Diffusion tensor imaging of human hyaline articular cartilage at 1.5T

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Introduction

Hyaline articular cartilage presents an anisotropic structure of various zones, defined mainly by the arrangement of the collagenous fibers. Changes within this fiber network are regarded to be a hallmark of early degeneration in cartilage subject to osteoarthritis (1). DTI has been demonstrated to be effective in combination with high-field MR tomography in analyzing the microstructure of human and bovine articular cartilage in (2,3). However, today no data are available about DTI of articular cartilage provided by clinical MR tomography. This work presents a first investigation of the structure of human articular cartilage with a clinical 1.5T whole-body MRI scanner using DTI.

Materials & Methods

The measurements were performed on ex-vivo human patellae taking care to maintain the integrity of the tissue. The DTI data were acquired on a clinical whole-body MR tomograph with a field strength of 1.5 Tesla and a maximum gradient strength of 40 mT/m (MAGNETOM Sonata, Siemens Medical Solutions, Erlangen, Germany). Using a navigator-corrected spinecho sequence, we obtained an in-plane resolution of 468×468µm² (matrix 256×256, FOV 120×120 mm², slice thickness 5 mm) with 2 repetitions, b-values of 0 and 500 s/mm², TR/TE=1150ms/56ms. 6 different diffusion gradient directions were applied; the total measurement time was 69min.
DTI data were evaluated using a self-developed software package based on the visualization system AVS (AVS Inc., Waltham, MA, USA). We determined the diffusion tensor eigenvalues and eigenvectors and visualized the results as trace maps, anisotropy maps based on different definitions (4,5), eigenvalue maps, and the eigenvectors using color map and their projections on arbitrary planes.

Results

The mean diffusivity map (Figure 1) shows zonal variations. The mean diffusivity varies between 1.5×10^{-3} mm²/s in the tangential zone and 0.3×10^{-3} mm²/s at the tide mark. The projection of the largest eigenvector on the image plane (Figure 2) has different directions in the different regions of the cartilage and is oriented predominantly tangentially at the cartilage surface and radially below.

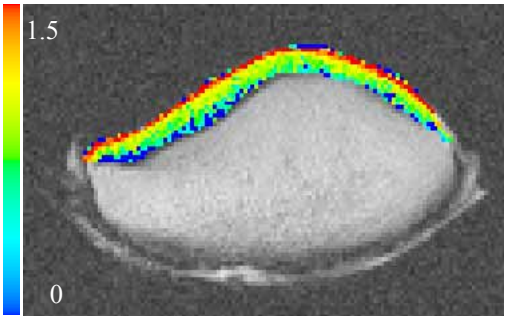

Figure 1. ADC map of the human articular cartilage. The color scale is given by 10^{-3} mm²/s.

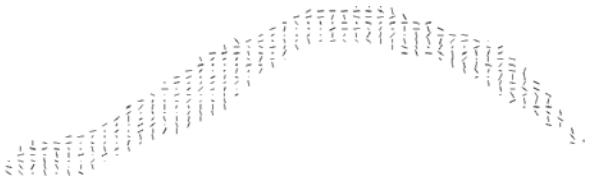

Figure 2. Projection of the (normalized) eigenvector associated with the largest eigenvalue on the image plane.

Discussion and Conclusion

Our results demonstrate the feasibility of DTI experiments for structural analysis of human articular cartilage with clinical MR systems. The technique holds reasonable potential for monitoring the zonal arrangement of the cartilage. The observed zonal pattern is in good agreement with current literature about the collagenous fiber architecture of cartilage (1,2). This could be a first step versus a future clinical application of MR analysis of articular cartilage with DTI.

References

1. Glaser C, Putz R, Osteoarthritis Cartilag 10: 83-99 (2002).
2. Filidoro L Dietrich O, Weber J, Rauch E, Oerther T, Wick M, Reiser M, Glaser C, MRM 53: 993-998 (2005). 3. Filidoro L, Dietrich O, Weber J, Reiser M, Weber T, Faber C, Jakob P, Glaser C, Poster 3630 at ISMRM2004.
4. Alexander AL, Hasan K, Kindlmann G, Parker DL, Tsuruda JS, MRM 44: 283-291 (2000).
5. Westin CF, Maier SE, Mamata H, Nabavi A, Jolesz FA, Kikinis R, Med Image Anal. 6: 93-108 (2002).