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## Introduction

- Many studies have used high resolution structural MRI scanning to study fixed human brain tissue.
- There are few reports of *DTI* studies in fixed human brain
- We acquired 3D high resolution DTI images of human cortex specimens (1-4).

## Objective

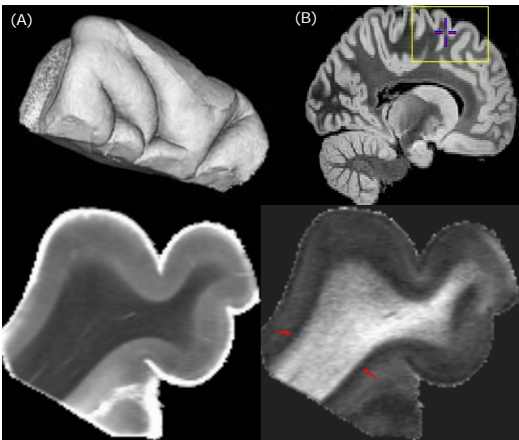
- To investigate the submillimeter structure of grey (GM) and white matter (WM) that is not apparent in in-vivo or ex-vivo structural scans.

## Methods

- Formalin fixed specimens of adult human brains were soaked in a 1mM solution of GdDTPA in phosphate buffered saline.
- Scans acquired on a Bruker Biospec Avance 4.7T system
- 3D spin-echo DTI scans: TR/TE 250/30ms, b=4000s/mm<sup>2</sup>, δ=7ms, Δ=10.4ms, 20 directions, 200-220μm isotropic spatial resolution), ~24 hr. total scan time.
- 3D T<sub>2</sub>\* weighted GRE structural scans at 100μm isotropic spatial resolution
- DTI reconstruction generated trace ADC and FA maps (MRVision software) and fiber tracts (DTI Studio)
- 3D visualizations created using Amira software.

## Results

- We present examples of high resolution DTI and DTI tractography in normal human motor and visual cortex and one case of pathology.



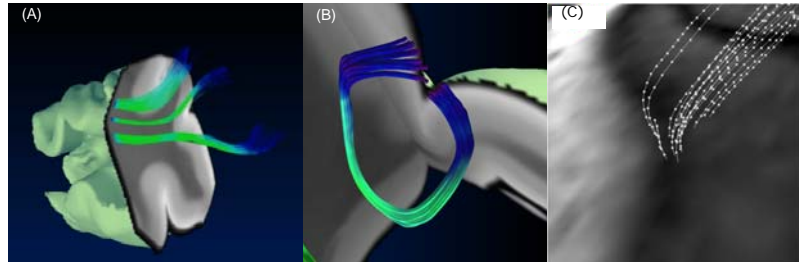
**Figure 1.** (A) 3D rendered view of excised normal motor/premotor cortex (B) box shows approximate position of cortical section in the brain (C) ADC and (D) FA – coronal view through section. Red arrows mark the low intensity cortical layer which abuts on the subcortical WM. The cortex showed clear structure (layering) within the GM strip and diffusion anisotropy in both GM and WM.

Normal fixed human cortex	FA	ADC x10 <sup>-3</sup> cm <sup>2</sup> s <sup>-1</sup>
White Matter	0.27±0.03	0.154±0.004
Gray Matter	0.09±0.01	0.249±0.018
G-W Interface	0.05±0.01	0.256±0.014

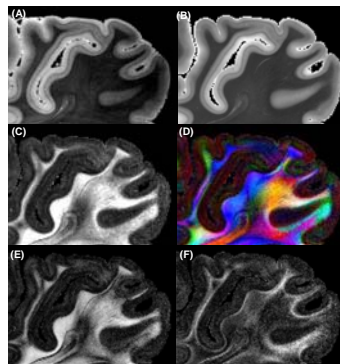
**Table 1:** ADC values in gray and subcortical WM were 3-4 fold lower than in vivo. FA values in the WM similar to in vivo values in the WM radiations. The GM FA of ~0.09 are likely the radial cortical fibers

## Conclusions

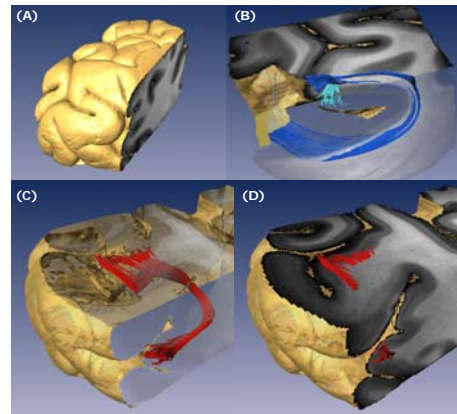
- High resolution DTI is a useful adjunct to structural MRI scanning for studying the human cerebral cortex ex vivo.
- It provides a new source of image contrast.
- It may prove a valuable aid for cortical parcellation work and for characterizing brain pathologies.
- Comparison of DTI tractography results at different spatial resolutions, by down sampling the high resolution data, may help to improve tracking algorithms.



**Figure 2.** DTI tractography (premotor cortex): Fibers are color coded according to FA (blue-low, green-higher). (A) fibers penetrating from the WM tracts into the gray matter strip (B) short U-shaped fibers connecting adjacent gyri. Overlaying fibers onto the FA map (C) indicates that the sharp curve into the cortex occurs at the low FA band at the gray-white interface.



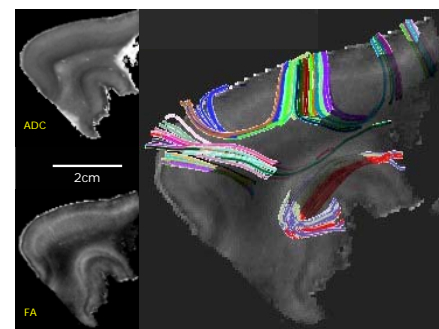
**Figure 3.** Normal human occipital cortex. (A) Low-b, (B) ADC trace, (C) FA, (D) color-coded FA, (E) CI (linear tensor index) (5) highlights areas (higher intensity) with prolate tensors i.e., unidirectional fibers, (F) Cp (planar tensor index) highlights (higher intensity) areas of oblate tensors i.e., areas of rapidly bending/crossing fibers.



**Figure 4.** Occipital cortex: (A) 3-D rendered view. (B) Seed in cortex (deeper WM) showing U-shaped fibers which run down into the WM and up into the cortex. (C) and (D) Seed in GM showing U-shaped fibers which penetrate the WM and terminate in the apices of adjacent gyri.

## Cortical Pathology – TSC (right)

- Tuberos Sclerosis Complex (TSC): a rare genetic disorder of embryogenesis.
- Tubers form on the lateral ventricles and basal ganglia.
- 2mm thick tissue resection samples were obtained from adult brain (for reduction of seizures).
- FA and ADC maps show reversed contrast from normal: i.e. greater FA in GM than WM and higher ADC in WM than GM.
- Tractography shows more arcuate (U) fibers than in normal cortical samples.



**Figure 5.** ADC and FA maps in a cortical resection sample in a case of TSC. Right: Tractography example in TSC cortex, showing a greater prevalence of arcuate fibers.

- Loss of axonal density in WM.
- Loss of longer range WM connections 'unmasks' shorter range intracortical fibers?

## References

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