Kinematic Biochemical Studies of Cartilage Transplants at 3Tesla

S. Trattnig[1], T. C. Mamisch[2], C. Plank[1], P. Szomolanyi[1,3], S. Quirbach[1], and G. H. Welsch[1]

[1]Department of Radiology, MR Centre - Highfield MR, Vienna, Austria, [2]Orthopedic Surgery Department, Inselspital, Bern, Switzerland, [3]Department of Imaging Methods, Institute of Measurement Science, Slovak Academy of Sciences, Bratislava, Slovakia

Purpose/Introduction: The articular cartilage provides weight-bearing function based on its highly-organized collagen architecture and osmotic pressure via water flux. Autologous chondrocyte implantation (ACI) and matrix-associated ACI (MACT) show a maturation of their matrix over time with development of organized collagen architecture. Thus, depending on the postoperative interval, the collagen disorganization and /or abnormality of water content in cartilage repair tissue may result in different biomechanical properties compared to normal healthy cartilage. Several studies have shown great potential of T2 mapping and Diffusion weighted imaging for the quantitative assessement of cartilage repair tissue (1,2). We have used a flexible knee coil which allows to assess quantitative cartilage data in different positions from 40° flexion to full extension. The aim of this study was to examine clinical feasibility of kinematic MR imaging with respect to changes in T2 and diffusivity values in the femoral cartilage and to assess possible differences in cartilage contact areas and non-contact areas in patients after MACT of the femoral condyle compared to healthy volunteers.

Subjects and Methods: Twenty patients and volunteers (ten in each group) were enrolled in the study. The mean age of the patients and volunteers was matched in both groups for better comparability (volunteers: mean age 28.4 ± 3.6, patients: mean age 28.0 ± 6.5; 6 male, 4 female in each group with the cartilage implant on the medial femoral condyle in 6 and lateral femoral condyle in 4 patients. All patients and volunteers provided informed consent to participate in the study, which was approved by the the Institutional Review Board. MR examinations were performed on a 3T MR unit (Magnetom Tim Trio, Siemens Erlangen, Germany) with a gradient strength of 40mT/m using an flexible eight channel (phased array) knee coil, consisting of two separate components with 4 channels on each side (Noras, Germany). On flexion and extension condition of the knee joint the following MR protocol was performed: The T2 relaxation times were obtained from T2 maps reconstructed using a multi-echo spin-echo technique with a repetition time (TR) of 1650ms. Six echo times (TE) were collected (12.9ms, 25.8ms, 38.7ms, 51.6ms, 65.5ms and 77.4ms). An 20.0 cm x 20.0 cm FOV, 320 x 320 pixels matrix and a slice thickness of 1mm with an in plane resolution of 0.6 mm x 0.6 mm was used. For diffusion weighted imaging a three-dimensional partially balanced steady state gradient echo pulse sequence with diffusion weighting (3D-DW PSIF) was used. In patients two regions of interest (ROI) were defined on two consecutive slices, one covering the cartilage transplant area in the medial femoral condyle. Each ROI was additionally separated into two equal zones covering the superficial and deep portion of cartilage layer. In case of flexion position these two zones showed no contact, however with the knee in the extended position, a broad contact was seen. In volunteers identical ROIs were drawn in the femoral cartilage layer in both positions of the knee joint. Considering the different measurements within each patient, analysis of variance using a three way ANOVA with random factor was performed using SPSS version 15. Differences between cartilage repair regions and normal hyaline cartilage sites in flexed and extended positions with a p-value less than 0.05 were considered as statistically significant.

Results: Table 1 lists the T2 values in MACT zone of the femoral condyle cartilage in healthy cartilage of volunteers in the flexed and extended position of the knee joint. No significant difference of T2 values and diffusivity between non contact and contact cartilage areas in superficial and deep zones could be seen, bottom part of the table 1 lists the T2 values and diffusion quotient in cartilage repair tissue. Mean T2 values are significantly lower in the extended position in the superficial zone with cartilage contact compared to the flexed position without contact (p=0.017) (Fig,1a,b). The diffusivity was significantly lower in the deep zone of the contact cartilage area compared to non contact areas (p=0.024).

Discussion/Conclusion: The present findings indicated clinical feasibility of kinematic biochemical MR imaging.with respect to yielding significant changes of T2 and diffusivity in zones of cartilage contact areas. Decrease of T2 values and diffusivity in cartilage contact zones may reflect efflux of water content or change of collagen fibre orientation produced by position dependent contact of two cartilage layers alone. Since repair tissue shows a different behaviour in the contact zone compared to healthy cartilage a possible marker for an improved evaluation of the repair tissue quality after ACI and MACT may be available and will allow biomechanical assessment of cartilage transplant.

References:

1. Mosher TJ, Dardzinski BJ, Smith MB. Human articular cartilage: influence of aging and early symptomatic degeneration on the spatial variation of T2—-preliminary findings at 3 T. *Radiology*. 2000;214: 259 –266
2. Mlynarik V, Sulzbacher I, Bittsansky M, et al. Investigation of apparent diffusion constant as an indicator of early degenerative disease in articular cartilage. *J Magn.Reson Imaging.* Apr 2003;17(4):440-444.

	Map		Deep_Contact	Sup_Contact	Mean_Contact	Deep_NonContact	Sup_NonContact	Mean_NonContact
volunteers	T2 [ms]	Mean	44.25	55.92	50.08	41.88	55.17	48.53
		St. Dev.	10.94	11.05	10.84	13.07	19.95	16.29
	Diffusion [mm^2/s]	Mean	1.21	1.30	1.26	1.25	1.26	1.26
		St. dev.	0.13	0.15	0.14	0.14	0.15	0.13
patients	T2 [ms]	Mean	46.29	48.41	47.32	48.61	56.67	52.64
		St. Dev.	12.44	9.32	10.40	16.63	12.45	14.03
	Diffusion [mm^2/s]	Mean	1.45	1.42	1.44	1.28	1.35	1.31
		St. dev.	0.20	0.17	0.18	0.18	0.19	0.17

Table 1. – summary of volunteers and patients

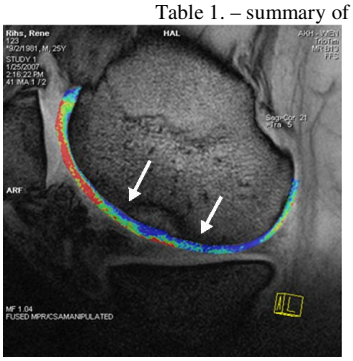

Fig. 1a.

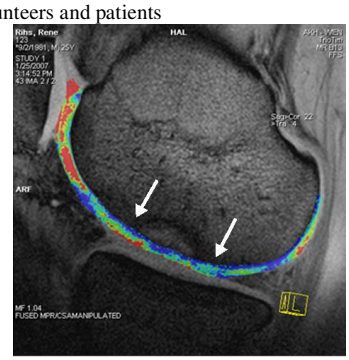

Fig. 1b.