

Axial Diffusivity and Fractional Anisotropy Correlate With Performance Following Traumatic Brain Injury

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INTRODUCTION

Diffusion tensor imaging (DTI) can provide information about the degree and directionality of tissue water diffusion. Water diffusion is commonly measured by quantifying fractional anisotropy (FA), but diffusivity can also be indexed with axial diffusivity (AD), diffusion of water parallel to axonal tracts, and radial diffusivity (RD), diffusion perpendicular to axonal tracts (see Figure 1). Research indicates that AD and RD differentially predict white matter pathology. For example, decreased axial diffusivity has been shown to be related to axonal damage, while increases in radial diffusivity correlate with myelin damage (Budde et al., 2006, Song et al., 2002). The current study aimed to examine the relationship between these distinct indices of diffusivity with change in reaction time during a working memory task at 3 and 6 months post moderate and severe traumatic brain injury (TBI) in the anterior corpus callosum (genu).

HYPOTHESES

- FA will be positively correlated with AD and negatively correlated with RD.

- Diffusivity measures will predict performance changes during recovery (e.g. reaction time). FA and AD will be negatively correlated with reaction time change and RD will be positively correlated with reaction time.

METHODS

Subjects: Six individuals with moderate and severe TBI. Subjects were Caucasian, ranging in age from 21 to 42, and included 3 males and 3 females.

DTI Data: Data were collected for participants at 3 and 6 months post-injury and values for AD, FA, and RD were calculated. In addition, change in reaction time for a non-verbal working memory task was calculated at both time points. The average duration between scans was 99.5 days (SD = 7.2). Scans were conducted on a Philips 3T MRI scanner at Hershey Medical Center.

Fiber Tracking: The DTI-track module in MedInria was utilized to track fibers and also to calculate average AD, FA, and RD for the genu ROI for each subject at time 1 and time 2. The processing parameters used for the current study were: FA threshold, .3; smoothness of reconstructed fibers, 20; minimum length of fibers to be valid, 50 mm; and sampling was performed for every one voxel out of four. See Figures 2 and 3.

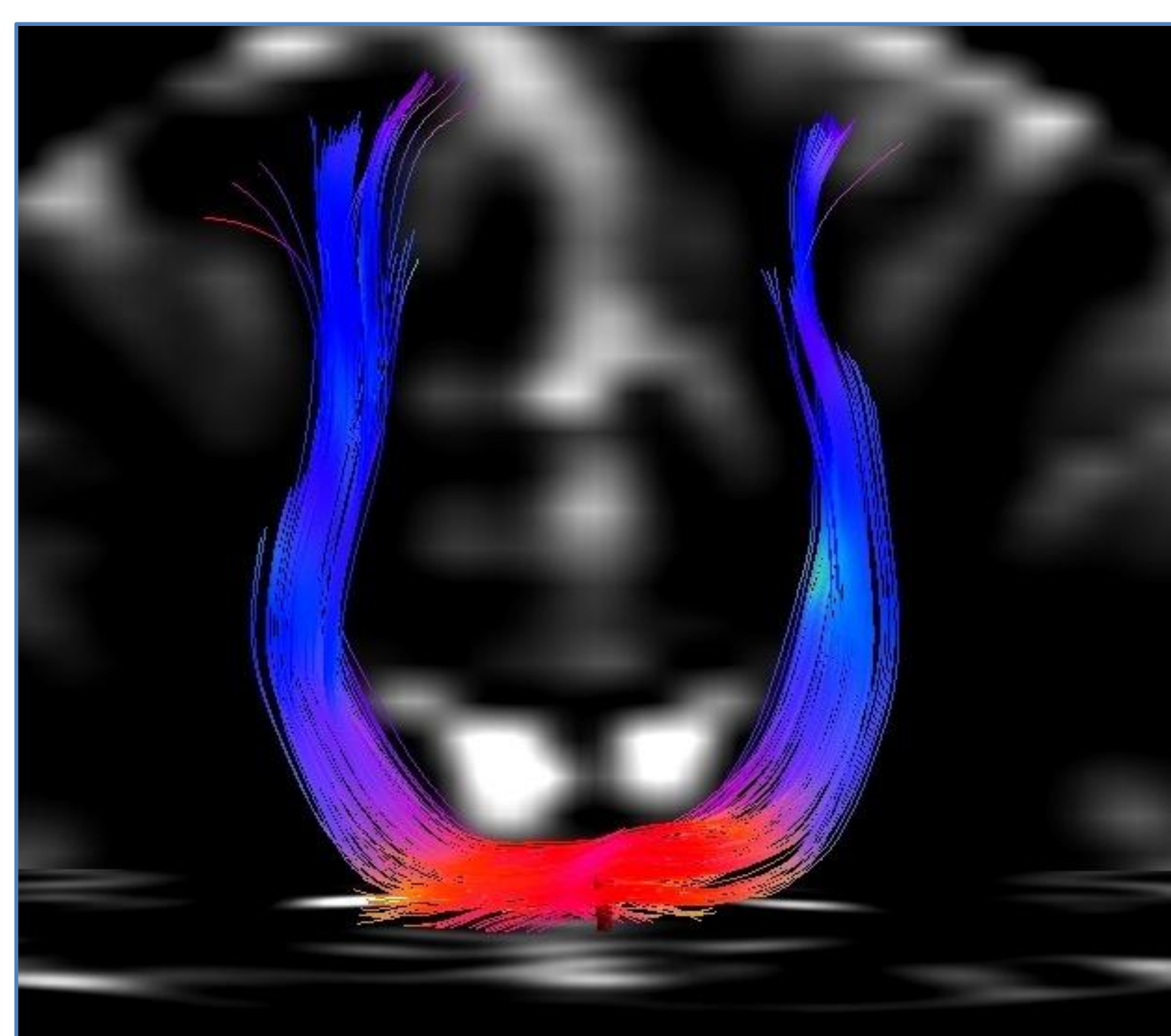


Figure 2. Coronal view of fiber tracking in the genu.

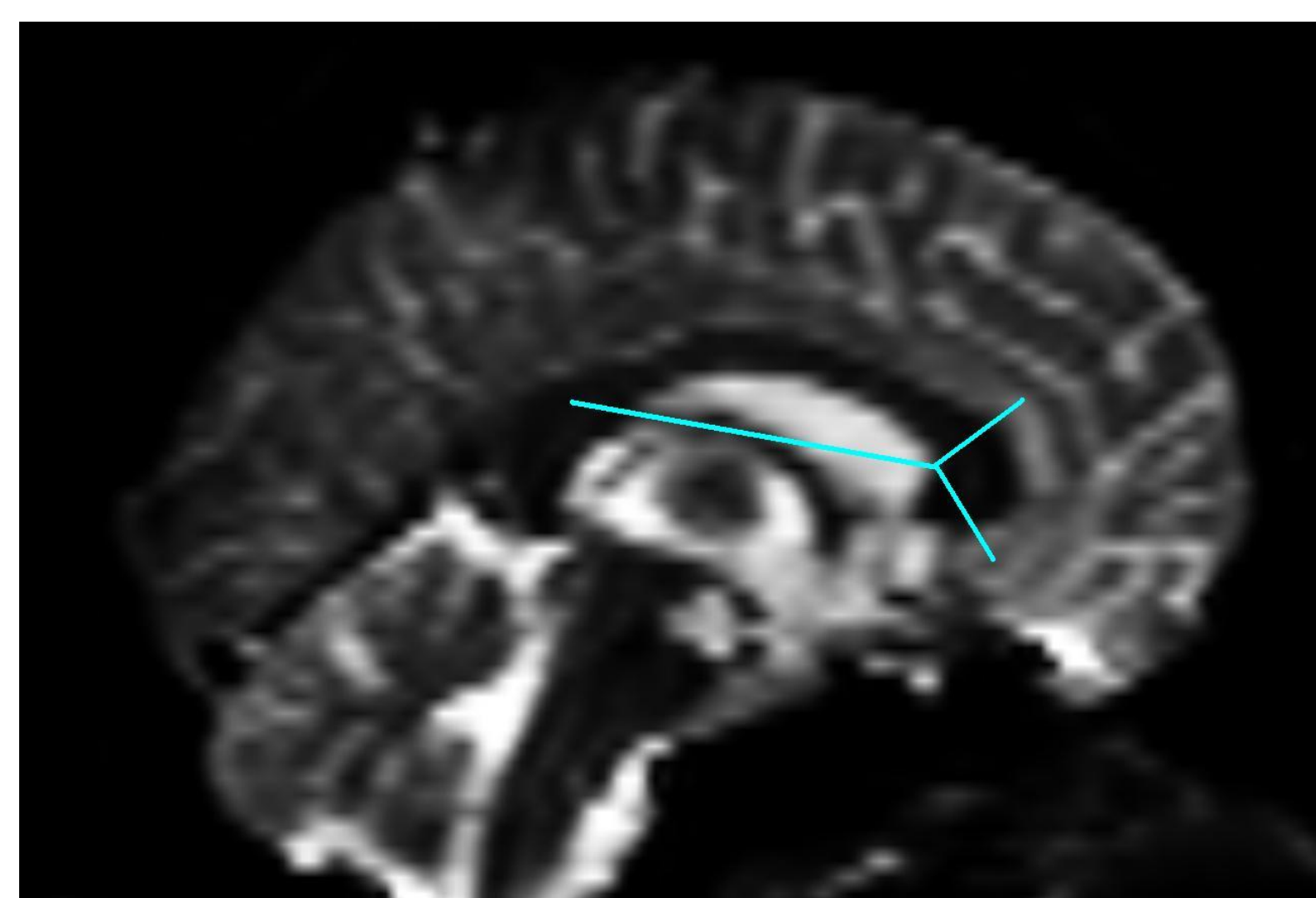
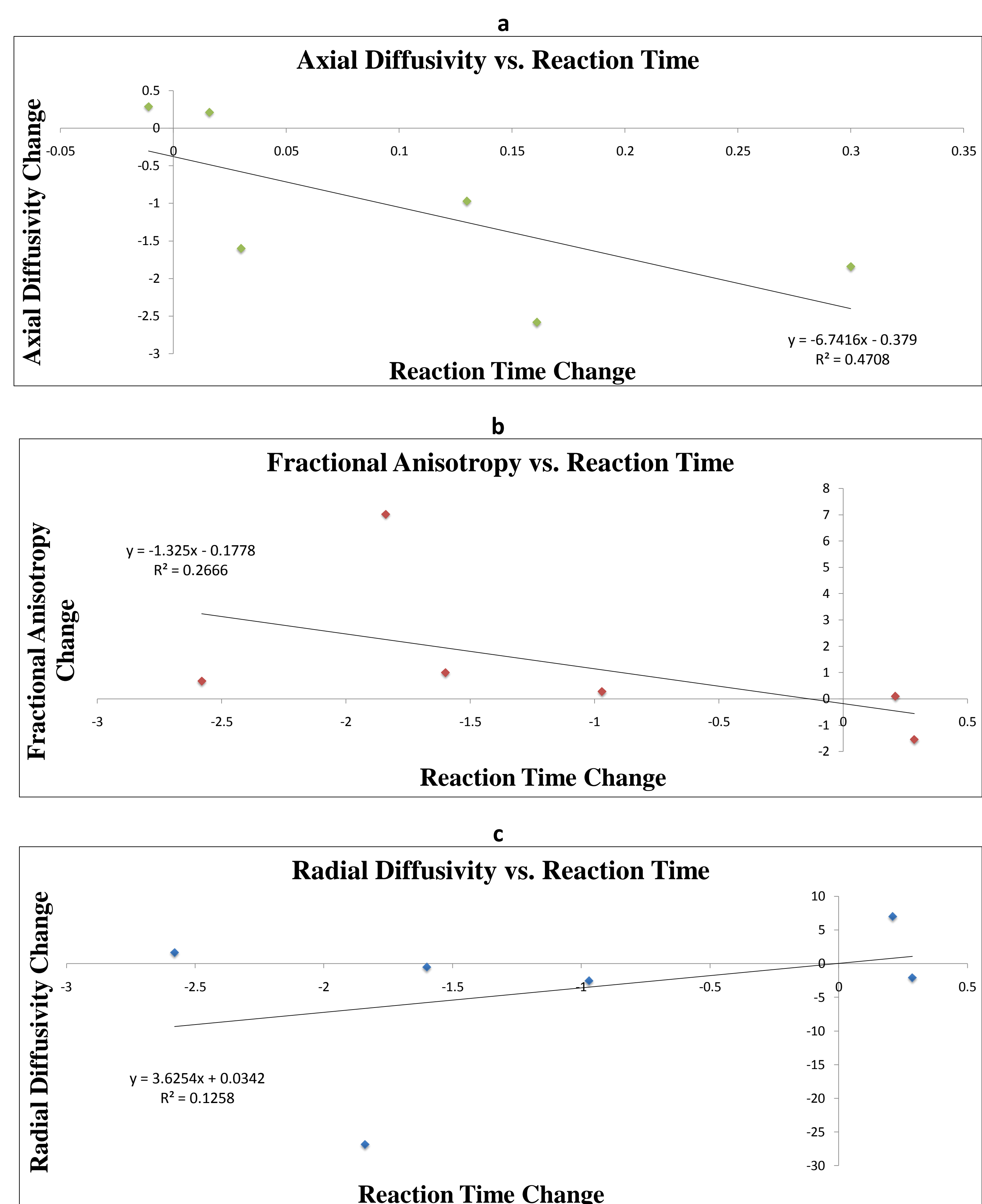


Figure 3. The genu was defined by tracing a line from the posterior 3rd ventricle to the anterior most part of the 3rd ventricle and from this point were two lines, each at 45° on the corpus callosum. This method was repeated for 3 slices in every subject, creating a three dimensional ROI to restrict fiber tracking to the anterior most region of the corpus callosum.

Figure 4 a-c. The following figures show the change in reaction time for each subject plotted against the change in AD, FA, and RD.



RESULTS

Preliminary correlation analyses revealed strong relationships between measures of diffusivity. FA and AD were positively correlated, ($r(5) = .873$, $p < .023$), and both FA and AD were negatively correlated with RD, ($r(5) = -.916$, $p < .010$) and ($r(5) = -.816$, $p < .048$), respectively. When examining the relationship between diffusion indices and reaction time, change in FA and AD were negatively correlated with change in reaction time at follow-up ($r(5) = -.516$, $p < .294$) and ($r(5) = -.686$, $p < .132$), respectively. RD was not as significantly correlated with reaction time as compared to FA and AD, ($r(5) = .349$, $p < .497$). See Figures 4a-c.

CONCLUSIONS

These preliminary results show that distinct indicators of white matter integrity may differentially predict performance following TBI. As predicted, FA and AD were both negatively correlated with reaction time change, though RD failed to show a similar relationship to cognitive improvement. FA and AD may maintain more of a relationship with cognitive recovery due to a greater sensitivity to changes in the acute recovery process following TBI. Continued research in our lab will focus on extending these methods to a larger sample to make determinations about how these distinct indicators of axonal integrity may differentially index recovery in white matter following TBI. It is a goal to determine how distinct methods for quantifying tissue water diffusion may quantify axonal pathology over the recovery course from moderate to severe TBI.

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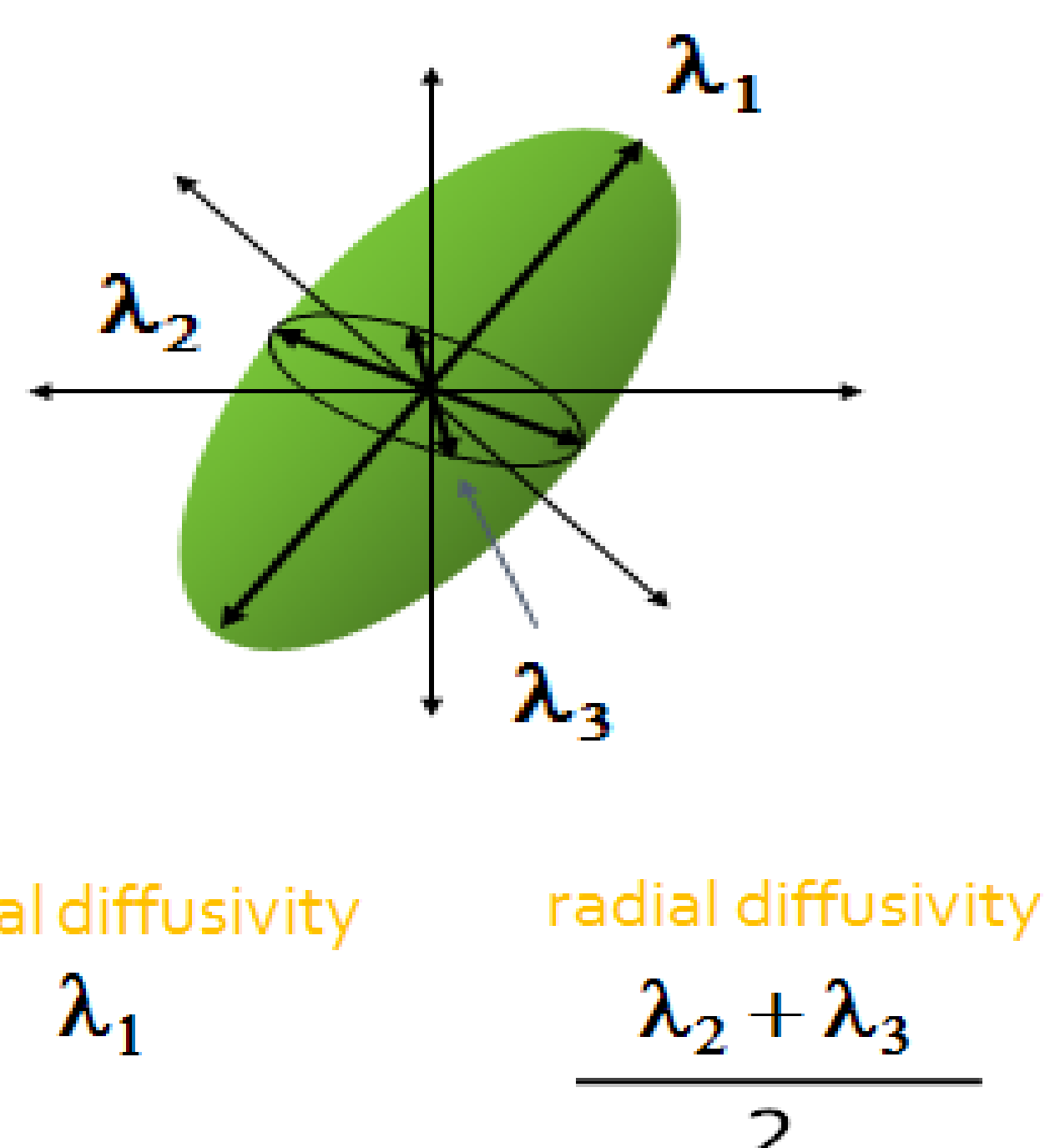


Figure 1. Eigen values extracted from DTI are utilized to quantify axial and radial diffusivity.