Detection of degenerative cartilage disease: Comparison of high resolution morphological MR and quantitative T2 mapping at 3.0 Tesla

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Osteoarthrithis is a multifactorial and heterogeneous disease associated with a progressive loss of hyaline articular cartilage. Standard MR sequences for cartilage are inconclusive in quantifying early degenerative changes of articular cartilage. Quantitative T2 mapping has been reported as a technique to visualize cartilage collagen concentration and water content. However the role of T2 mapping in different stages of cartilage degeneration is still not well defined [1] .

The purpose of this study was to determine the relationship between morphological changes of cartilage shown on high-resolution MRI and biochemical imaging on T2 mapping in different stages of cartilage degeneration.

Materials and methods

Forty-two patients (13 females and 29 males, age range: 24 to 52 years, mean age: 37.6 years) with clinical symptoms of possible femoral condyle cartilage lesions and clinical signs of internal knee derangement were retrospectively evaluated. In total 32 medial and 13 lateral femoral condyles were analysed. MR imaging was performed on a 3T MR scanner (Magnetom Trio, Siemens Medical Solutions, Erlangen, Germany) with a gradient strength of 40 mT/m, using an eight-channel knee coil (IN vivo, Gainesville, FL, USA).

For morphological MRI evaluation high resolution proton-density (PD) FSE sequence (TR 2400ms; TE 38 ms; flip angle 160°. FoV 120x120mm, pixel matrix 512x512; voxel size 0.2x0.2x2mm; 24 slides; total scan time 6:11 minutes) was used.

The cartilage layer above the posterior horn of the meniscus was analysed on three consecutive slices and the whole cartilage of each femur condyle for the most severe cartilage defect. Cartilage defects were graded according to the ICRS classification system from 0 – 4 [2]

T2 maps were calculated from a multiecho spin-echo measurement (TR 1200 ms; TEs of 13.8 ms, 27.6 ms, 41.4 ms, 55.2 ms, 69 ms and 82.8 ms; FoV 160x160 mm, pixel matrix 384x384, voxel size 0.4x0.4x3.0mm; bandwidth 228 Hz/pixel; 12 slices; total acquisition 4:09 minutes) at the beginning of the MR examination and 40 minutes later. T2 mapping was performed a second time to evaluate possible unloading over time.

For assessment of the quantitative T2 values regions of interest (ROI) analysis was manually performed within the same anatomical site than the morphological evaluation. For zonal evaluation the ROIs were divided in two equal-sized deep and superficial parts. This anatomical site, the articular cartilage above the posterior horn of the meniscus, is seen to display the main area of weight bearing. The ROIs were assessed on three consecutive slices according to the selected slices on PD-FSE sequence. Statistical evaluation was performed using SPSS 16.0 using analysis of variance (ANOVA) as well as the Pearson correlation coefficient.

Differences between the zonal T2 values related to the respective grade of cartilage defect were determined. Correlation coefficients were calculated between morphological cartilage defects in the defined femoral condyle region above the posterior horn of the meniscus and T2 values; furthermore correlation coefficients were assessed regarding to age and T2 values as well as the most severe cartilage lesion of the femoral condyle and T2 values

Results

A significant increase of T2 values with increasing morphological cartilage defect grade was found ($p<0.05$) (table 1). A good correlation between grade of cartilage defect and T2 maps, in particular for the superficial layer of cartilage, was shown, which was further enhanced by unloading of the joint (second T2 mapping) (Pearson: 0.512; $p = 0.004$). No correlation was found between most severe cartilage lesion of the femoral condyle and T2 values and between age and T2 values.

Conclusion

In this ongoing study T2 mapping provided a localized high sensitivity for early degenerative cartilage disease, which is further enhanced by unloading of the knee joint. In particular the difference between healthy cartilage and grade 1 cartilage disease is high when looking at the clear differences between the reported T2 values. This might empower T2 mapping as a promising tool for the detection of early degenerative cartilage disease and for follow-up examinations of cartilage defects in the use of disease modifying drugs.

1 Burstein D, Gray ML; Ostearthritis and Cartilage 2006; 14: 1087-1090

2 Brittberg, M Winalski, CS; J Bone Joint Surg Am, 2003; 85-A Suppl 2: 58-69.

		loaded			unloaded		
ICRS grade		deep	sup	total	deep	sup	total
0	Mean	28,4	42,1	35,2	30,7	46,6	38,6
	Std. Dev.	8,5	9,7	8,4	9,0	8,7	7,8
	N	69	69	69	42	42	42
1	Mean	33,3	49,6	41,4	34,1	54,9	44,5
	Std. Dev.	9,5	10,1	9,0	9,9	9,8	8,8
	N	21	21	21	13	13	13
2	Mean	36,2	52,5	44,4	39,9	61,2	50,5
	Std. Dev.	11,9	12,5	11,6	12,7	11,7	11,0
	N	43	43	43	23	23	23
3	Mean	46,0	66,8	56,4	43,8	70,6	57,2
	Std. Dev.	0,6	2,1	0,7	5,5	8,0	6,8
	N	2	2	2	2	2	2

Table 1: A significant increase of T2 values with increasing morphological cartilage defect grade.

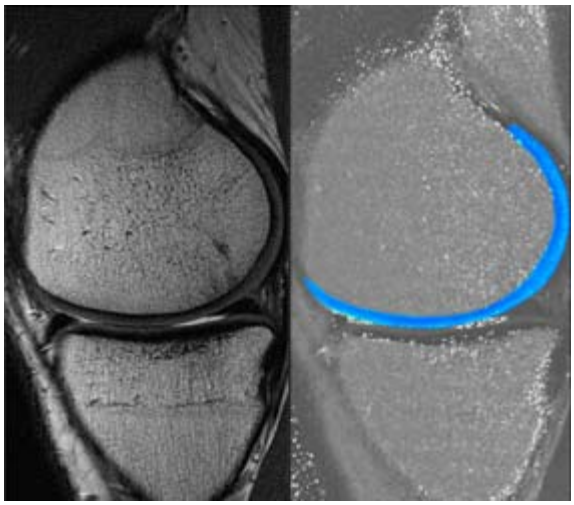

Figure 1: comparison between morphological grade of cartilage defect and T2 map.