidence of its efficacy is still lacking¹. It has been shown that removal of the entire meniscus can lead to the development of osteoarthritis (OA) in a high proportion of cases in a long term². Advances in arthroscopic surgery have enabled to minimize the portion of damaged meniscus to be removed during partial meniscectomy, or even the preservation of the damaged meniscus by means of meniscal repair. However, the effect on articular cartilage in the early postoperative period after PMA has not been investigated. 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 surgery^{3,4}. This study used gagCEST MRI for early postoperative quantitative evaluation of biochemical changes in articular cartilage adjacent to operated meniscus after PMA.

Methods: Thirteen patients (age 38±9 years, mean ±SD) underwent arthroscopic partial medial meniscectomy and were divided into two groups. The first group (I), consisted of five patients who had minor or intermediate removal of lateral meniscus, and second group (II) with eight patients who had complete removal of lateral meniscus. Institutional Review Board (IRB) approval as well as written informed consent from patients were obtained prior the measurements. Imaging was performed on a 3T MRI scanner using 8-channel Tx/Rx knee coil (Siemens Medical Solutions, Erlangen, Germany). For gagCEST imaging, CEST effects were induced 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 μ T, pulse duration PD = 99 ms, interpulse delay IPD = 100 ms, number of CEST pulses = 8. The GRE imaging parameters were: FOV = 130 x 160 mm², slice thickness = 3.3 mm, TR/TE = 927ms/3.3ms, spatial resolution = 1.6 mm x 1.6 mm, flip angle = 11°, acquisition duration (min:sec) = 10:23. The CEST curves were calculated for each pixel and were shifted for the water resonance to appear at 0 ppm of the Z-spectrum. MTR_{asym}(δ) was calculated as MTR(+ δ)-MTR(- δ) integrated over the offset range δ from 0.5 to 2 ppm, which corresponds to the resonance frequencies of exchangeable hydroxyl protons of glycosaminoglycans. Afterwards, a region of interests (ROI) were placed at the area of the femoral cartilage adjacent to partially removed meniscus (ROI1) and at the healthy femoral cartilage (ROI2). A Student's paired two-tailed test was performed for statistical analysis (IBM SPSS Statistics 21).

Results: gagCEST showed nonuniform regional distribution in the weight-bearing zone in patients with PMA (Fig.1). Measured values of gagCEST effect showed a significant difference between two different ROIs in all patients (Fig.2). For the two groups, gagCEST effect values (mean±SD [a.u.]) were as follows: group I: ROI1= 4.5±1.1 and ROI2= 9.0±1.3 (CI = 95%, p=0.044). For the group II: ROI1=4.7± 1.8 and ROI2= 10.3±2.1 (CI=95%, p=0.007). Difference in gagCEST effects between group I and group II was not significant.

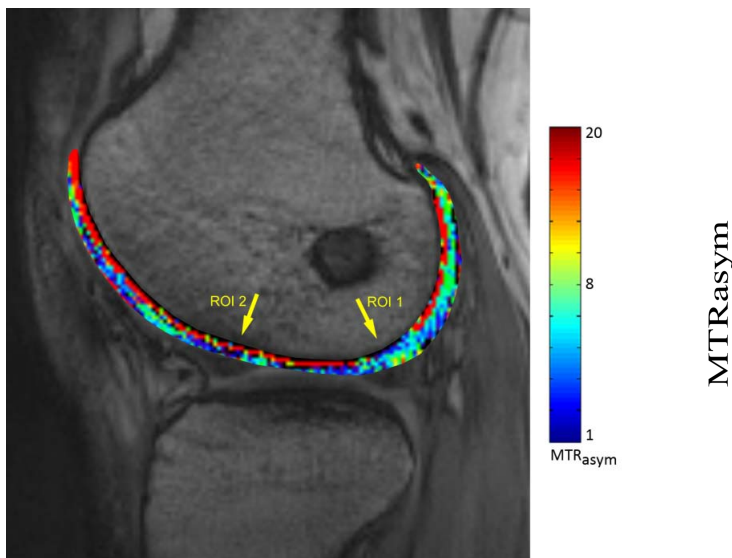


Fig.1.: gagCEST map overlaid with morphological image in patient after PMA. Yellow arrows show cartilage gagCEST intensity in PMA region (ROI1) and normal hyaline cartilage region (ROI2).

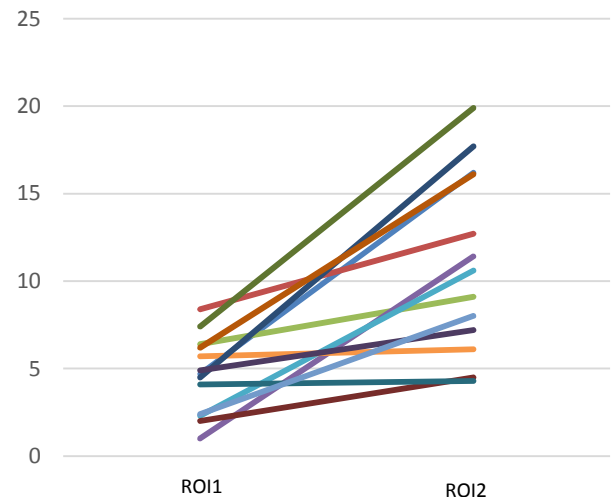


Fig.2.: gagCEST effect comparison between ROI1 and ROI2 for each individual patient included into this study.

Discussion: Our results showed differences in gagCEST effects in articular cartilage after PMA. We observed lower gagCEST values in cartilage adjacent to the operated meniscus than in the healthy cartilage within the same subject. This loss in GAG content could be biomarker of early cartilage degeneration.

Conclusion: Biochemical MRI of cartilage using gagCEST at 3 Tesla has a great potential as a possible tool in the observation and investigation of early signs of osteoarthritis. The efficacy of PMA could be better understood by using gagCEST at 3 Tesla in clinical practice.

References: [1] Hoser et al. J Bone Joint Surg 2001; 83-B:513-6; [2] Sanchis et al. Arthroscopy 1998; 4:206-210 [3] Kogan et al. Curr Radio Rep (2013) 1:102-114; [4] Schmitt et al. Radiology. 2011;260(1):257-264