Cartilage T2 assessment at 3 Tesla: In vivo differentiation of normal hyaline cartilage and reparative tissue in patients after different cartilage repair procedures

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Introduction: MR imaging of articular cartilage is becoming increasingly important due to the development of new surgical therapies for cartilage repair. A diversity of different techniques needs to be validated particularly as in different clinical follow-up studies the qualitative results vary[1,2]. Recently multiparametric maps are used in MRI to assess biochemical composition of cartilage. In animal studies T_2 mapping helped differentiate hyaline cartilage from fibrocartilage after cartilage repair[5,6].
Therefore In our study two cartilage repair techniques, Microfracture (MFX), a simple one-stage arthroscopic technique showing good clinical results, however the repair tissue has been reported fibrocartilage[1,2] and a new generation of matrix-associated autologous chondrocyte transplantation (MACT), which shows good to excellent clinical results with the formation of hyaline or hyaline-like repair tissue[3,4], were compared by means of MR T_2 mapping to quantify the reconstitution of cartilage .

Material and Methods: Twenty patients who had a single symptomatic cartilage defect on the femoral condyle treated with MACT or microfracture (ten in each group) were enrolled in this study. For MACT Hyalograft®C, a hyaluronan based scaffold (Fidia Advanced Biopolymers, Abano Terme, Italy) was used. Ethical approval for this study was provided by the Medical University of Vienna. Quantitative T_2 mapping was performed in ten patients following MACT and ten matched patients after MFX. Matching was done by means of age (MACT: 41.00 ± 8.93 years; MFX: 40.00 ± 15.42 years) and follow-up interval (MACT: 27.40 ± 13.11 months; MFX: 28.60 ± 15.17 months). For further evaluation, concerning the post-operative time points and in consideration of cartilage alteration over time, we subdivided each patient group in a shorter and longer follow-up group with five patients at a time (Group 1: 12-24months; Group 2: > 24 months). MRI was performed on a 3 Tesla scanner (Magnetom Trio, Siemens, Erlangen, Germany) using a dedicated eight channel knee coil. The T_2 maps were calculated from a multi-echo spin echo (SE) measurement with 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 using a pixel wise, mono-exponential non negative least squares (NNLS) fit analysis to obtain T_2 (SE) maps. Field of view (FoV) was 200x200 mm, pixel matrix 320x320 and voxel size 0.63x0.63x1mm with a total acquisition time of 8:46 minutes.

Results: Quantitative T_2 assessment of native hyaline cartilage showed similar results for all patients. Healthy cartilage areas in patients who underwent MACT showed a mean T_2 value of 55.23 ± 7.63 ms; mean T_2 values for normal cartilage of patients after MFX were 56.70 ± 10.89 ms. The cartilage repair area in all patients after MACT showed slightly higher T_2 values of 58.24 ± 9.99 ms. These differences were not statistically significant ($p \geq 0.05$). After MFX however we found a significant reduced mean T_2 value with 47.07 ± 12.29 ms ($p < 0.05$) for all patients. Subdivided into groups in terms of follow-up time points, MACT patients showed a slight increase between Group 1 and Group 2 (57.42 vs. 59.06 ms), whereas MFX patients showed a clear decrease over time between Group 1 and Group 2 (50.93 vs. 43.20 ms).

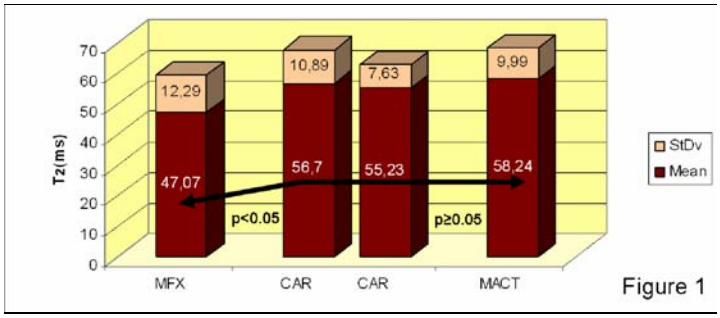

Figure 1

Fig.1: T_2 values (Mean and StDv) of control/healthy cartilage sites (CAR) in the middle. Significant decrease in MFX (left) ($p<0.05$), no change in MACT (right)($p\geq0.05$).
Fig.2: Exemplary patients for MFX (left) and MACT (right): Qualitative T_2 raw images (left sides) and corresponding fused quantitative coloured T_2-maps (right sides).

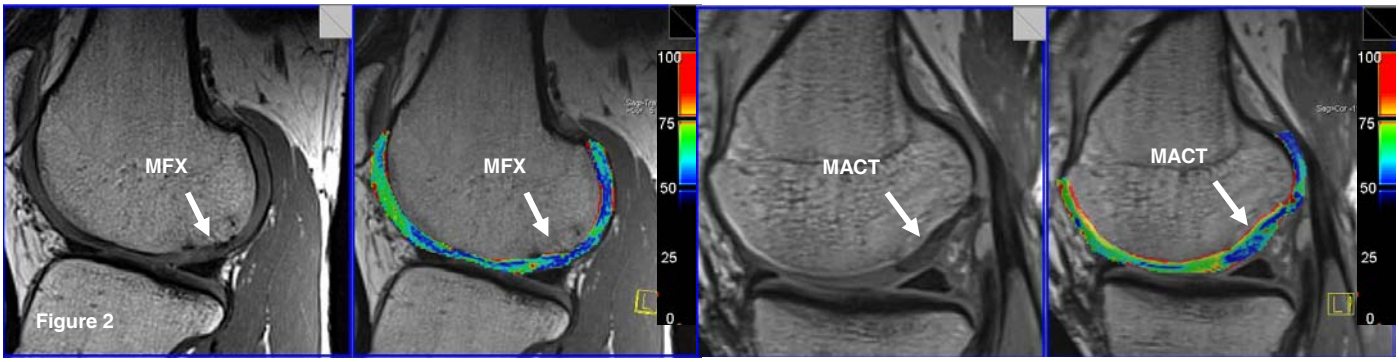

Figure 2

Discussion: Our results demonstrate the feasibility of quantitative T_2 mapping as a follow-up of different cartilage repair techniques. Reported arthroscopically gained histological biopsies in follow up examinations showed more hyaline cartilage after MACT[2,3] and more fibrocartilage after MFX[1,2], this was proven in our study by quantitative T_2-mapping which therefore allows a similar evaluation non-invasively. T_2 relaxation time measurements, in our study, seem to be sensitive to cartilage reorganisation in repair tissue and may allow differentiating between fibrous and hyaline repair tissue. Further investigations on larger patient groups in comparison with clinical outcome will show the possible clinical benefit of these techniques as predictive value.

References:
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