Investigation of SNR for DTI with human articular cartilage at 17.6 Tesla

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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]. As is generally known [4,5] the dependency of the fractional anisotropy (FA) and the relation of the mean diffusion directions from the SNR, in general, play a critical role for accurate DTI analysis. This work investigates the required SNR for DTI of human articular cartilage at 17.6 Tesla for an accurate analysis of the data.

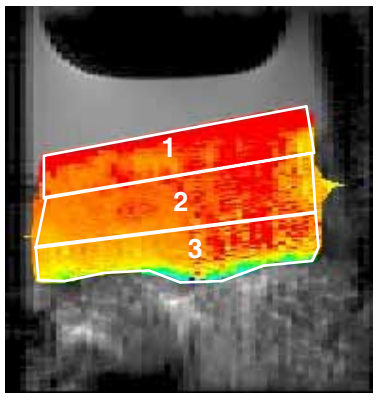

Fig. 1: ADC in the articular cartilage. The cartilage is divided in 3 areas: 1 = surface, 2 = center, 3 = close to bone.

Material & Methods

The measurements were performed on ex-vivo human patellae, and extra care was taken to maintain the integrity of the tissue. DTI data were acquired on a Bruker Avance 750WB at 17.6 Tesla with a maximum gradient strength of 1 T/m (Bruker Biospin GmbH, Rheinstetten, Germany). A cylindrical probe with a diameter of 16 mm was drilled out of the articular cartilage in order to scan it. Using a diffusion-tensor sequence, we obtained an in-plane resolution of 62.5 × 250 µm² (matrix 256 × 64, FOV 16×16 mm², slice thickness 1.5 mm) with 32 repetitions, b-values of 0 and 500 s/mm², TR/TE = 1000ms/16ms. Six different diffusion gradient directions were applied for the diffusion tensor measurement; the total acquisition time was 4 hours. DTI data were evaluated using a self-developed software package based on the visualization system AVS (AVS Inc., Waltham, MA, USA).

To assess the SNR dependence of the FA the cartilage was divided in three regions of interest with different distances to the surface (Fig. 1). To obtain different SNRs we averaged different numbers of repetitions (1, 2, 4, 8 and 16). The noise in the regions of interest was determined using difference images of identical acquisitions [6].

Results

In Figure 1 an ADC-map of the probe is shown. The SNR dependency of the FA is shown in Figure 2. The FA decreases as expected with increasing SNR and reaches approximately constant values for SNRs greater than 70.

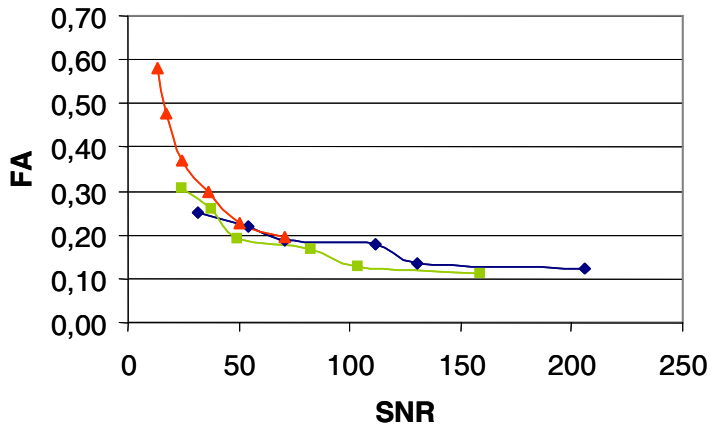

Fig. 2: The dependency of the fractional anisotropy from the SNR is shown. Diamonds are area1, squares are area 2, and triangles are area 3.

Discussion & Conclusion

An accurate analysis of diffusion tensor data can only be done if it is guaranteed that the SNR is high enough to determine the correct ratio between the eigenvalues of the diffusion tensor. Figure 2 shows that this is given in our setup for an SNR of 70 and higher.

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