CHARACTERIZATION OF WHITE MATTER FASCICULI WITH T1 QUANTIFICATION: A FEASIBILITY STUDY AT HIGH FIELD

N. D. Papinutto[1], and J. Jovicich[1]
[1]Center for Mind/Brain Sciences, University of Trento, Mattarello, Trento, Italy

INTRODUCTION

Diffusion tensor imaging (DTI) of *in-vivo* human brains is a technique that is becoming widely used to get insight into normal and abnormal white matter anatomical connectivity. Characterization of pathologies with fractional anisotropy (FA) losses have been done, both at voxel level and along tracts [1,2]. A promising method to further improve the characterization of main streamlines consists on adding relaxation times measurements [3,4,5]. We present a simple method for T1 quantification of white matter tracts using sequences available in most commercial scanners. The main challenges include the precision of the T1 fits and the co-registration of images with very different contrasts and distortions, in particular when working at high magnetic field strength.

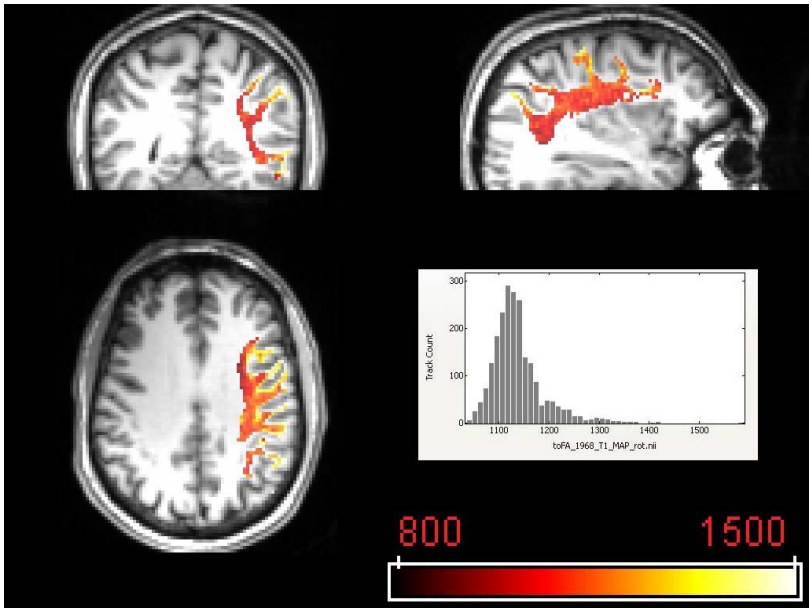
MATERIALS AND METHODS

Data Acquisition: On four healthy volunteers (4m, mean age 43±10) we acquired three 3D IR-TSE volumes (TR=4000ms, 1x1x1mm^3, sagittal, real value, 4:13 min per volume) with different inversion times (TI=30, 1200, 2940 ms) using a 8-channel array coil (iPAt=2) on a Bruker Medspec 4T scanner [6]. In the same session two equal DTI datasets (voxel size 2^3 mm^3 and b-value 1000 s/mm^2, 30 gradient directions, 5b0 images), a 3D T1 weighted image (MPRAGE) and a 3D T2 weighted image (TSE) were acquired.
Data Analysis: T1 maps were estimated on a voxel basis fitting the 3D IR-TSE real signal of the 3 inversion times. For the fit we used Matlab with a 3-parameter equation $A*(1-B*\exp(-S_i^{x,y,z}/T1)+\exp(-TR/T1))$ [7], where $S_i^{x,y,z}$ is the x,y,z voxel Signal of the i-esim image. The parameter B wasn't fixed to 2 (full inversion) to allow for B1 inhomogeneities. FA estimates and Tensor calculation were done with TrackVis after the FSL Eddy Current (EC) correction. For each subject the FA map to MPRAGE transformation was estimated (FSL, affine transformation). Finally the inverted transformation was applied to both MPRAGE and T1 map to work in the "FA space" unvaried. "*Corpus Callosum*" (CC), "*Inferior Longitudinal fasciculus*" (ILF), "*Arcuate fasciculus*" (AF) and "*Cingulum*" (C) ROIs were drawn with TrackVis following the guidelines described in [8] to dissect the four relative *fasciculi*. T1 mean and its standard deviation were measured for each streamline, after a visual inspection of the streamline on the co-registered T1 map (MRIcro).

RESULTS

We found good T1-tract co-registrations for *fasciculi* that are distant from non-white matter tissue, like the *Arcuate* (Fig. 1) and ILF. In these structures group T1 values were: *Arcuate*: 1448+-277 ms, ILF: 1511+-205 ms. However, for *fasciculi* that are either thin (5/6 mm) or close to cerebral spinal fluid (CSF) spaces (i.e. areas with long T1, typically>3000 ms at 4T), like *Cingulum* or *Corpus Callosum*, our analysis methods led to misalignments that need to be corrected.

Figure1: T1 of the *Arcuate Fasciculus* of a subject (T1 varying from 800 ms to 1500 ms). In the inset the statistics on the whole streamline is reported.



DISCUSSION AND CONCLUSIONS

Potential sources for the misalignments include T1 inaccuracies derived from co-registration inaccuracies of the multiple inversion recovery images (which have very different contrasts). These spatial co-registration errors need to be evaluated in space, particularly close to CSF areas. For this purpose ongoing work is also evaluating the use of the T2 structural data as means of minimizing co-registration errors. In addition, co-registration of the T1 maps directly on the b0 volumes of the DWI datasets that have very similar contrast should be investigated [4]. In summary, a method to characterize white-matter streamlines with quantitative T1 measurements has been investigated, with the longer term goal of establishing a method that can be extended to to have a full T1, T2, T2* and FA statistics on streamlines, which may lead to more reproducible white matter characterization. Further data acquisition and co-registration improvements are in progress to improve the accuracy of the results across all main streamlines.

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