

3D GRE sequence with two different flip angle excitation pulses for zonal T1- mapping of articular cartilage at 3T: One-year follow-up in patients after matrix-associated autologous chondrocyte transplantation (MACT) of the knee joint

K. Pinker¹, P. Szomolanyi², G. Welsch¹, T. C. Mamisch³, S. Marlovits⁴, and S. Trattnig¹

¹Department of Radiology, MR Centre of Excellence, Vienna, Vienna, Austria, ²Slovak Academy of Sciences, Bratislava, Slovakia, ³Orthopedic Surgery Department, Inselspital, Bern, Switzerland, ⁴Department of Traumatology, Centre for Joints and Cartilage, Medical University Vienna, Vienna, Vienna, Austria

Introduction

To evaluate the zonal distribution of glycosaminoglycans in normal weight-bearing cartilage and repair tissue by dGEMRIC method and to monitor the development of GAG content in MACT over one year.

Material and Methods

In this longitudinal study 15 patients after MACT in the knee joint with different post-operative intervals were examined in a baseline and a follow-up examination one year later using an eight-channel knee-coil at 3T. The dGEMRIC technique for T1-mapping was performed using a 3D GRE sequence with a 35/10° flip angle excitation pulse combination. The $\Delta R1$ relaxation rate ($\Delta R1$) was calculated for repair tissue and the weight-bearing normal hyaline cartilage, which was divided into two zones (deep and superficial). From these measurements, relative $\Delta R1 = [\Delta R1 \text{ repair tissue} / \Delta R1 \text{ normal cartilage}]$ were calculated. Zonal mean values as well as total mean values were compared using analysis of variance.

Results and Discussion

The mean $\Delta R1$ for the cartilage repair tissue dropped significantly from 2.2 s⁻¹ to 1.71 s⁻¹ in a one-year follow-up period, with a $\Delta R1$ of 1.34 s⁻¹ to 1.07 s⁻¹ for the reference hyaline cartilage. Regarding zonal variation there was an increase of values and therefore a decrease of GAG content from the deep to the superficial layer in the reference cartilage ($\Delta R1$ 1.14 s⁻¹ for the deep to 1.60 s⁻¹ for the superficial zone), with reduced variation and significantly higher values for the repair tissue ($\Delta R1$ 2.10 s⁻¹ for the deep to 2.38 s⁻¹ for the superficial zone). In a one-year follow-up $\Delta R1$ changed to 1.80 s⁻¹ for the deep and 1.66 s⁻¹ for the superficial zone of the cartilage transplant. The decrease of $\Delta R1$ for the superficial zone of the cartilage transplant with a drop from 2.38 s⁻¹ to 1.66 s⁻¹ was statistically significant. Table 1 shows the change of relative $\Delta R1$ values from the baseline MRI (0 Scan) and after one year (1 Year Follow Up).

Conclusion

The dGEMRIC technique, based on 3D GRE sequences with two different flip angle excitation pulses, is feasible for the zonal T1-mapping of normal hyaline cartilage and repair tissue. Global GAG as well as zonal GAG content demonstrates an increase over a follow-up period of one year in patients after MACT of the knee joint.

References

1. Watanabe A, Wada Y, Obata T, et al. Delayed gadolinium-enhanced MR to determine glycosaminoglycan concentration in reparative cartilage after autologous chondrocyte implantation: preliminary results. *Radiology* 2006; 239:201-208.
2. Trattnig S MS, Gebetsroither S, Szomolanyi P, Welsch GH, Salomonowitz E, Watanabe A, Deimling M, Mamisch TC. Three-dimensional delayed Gadolinium enhanced MRI of cartilage (dGEMRIC) for in vivo evaluation of reparative cartilage after matrix-associated autologous chondrocyte transplantation at 3.0 Tesla - preliminary results. *Journal of Magnetic Resonance Imaging* 2007; 26:974-982
3. Burstein D, Velyvis J, Scott KT, et al. Protocol issues for delayed Gd(DTPA)(2-)-enhanced MRI (dGEMRIC) for clinical evaluation of articular cartilage. *Magn Reson Med* 2001; 45:36-41.

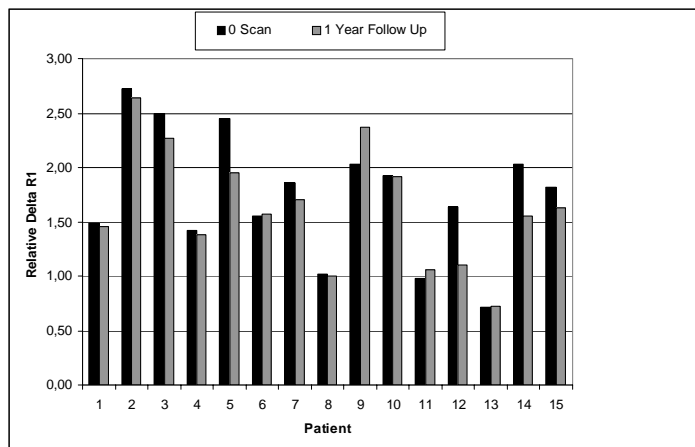


Table 1: Relative $\Delta R1$ values for the baseline scan (0 Scan) and after one year (1 Year Follow UP).

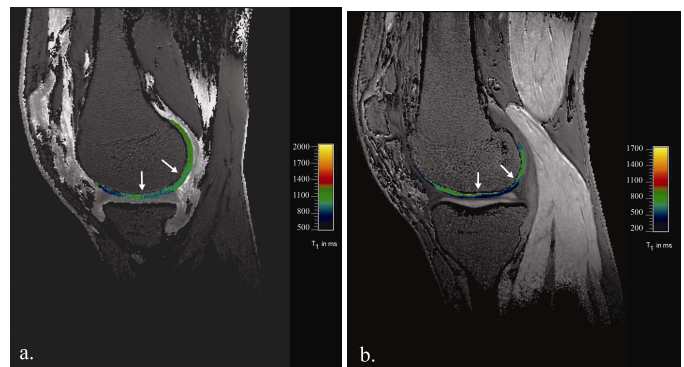


Fig.1: Color-coded cartilage transplant precontrast (a) of a patient 22 months after MACT. There are slightly higher T1-values in the cartilage transplant region compared with normal cartilage. b: The figure shows contrast enhancement of cartilage transplant after i.v. administration of contrast agent. White arrows mark the borders of the transplant.