Assessment of T1 and T2 MRI Parameters as a Predictors of Cartilage Implants Maturation: the Equine Subject Study

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Purpose/Introduction:

Nowadays, Magnetic Resonance Imaging (MRI) is successively used to visualize articular cartilage and to examine its pathological changes [1,2]. MRI is a prospective approach to grade the maturation of the implant tissue in-vitro or in-vivo [3]. The purpose of this study was to qualitatively assess MRI parameters (T_1, T_2) in animal model and to compare these with histological results to prove the MRI suitability of a non-invasive imaging for the cartilage repair evaluation.

Subjects and Methods:

Sample preparation: 20 cartilages plugs were harvested from the equine subjects previously treated by the three different implant types (Hyalograft - 5, Biogide - 7, CaRes - 8). Mean size of the harvested plug was 9.0 x .7.2 x 10.5 mm.

MRI procedure: A 3T Bruker Medspec (Bruker; Ettlingen, Germany) with a microimaging gradient insert was used to acquire data for high-resolution 2D MR maps, in-plane resolution 0.23x0.31mm. dGEMRIC maps of T_1 and T_2 maps were calculated from 6 inversion recovery images with different TIs and 6 multiecho T_2-weighted images. Regions of interest (ROI) were selected for deep and superficial zone separately, as well as for native and defect zone, and evaluated in custom-made IDL (RSI; Boulder, CO) software. Qualitative and quantitative T_2 and quantitative R_1 ($R_1 = 1/T_1$) assessment were compared to histological findings and evaluated by the means of the calculation of the kappa coefficient. Relative delta relaxation rate ($R_{1\ rel} = (R_{1\ implant\ postcontrast} - R_{1\ implant\ precontrast})/(R_{1\ native\ postcontrast} - R_{1\ native\ precontrast})$) was calculated as well.

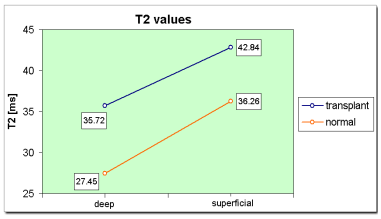
Histology procedure: Samples were fixed in 7.5% formalin for at least 1 week, followed by decalcification with EDTA- Solution (Titriplex; Gatt-Koller) for several weeks. Afterwards, samples were dehydrated and embedded in paraffin. Samples were cut in 2 µm thick sections and stained with haematoxylin-eosin as commonly used and with alcian-blue for staining of proteoglycans. 17 sites were histological evaluated and graded by experienced physician.

Results:

In case of T_2 quantification, significant differences in superficial and deep zone ($p<.001$) were found, as well as between native and transplant tissue ($p<.001$). Qualitative T_2 assessment showed almost perfect agreement (kappa coefficient = 0.88) (Table 1). Precontrast, R_1 (1/s) was slightly lower in defect compared to native compartment, 3.13 ± 1.71 and 3.62 ± 1.95 (mean ± SD), respectively, ($P = 0.18$) Postcontrast, R_1 was higher in defect than in native compartment, 6.06 ± 2.20 and 5.83 ± 2.27, respectively, ($P = 0.19$). Comparison of R_{1rel} and histology grading showed significant differences ($p<.01$) between hyaline cartilage ($R_{1rel} = 0.49 \pm 0.12$) and mixed hyaline-fibrous cartilage ($R_{1rel} = 0.88 \pm 0.09$).

Histologic Findings	No. of Organized T2 Patterns	No. of Disorganized T2 Patterns
Hyaline Cartilage	9	1
Hyaline-Fibrous or Fibrous Cartilage	0	7

Table 1 Qualitative T2 Evaluation Relative to Histology



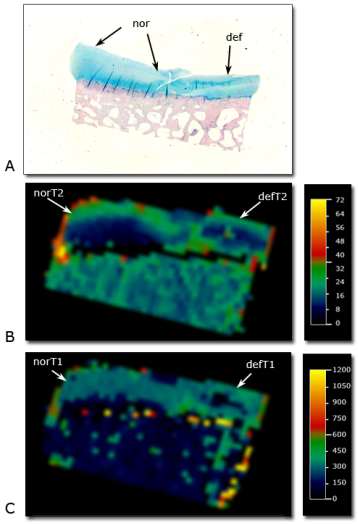


Fig. 1. **A:** Photomicrograph of a MACI plug with native cartilage tissue (nor) and defect zone (def) partly rich of fibers, stained with alcian-blue (original magnification, × 1); **B:** corresponding T2 map - native cartilage (norT2) with highly organized pattern and disorganized defect (defT2); **C:** T1 map - low T1 values in the area of defect tissue (def T1) and normal appearance in the native tissue (norT1).

Discussion and Conclusion

Obtained results showed that MRI has a competent sensitivity for evaluation of the degree of cartilage implant maturation. dGEMRIC can determine proteoglycan content in implant tissue and thereby qualitatively assess maturation of implant tissue. T_2 zonal organization as well as a T_2 quantitative analysis complements this information.

Objective non-invasive MRI measures may improve post operative monitoring following matrix-associated autologous chondrocyte implantation.

References

[1] Trattnig S. et al., Magn Reson Imaging. 1999 May;17(4):577-83

[2] Eckstein F. et al., Surg Radiol Anat. 1994;16(4):429-38

[3] Alparslan L. et. al., Semin Ultrasound CT MR. 2001 Aug;22(4):341-51