dGEMRIC at 7 Tesla - Feasibility Study

S. Trattnig[1], G. H. Welsch[1], K. Pinker[1], T. Hughes[2], O. Kraff[3], M. Ladd[3], P. Szomolanyi[1,4], O. Bieri[5], K. Scheffler[5], and T. C. Mamisch[6]

[1]Department of Radiology, MR Centre - Highfield MR, Vienna, Austria, [2]Medical Solutions, Siemens AG, Erlangen, Germany, [3]Department of Diagnostic and Interventional Radiology and Neuroradiology, University Hospital, Essen, Germany, [4]Department of Imaging Methods, Institute of Measurement Science, Slovak Academy of Sciences, Bratislava, Slovakia, [5]Department of Medical Radiology, University of Basel - MR Physics, Basel, Switzerland, [6]Orthopedic Surgery Department, Inselspital, Bern, Switzerland

Purpose/Introduction: In the recent years new techniques have been developed to directly visualize molecular cartilage composition. Two techniques are of particular interest: quantitative T2 mapping and delayed Gadolinium Enhanced Magnetic Resonance Imaging of Cartilage (dGEMRIC) (1). Recently, whole-body scanner operating at 7 Tesla were installed and are increasingly used for clinical studies in patients (2). Ultrahigh field systems provide higher resolution which may improve diagnostic accuracy. The aim of this study was therefore twofold:

1. to evaluate the feasibility of dGEMRIC technique at 7T in volunteers, in particular to define how large the range between pre-and postcontrast T1 values at 7T is which is a pre requirement for application of dGEMRIC technique in patients
2. to compare standard inversion recovery sequence for T1 mapping with a dual flip angle excitation pulse technique in GRE sequences in phantom as well as in volunteers at 7T

Subjects and Methods: Measurements were performed on a Magnetom 7T whole body system (Siemens Medical Solution, Erlangen, Germany) equipped with actively shielded magnetic field gradient coils of 200 mT/m/ms slew rate with maximal amplitude of 45mT/m. For phantom studies a circular polarized transmit/receive (TX/RX) extremity coil (In vivo) was used.
Phantom probes were prepared from 8 different concentrations of NaCl and gadopentate dimeglumine (Magnevist, Schering, Berlin, Germany). In order to calibrate the phantom fluids an inversion recovery sequence was performed at 7 different nonequidistant TI times: 25, 75, 180, 350, 650, 1100,and 1680 ms. TR/TE times were 4800ms/9ms. Two 2D slices with a matrix size of 384 x 384, a field of view (FOV) of 150 x 150 mm resulting in a nominal resolution of 0.39 x 0.39 mm and a 3mm slice thickness were measured. A bandwidth of 260 Hz/pixel was used. The same sequence parameters were used for the volunteer study. The 3D dual flip angle GRE sequence for dGEMRIC technique was used for the evaluation of the same probes and volunteers. Several different flip angles were measured: 35°,25°,20°,15°,10°,5°. The parameters of the 3D GRE sequence were as follows: TR/TE : 27.1ms/5.3ms, matrix size: 384x384, FOV: 150x150mm, nominal resolution: 0.39 x 0.39 mm, The effective slice thickness was 3mm.
In vivo study: Five asymptomatic volunteers, 4 male, one female, age range 20-48 a, mean age:32 a were enrolled in the study. All studies were approved by the institutional review board, and all subjects gave their informed consent. Three regions of interest (ROI) encompassing the anterior, central and posterior portion of the medial femoral cartilage and three regions of interest within the anterior and posterior portion of the medial tibial cartilage were drawn on each image using the anterior and posterior horn of the meniscus as a reference. The precontrast relaxation rate R1 (R1precontrast=1/T1precontrast) and the postcontrast R1(1/T1Gd) and the delta relaxation rate R1 (R1precontrast – R1Gd) were evaluated with IR and dual flip angle GRE technique in comparison.

Results: The results of the phantom study are graphically displayed in figure 1. The comparison of IR and dual flip angle 3D GRE showed a lower correlation in the longer range of T1 values from 800ms and higher. For IR sequence the mean precontrast T1 relaxation time for femoral condyle was 1259ms with a mean R1 of 0.83, the mean T1Gd was 682ms with a mean R1 of 1.52 resulting in a delta R1 of 0.70 (figure 2, 3). The corresponding values for GRE femoral condyle were precontrast: 1555/0.70 and postcontrast: 1166/0.91 with a delta R1 of 0.22. For IR sequence the mean precontrast T1 relaxation time for tibia condyle cartilage was 1092ms with a mean R1 of 0.97, the mean T1Gd was 769ms with a mean R1 of 1.35 resulting in a delta R1 of 0.38. The corresponding values for GRE tibia cartilage were precontrast: 1352/0.81 and postcontrast: 1262/0.91 with a delta R1 of 0.10. Figure 4 and 5 shows the range of T1 and R1 values between pre-and postcontrast for all femoral condyle cartilage regions and all volunteers in IR. Figure 6 shows the range of T1 values between pre-and postcontrast for all femoral condyle cartilage regions and all volunteers in GRE. Similar separation between T1Gd and T1 precontrast as well as R1Gd and R1precontrast is observed at 7T compared to reported values at 3T.

Discussion: Similar separation between R1Gd and R1precontrast at 7T compared to 3T (3) was found suggesting that the effects of T1precontrast on estimation of contrast agent concentration in the tissue are important at 7T, too. In addition these findings show that dGEMRIC is feasible at 7T, but has to be performed with inversion recovery technique for T1 mapping and the calculation of the delta relaxation rate is mandatory to get reliable results.

References:

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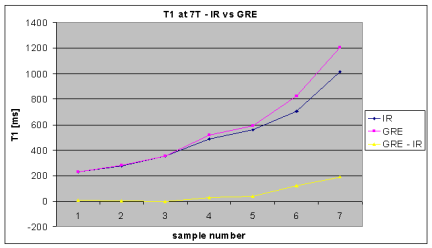

Fig.1

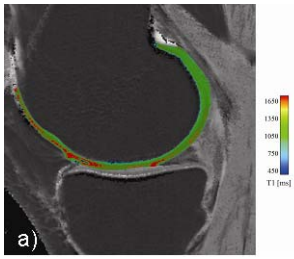

Fig.2

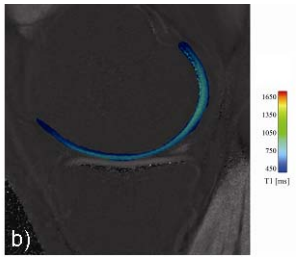

Fig.3

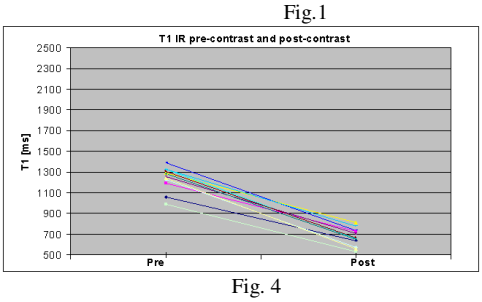

Fig. 4

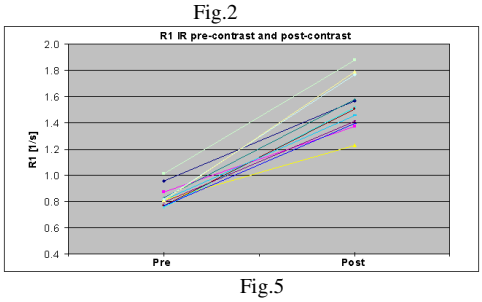

Fig.5

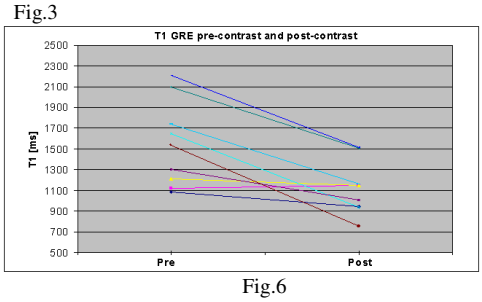

Fig.6