Quantitative T2 mapping of matrix-associated autologous chondrocyte transplantation at 3 Tesla: an in vivo cross-sectional study

S. Trattnig[1], C. T. Mamisch[2], C. Glaser[3], P. Szomolanyi[1,4], S. Gebetsroither[1], O. Stastny[5], W. Horger[6], and S. Marlovits[7]

[1]MR Centre-Highfield MR, Department of Radiology, Medical University of Vienna, Vienna, Austria, [2]Orthopedic Surgery Department, Inselspital, Bern, Switzerland, [3]Campus Grosshadern, Institut für klinische Radiologie der Ludwig-Maximilians-Universität München, München, Germany, [4]Department of Imaging Methods, Institute of Measurement Science, Bratislava, Slovakia, [5]Medizinische Radiologie, Diagnostik und Intervenstion, Zentralklinikum, St.Pölten, Austria, [6]Siemens Medical Solutions, Erlangen, Germany, [7]Department of Traumatology, Center for Joints and Cartilage, Medical University of Vienna, Vienna, Austria

Introduction: MR imaging of articular cartilage is increasingly important due to the development of new surgical therapies for cartilage repair such as autologous chondrocyte transplantation and the new generations of matrix-associated autologous chondrocyte transplants (MACT) [1][2]. So far, clinical evaluation and biopsies have been used to follow-up cartilage repair procedures. However, MRI allows in vivo evaluation of articular cartilage making it a potentially powerful tool for the non-invasive assessment of cartilage repair status. T_2 mapping provides information about collagen matrix concentration and organization[3][4]. Thus, the aim of this study was to evaluate *in vivo* T_2 mapping as a possible non-invasive tool for the visualization of the maturation process of MACT grafts.

Materials and Methods: Quantitative T_2 mapping was performed in fifteen consecutive patients (two females; thirteen males; age range: 21-54 years, mean age: 37.8 years) after MACT on the femoral condyle using a hyaluronan based scaffold (Hyalograft®C scaffold [Fidia Advanced Biopolymers, Abano terme, Italy]). With respect to the postoperative time interval patients were subdivided into four groups: Group I, 3-6 months (three patients); group II, 10-13 months (three patients); group III, 19-22 months (five patients); and group IV, 26-42 months (four patients). MR examinations were performed on a 3T MR unit (Magnetom Trio, Siemens Erlangen, Germany) with a gradient strength of 40mT/m using an 8 channel knee coil. The T_2 relaxation times were obtained from T_2 maps reconstructed from a multiple spin echo technique with a repetition time (TR) of 2.060 s. Six echo times (TE) were collected, (16.4 ms, 32.8ms, 49.2 ms, 65.6 ms, 82.0 ms and 96.4 ms). A 18.0 cm x 20.0 cm FOV, 320 x 288 pixels matrix and a slice thickness of 1mm were used. The total scan time was 6mins 43secs.

Results

The mean global T_2 values [ms] in cartilage repair tissue of all patients in group I was 85.4 compared to 49.4 for native cartilage; this difference was statistically significant ($p<0.036$). In group II to IV mean T_2 values of repair tissue were in the range of 53.4 to 61.5 compared to 51.3 to 59.0 for native cartilage (Fig. 1). These differences were not statistically significant ($p>0.05$).

The spatial distribution of T_2 relaxation times are shown in figure 2 for the anterior, middle and posterior aspect of the grafts. A statistically significant difference between the mean T_2 values of all patients in group I between the anterior as well as the middle portion of the implant compared to the reference T_2 values was found ($p<0.035$,$p<0.009$) with higher T_2 values at the graft site. However, statistical significance was only marginally present for the posterior portion ($p<0.047$). In group II to IV no statistically significant difference between different locations within the cartilage implant compared to the reference site was found ($p>0.05$). In figure 3 the spatial distribution of T_2 relaxation times are shown for the medial and lateral portions of the implant. A statistically significant difference between the mean T_2 values of all patients in group I between the medial portion of the implant compared to the reference T_2 value was found ($p<0.005$), with higher T_2 values at the medial graft site, however this difference was not present for the lateral aspect within the graft ($p<0.074$). There were no statistically significant differences between the medial and lateral positions compared to normal cartilage in groups II to IV ($p>0.05$). Figure 4 shows the time table of individual T2 values in the postsurgery period within the cartilage transplant in comparison to native hyaline cartilage. Image 5 of T_2 map shows different behaviour in case of a patient 22 months after the surgery. T_2 values presented in pseudo-colour image are lower in cartilage transplant, compared to the normal hyaline cartilage reference. White arrows mark the borders of the cartilage transplant.

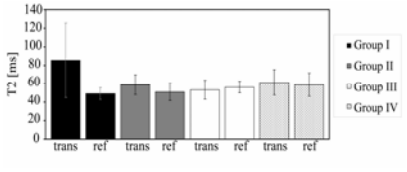

Figure 1

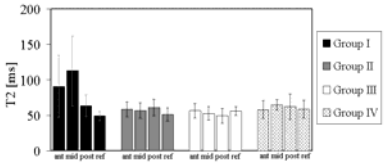

Figure 2

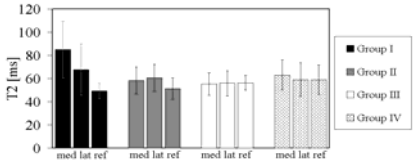

Figure 3

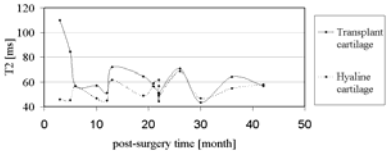

Figure 4

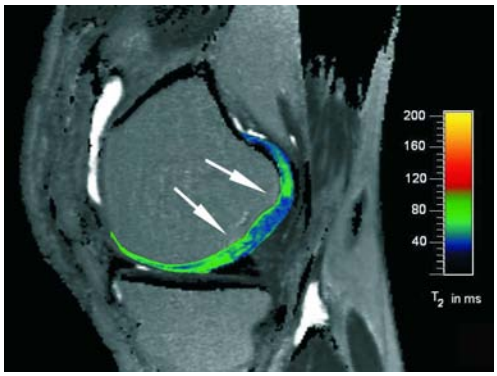

Figure 5

Discussion/Conclusion: Using quantitative T_2 mapping of patients at different post operative intervals after MACT surgery we found significantly higher T_2 values in cartilage repair tissue, in the early stage (3-6 months) compared to native hyaline cartilage. Furthermore, we found a decrease in repair tissue T_2 values over time with the T_2 values becoming similar to native healthy cartilage by approximately 10 to 13 months. Regarding the spatial distribution, the areas of higher T_2 values in group I corresponded roughly to the weight bearing regions of the grafts in the femoro-tibial compartment. Quantitative T2 mapping provides deeper insight into the maturation process of cartilage repair tissue which may help to better differentiate between normal maturation and development of abnormality in cartilage implants.

References:

1. Minas T, Chiu R. Autologous chondrocyte implantation. Am J Knee Surg 2000;13(1):41-50.
2. Marlovits S, Zeller P, Singer P, Resinger C, Vecsei V. Eur J Radiol 2006;57(1):24-31.
3. Nieminen MT, Rieppo J, Toyras J, et all..Magn Reson Med 2001;46(3):487-493.
4. Glaser C.Radiol Clin North Am 2005;43(4):641-53