# Magnetization Transfer Contrast and T2 relaxation in the evaluation of cartilage repair tissue at 3T MRI

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**Introduction:** Recent studies show high potential of biochemical MR imaging with the aim to directly visualize the constitution of cartilage repair tissue(1). Here T1 mapping using delayed Gadolinium enhanced MRI of cartilage (dGEMRIC) and T2 mapping are the most often described procedures (2,3). Concerning T2 mapping special interest is given to a visible zonal variation seen in healthy cartilage with an increase in T2 values from deep to superficial, possibly indicating hyaline cartilage composition. Besides T1 and T2 mapping however various other techniques are showing their potential. Magnetization Transfer Contrast (MTC) has been utilized in neuroradiology but has been rarely used in musculoskeletal MRI(4,5). Nevertheless it could have its potential as a relatively fast technique covering a whole joint in reasonable scan time. Within the present study, MTC is demonstrated using magnetization transfer sensitized steady-state free precession (MT-SSFP) (6).
Cartilage repair procedures within the knee as a widely used treatment of chondral defects needs to be assessed in its post-operative follow-up. Among others, techniques as microfracture (MFX) and matrix associated autologous cartilage transplantation (MACT) show good clinical results. As both cartilage repair procedures are used in the treatment of single full thickness cartilage lesions, both patient groups post operatively show areas of cartilage repair and areas of intact hyaline cartilage. Thus in the evaluation of emerging techniques in the visualization of articular cartilage and its ultrastructure, these patients may help to highlight the potential of the techniques within healthy and affected articular cartilage.
The purpose of this initial study was to show the potential of MTC imaging in the assessment of articular cartilage and compare it to widely used T2 mapping. Furthermore to evaluate deep and superficial cartilage aspects to elucidate a possible zonal difference.

**Material and Methods:** Thirty-four patients were enrolled in this study. Mean age 36.6±13.5 years, 14 female, 20 male were treated for single symptomatic full thickness cartilage defect on femoral condyle. 17 patients were treated with MFX; MRI was performed 30.2 ± 18.2 months post-operatively. 17 other patients were treated with MACT; MRI was performed 36.6 ± 19.6 months post-operatively. In terms of follow-up patients were divided into a shorter follow-up (<31 months) and a longer follow-up (>42 months). MRI was performed on a 3 Tesla MR scanner (Magnetom Trio, Siemens, Erlangen, Germany) using a dedicated eight channel knee coil. MT-weighted images ($MT_{sat}$ ) were acquired with TE/TR=1.8/4.3ms, whereas MT-free images ($MT_{none}$ ) based on TE/TR=2.8/6.4ms. 120 slices were acquired within 6:11 ($MT_{sat}$) and 6:07 ($MT_{none}$) minutes with a FoV 150x200mm, Pixel Matrix 240x320, Slice Thickness 1mm and the signal (S) was evaluated based on the MT ratio ($MTR= (MT_{none} - MT_{sat}) / MT_{none}$) expressed in percental units [%]. The flip angle and the pixel bandwidth was fixed to 35° and 580Hz, respectively. T2 relaxation times were obtained from T2 maps reconstructed using a sagittal multi-echo spin echo (SE) acquisition with a repetition time (TR) of 1.650 s and six echo times (TE) of 12.9 ms, 25.8 ms, 38.7 ms, 51.6 ms, 65.5 ms and 77.4ms. Field of view (FoV) was 200x200 mm, pixel matrix 320x320 and voxel size 0.63x0.63x1mm. The bandwith was 240 Hz/pixel, the number of averages was 1; 16 slices, total acquisition time was 8:46 minutes. T2 maps obtained by a pixel wise, mono-exponential non-negative least squares (NNLS) fit analysis. Regions of interest (ROI) analysis were manually done for image evaluation. ROIs were drawn by an experienced senior musculoskeletal radiologist in consensus with an orthopedic surgeon with special interest in musculoskeletal MR imaging. An area of cartilage repair and an area of healthy seen control cartilage were identified using the morphological images as well as the surgical reports. The ROIs had to cover the full thickness of cartilage repair / control cartilage. For further evaluation on the zonal variation, the ROIs were divided into two equal sized deep and superficial regions. Statistical evaluation was done by analyses of variance using a three way ANOVA with random factor.

**Results:** Global mean MTR for control cartilage sites was 34.3 ± 11.2 within healthy seen cartilage sites of MFX patients and 37.1 ± 9.5 within healthy seen cartilage sites of MACT patients. Global MTR for all healthy seen control cartilage showed no significant difference. For zonal variation a significant increase could be observed from deep to superficial aspects of healthy control cartilage. Concerning global MTR of cartilage repair tissue all assessed mean values where significantly decreased in both patient groups. MTR of all MFX patients was 21.8 ± 8.1 whereas MTR after MACT was 24.5 ± 9.5. A zonal variation could not be observed within the cartilage repair tissue. In terms of follow-up interval, MTR values were relatively stable after MACT whereas after MFX a further decrease between the shorter and longer follow-up was observed. The further evaluation of T2 relaxation times showed stable values (~ 55ms) and a clear zonal variation (deep ~ 51ms; superficial 58ms) for healthy control cartilage. Concerning cartilage repair tissue mean T2 values showed no decrease in patients after MACT; however a clear decrease in patients after MFX. Zonal variation could be assessed after MACT, but not after MFX.

**Discussion:** MTC evaluation showed to be capable in the differentiation between healthy seen control cartilage and cartilage repair tissue after different cartilage repair procedures. Furthermore it was possible to assess a deep and superficial aspect of articular cartilage and describe an increase in MTR from deep to superficial in healthy cartilage sites. Compared to T2 mapping, MTC showed to be more sensitive in the discrimination between healthy cartilage sites and cartilage repair tissue after MACT, however the differentiation between both cartilage repair tissues was more visible using T2 relaxation.

**References:** 1. Trattnig et al. Invest Radiol 2007;42:442-448. 2. Burstein et al. Magn Reson Med 2001;45(1):36-41. 3. Mosher et al. Semin Musculoskelet Radiol 2004;8(4):355-368. 4. Henkelman et al. NMR Biomed 2001;14(2):57-64. 5. Palmieri et al. Skeletal Radiol 2006;35(12):903-908. 6. Bieri et al. Magn Reson Med 2007; 58

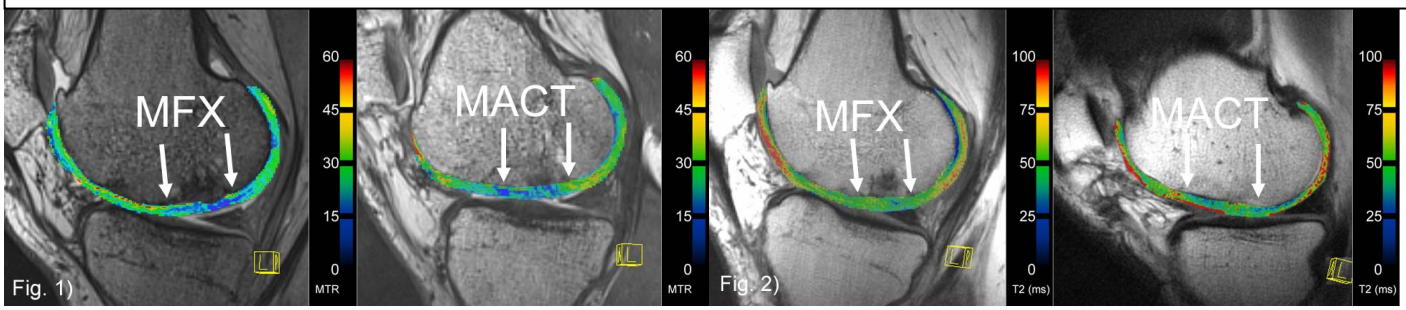


Figure 1) shows an exemplary MT map of one patient after MFX and one patient after MACT. The lower MTR within the area of cartilage repair gets visible (blue). Figure 2) shows T2 maps of the same patients were the areas of cartilage repair are slightly less visible.