Skeletal muscle diffusion tensor imaging of the human forarm at 7T

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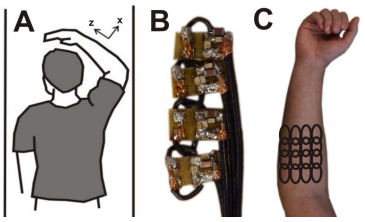
Introduction: Diffusion tensor imaging (DTI) at 1.5 and 3.0T has been shown to be a very useful tool for the visualization of human skeletal muscle anatomy[1], as well as for quantification of muscle architectural parameters[2] and diffusion properties[3]. However, limiting factors are the typical poor spatial resolution and low SNR. Data acquisition at higher field strength increases the SNR allowing for higher spatial resolution. In this study we investigated the feasibility of DTI of human forearm skeletal muscle at 7T, exploiting the increased SNR for maximizing the spatial resolution.



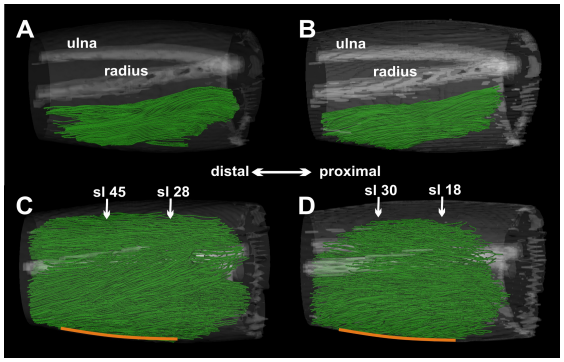
^ ***Fig 1:*** *A) Top view of the subject position in the MRI scanner B) single 4 coil module. C) Positioning of the coils.*

MRI: One healthy 29 year old male volunteer was measured on a 7T Philips scanner using a volume transmit coil and a custom-build 16 channel small element surface receive coil array consisting of 4 independent 4 coil modules[4] as illustrated in figure 1. First image-based shimming was performed using a gradient echo scan (FOV: 128x128, voxel size 2x2x2mm^3) after which two DTI data sets were acquired with: SE-EPI, FOV: 128x128mm^2, 32 diffusion gradient directions, NSA: 2, b=400 s/mm^2, fat suppression: SPIR, SENSE factor: 3. Further scan parameters were ***DTI1:*** voxel size: 2x2x2 mm^2, acquisition matrix 64x64, 75 slices, TR/TE: 9100/43 ms; ***DTI2:*** voxel size: 1x1x3 mm^2, acquisition matrix 128x128, 50 slices, TR/TE: 6300/49 ms.

Tabel 1: *DTI parameters. λ_1, λ_2, λ_3,MD in [10-3 mm^2/s]*

	DTI1	DTI2
λ_1	2.21 ± 0.24	2.11 ± 0.31
λ_2	1.69 ± 0.21	1.63 ± 0.27
λ_3	1.37 ± 0.22	1.38 ± 0.28
MD	1.75 ± 0.19	1.69 ± 0.27
FA	0.24 ± 0.06	0.20 ± 0.06

Analysis: The data was processed using a custom-build toolbox for Mathematica 7.0. First the data was filtered using a rician noise suppression algorithm[5] after which the diffusion weighted data was registered to the non-weighted images using an affine transformation and corresponding b-matrix rotation[6]. Fiber-tractography was performed using the DTI-tool developed in house.

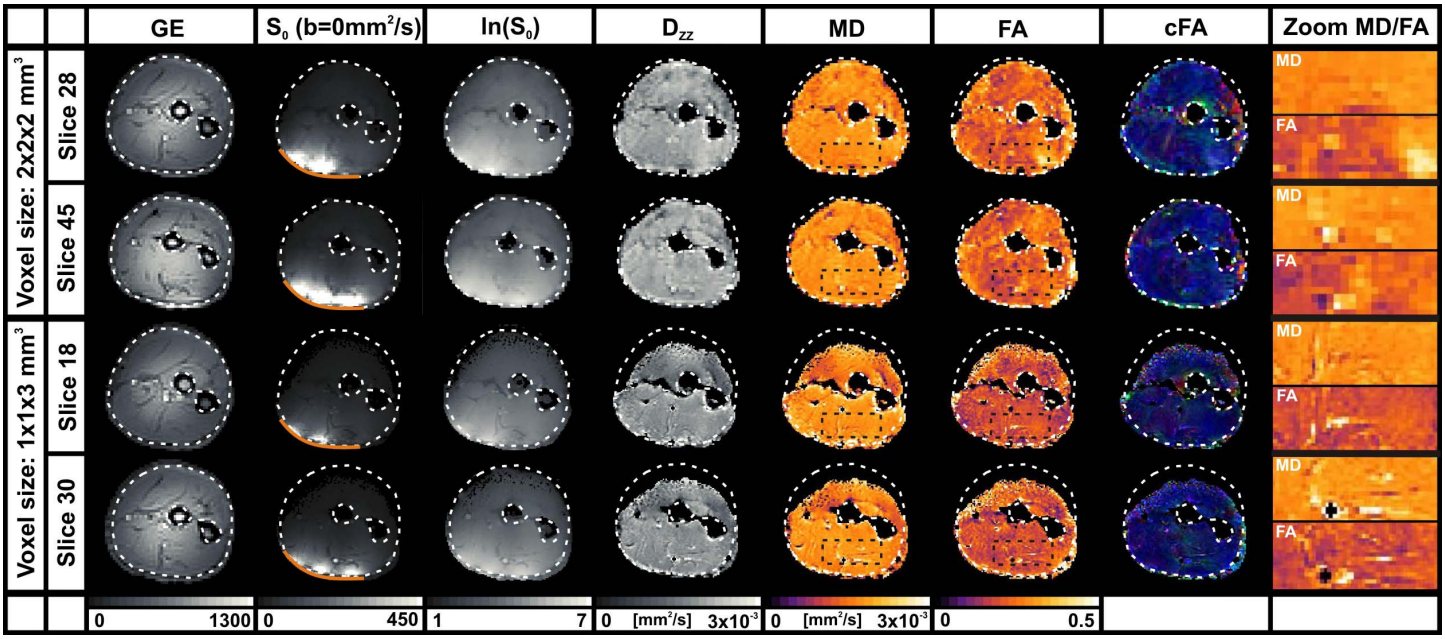


^***Fig 2:*** *Fiber tractography, left **DTI1**, right **DTI2** with coil position in orange A-B) Part of the Flexor carpi radialis. C-D) Whole volume.*

Results and Discussion: Figure 2 shows fiber tractography of part of the Flexor carpi radialis muscle as well as whole volume tractography for both datasets. However, a small part of the acquired volume further away from the coil had insufficient SNR to accurately perform fiber tractography. Especially with the 1 mm in plane resolution small regions could not be tracked successfully (figure 2D). This lack of signal can also be seen in figure 3, which depicts axial slices for both the datasets at two locations. The bottom two rows (DTI2) clearly show the benefit of the high in-plane resolution revealing great detail in the tensor as well as the MD and FA maps. This is emphasized by the right most column, which shows an enlarged part of the MD and FA maps and clearly visualizes the extra information obtained using the high acquisition resolution. Quantification of the tensor parameters in the areas that could be measured yielded mean values and standard deviations (table 1) similar to those found in the human forearm at 3T[3]. Increasing the number of coil modules and placing them evenly spaced around the arm will allow coverage of the entire forearm.

Conclusion: We have shown the feasibility of high spatial resolution human forearm skeletal muscle DTI data acquisition at 7T. Following optimization of the protocol and coil setup, coverage of the entire forearm will become feasible in the near future.

v Fig 3: *Image matrix showing axial slices at two locations in both DTI1 (top rows) and DTI2 (bottom rows) dataset. The orange line indicates the coil placement.*



References: **[1]** Budzik et al. Eur Radiol 2007: 17(12): 3079-85; **[2]** Heemskerk et al. MRM 2009; 61(2): 467-72; **[3]** Froeling et al. MRM 2010;64(4): 1182-90; **[4]** N. Petridou et al, Proc ISMRM 18 2010: 3849 ; **[5]** Aja-Fernandez et al. J IEEE 2008; 27(10): 1389-1403; **[6]** Leemans et al. MRM 2009: 61(6): 1336-49;