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

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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. T2 mapping provides information about collagen matrix concentration and organization[3][4]. Thus, the aim of this study was to evaluate in vivo T2 mapping as a possible non-invasive tool for the visualization of the maturation process of MACT grafts.

Materials and Methods: Quantitative T2 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 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 T2 relaxation times were obtained from T2 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 T2 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 T2 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 T2 relaxation times are shown for the anterior, middle and posterior aspect of the grafts. A statistically significant difference between the mean T2 values of all patients in group I between the anterior as well as the middle portion of the implant compared to the reference T2 values was found (p<0.035, p<0.009) with higher T2 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 T2 relaxation times are shown for the medial and lateral portions of the implant. A statistically significant difference between the mean T2 values of all patients in group I between the medial portion of the implant compared to the reference T2 value was found (p<0.005), with higher T2 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 post surgery period within the cartilage transplant in comparison to native hyaline cartilage. Image 5 of T2 maps shows different behaviour in case of a patient 22 months after the surgery. T2 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.

Discussion/Conclusion: Using quantitative T2 mapping of patients at different post operative intervals after MACT surgery we found significantly higher T2 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 T2 values over time with the T2 values becoming similar to native healthy cartilage by approximately 10 to 13 months. Regarding the spatial distribution, the areas of higher T2 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: