Exploring White Matter Microstructure Differences Following Pediatric TBI

ACNN 2023

Florencia Ontiveros

The Social Cognition Adjustment and Neurodevelopment (SCAN) Lab

- Behavioral neuroimaging lab
- Utilize **structural** and **functional** neuroimaging to understand **social and cognitive outcomes** of pediatric chronic illness or brain injury

Dr. Kristen Hoskinson

Principal Investigator

My Experience as an ADNiR Scholar

Data Analysis

- Preprocessing scans
- Statistics

Data Collection

- Neuropsychological assessment and survey administration
- MRI task training
- Obtain MRI data

Developing Skills

- Coding and scripting
- Development of new pipeline
- Writing and communication

Professional Development

- Posters and talks

Traumatic Brain Injury (TBI)

- Falls, motor vehicle-traffic, and struck by/against events are among the leading causes
- Cause of almost half a million ER visits annually from children aged 0-14 years
- One of the most common cause of shearing of white matter pathways
- This puts children at increased risk of white matter degradation even years after injury

How does pediatric TBI affect white matter microstructure?

Faul, M., Wald, M. M., Xu, L., & Coronado, V. G. (2010). Traumatic brain injury in the United States: emergency department visits, hospitalizations, and deaths, 2002-2006.

Neuroimaging of Mechanisms Subserving Cognitive and Social Outcomes in Childhood TBI

- Explores the effect of **childhood TBI** on **cognitive and social development**

- **OI**
  - N=24 (male=16, female=8)
  - Mean age=11.65 yrs

- **cmTBI**
  - N=12 (male=9, female=3)
  - Mean age=12.59 yrs

- **msTBI**
  - N=13 (male=9, female=4)
  - Mean age= 11.30 yrs

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Neuroimaging of Mechanisms Subserving Cognitive and Social Outcomes in Childhood TBI

Neuroimaging data acquired:

- T1- and T2-weighted structural
- DWI
- Resting state fMRI
- Task-based fMRI

Questionnaires:

- ABAS-3 (adaptive skills)
- CBCL (child behavior and emotions)
- BRIEF (executive function)
- Demographics

Tractography

Diffusion weighted imaging (DWI)

- Random movement of water molecules

Tractography

- Reconstruct tracts

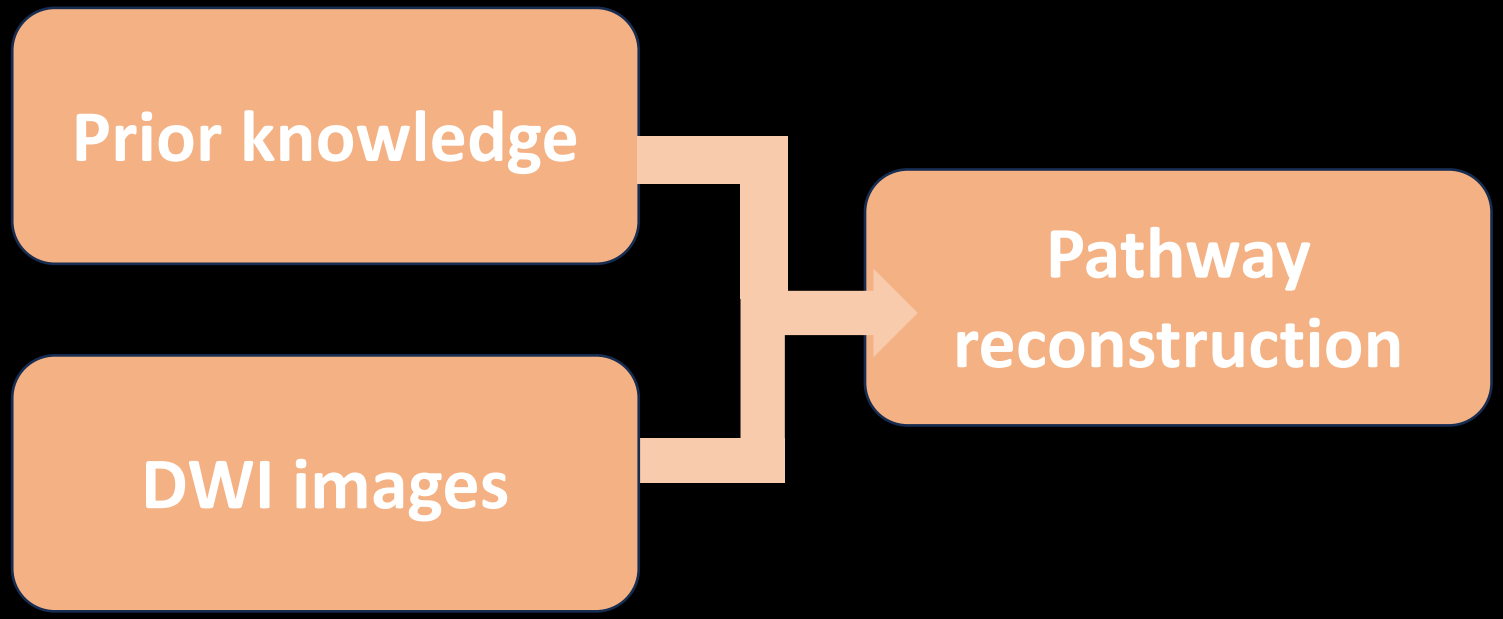
White Matter Measures

- **Fractional anisotropy (FA)**
  - Measures fraction of the diffusion that is anisotropic
  - Ideally: greater FA, better integrity
- **Mean diffusivity (MD)**
  - Ideally: lower MD, better integrity

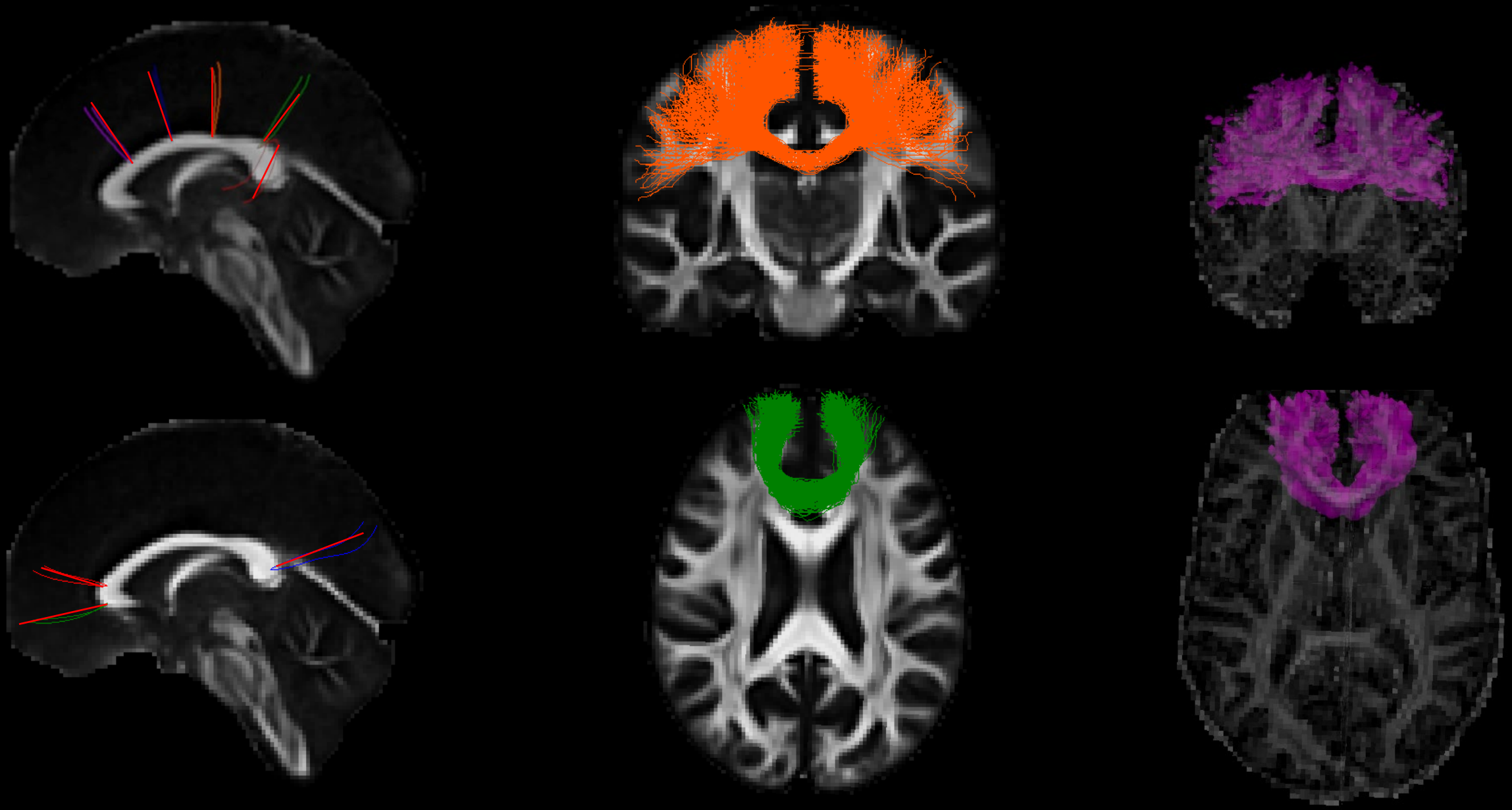
O'Donnell & Westin (2011). An introduction to diffusion tensor image analysis. *Neurosurgery Clinics of North Am*erica.

Freesurfer's TRACULA

- TRActs Constrained by UnderLying Anatomy
- Automatic reconstruction of 42 white matter pathways



Yendiki et al. (2011). Automated probabilistic reconstruction of white-matter pathways in health and disease using an atlas of the underlying anatomy. *Frontiers in Neuroinformatics.*
Maffei et al. (2021). Using diffusion MRI data acquired with ultra-high gradients to improve tractography in routine-quality data. *NeuroImage.*



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Data Analysis

Table 1. One-way ANOVAs between groups.

	Side	df	Mean Square	F	*p*-Value
FA					
CC	Central body	2	.001	.731	.487
	Parietal body	2	.002	1.09	.346
	Prefrontal body	2	.006	3.68	.033*
	Premotor body	2	.001	.361	.699
	Temporal body	2	.000	.151	.860
	Genu	2	.005	2.99	.060
	Rostrum	2	.007	2.42	.100
	Splenium	2	.012	6.55	.003**
MD					
CC	Central body	2	.000	4.95	.011*
	Parietal body	2	.000	6.90	.002**
	Prefrontal body	2	.000	3.15	.052
	Premotor body	2	.000	4.04	.024*
	Temporal body	2	.000	4.41	.018*
	Genu	2	.000	4.07	.024*
	Rostrum	2	.000	8.47	.001**
	Splenium	2	.000	7.94	.001**

Note. Abbreviations: FA = Fractional Anisotropy; CC = Corpus Callosum; MD = Mean Diffusivity.
*the mean difference is significant at the 0.05 level.
**the mean difference is significant at the 0.01 level

Table 1. One-way ANOVAs of FA and MD measures on tracts of the CC.

Data Analysis

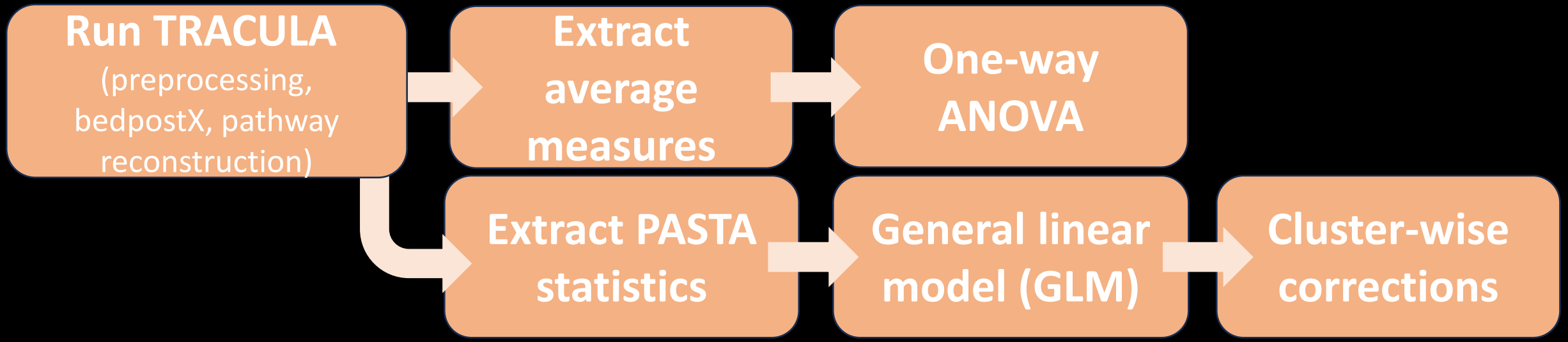
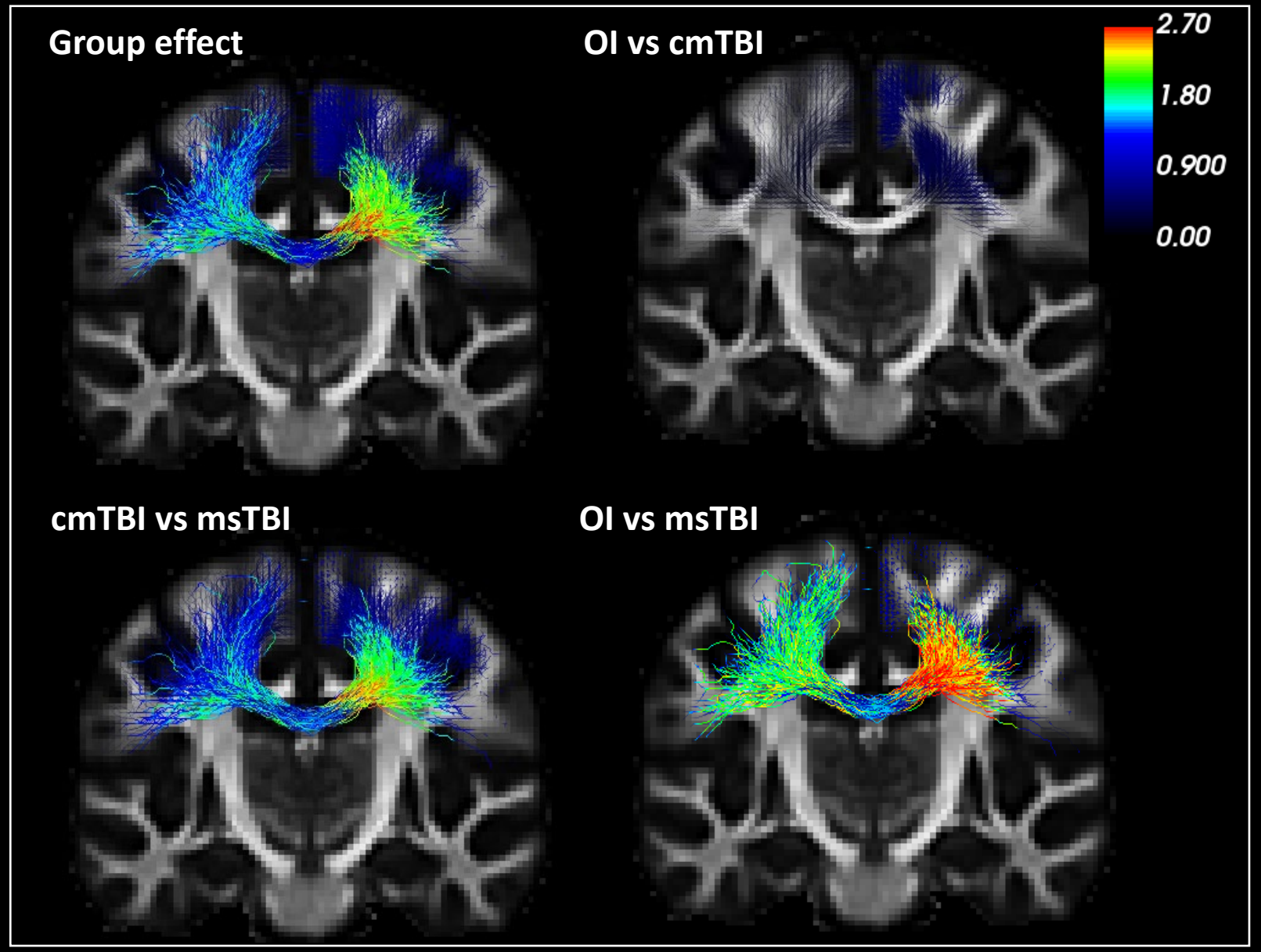


Table 2. Significant FA and MD clusters.

	Side	Size (mm^3)	Peak segment	F-Statistic	*p*-Value*
FA					
CC	Central body	60.8	50.00	2.15	<.04
	Genu	33.8	18.00	2.51	<.05
	Splenium	74.2	25.00	5.14	.005
		60.8	48.00	3.13	<.02
MD					
CC	Central body	70.9	51.00	3.35	<.03
		67.5	73.00	2.29	<.03
	Parietal body	84.4	34.00	3.47	.005
		67.5	89.00	3.69	<.02
		43.9	61.00	2.44	<.05
	Genu	84.4	32.00	2.36	<.01
		47.2	18.00	2.88	<.03
	Rostrum	57.4	19.00	3.12	<.02
		33.8	30.00	2.85	<.05
	Splenium	50.6	74.00	2.88	<.04

Note. Abbreviations: FA = Fractional Anisotropy; CC = Corpus Callosum; MD = Mean Diffusivity.
**p*-values represent cluster-wise corrected *p*-values.

Table 2. Significant group differences in FA and MD on tracts of the CC.



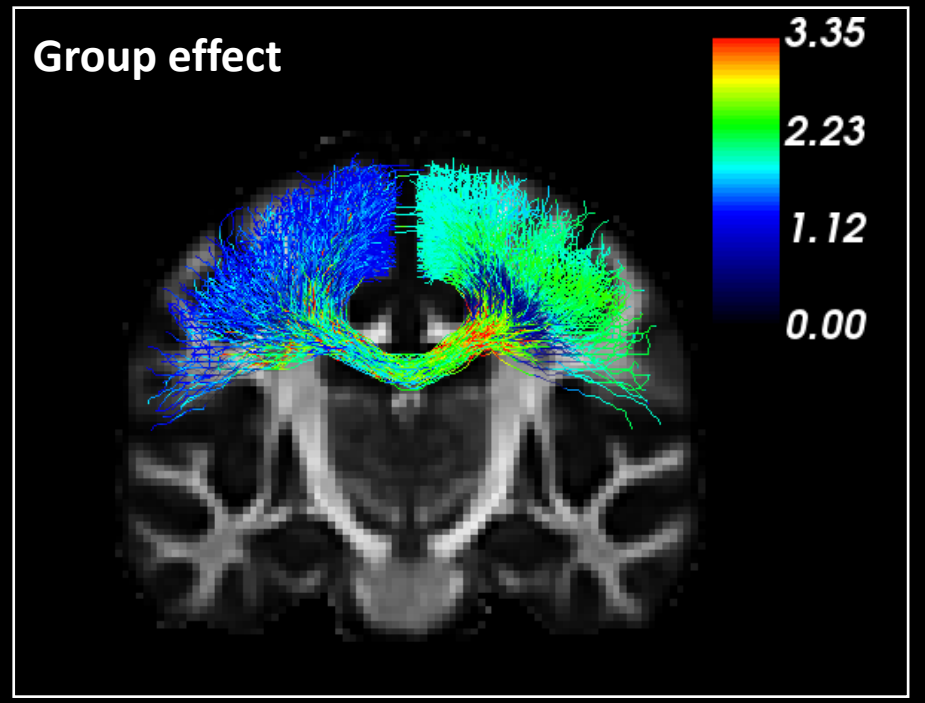
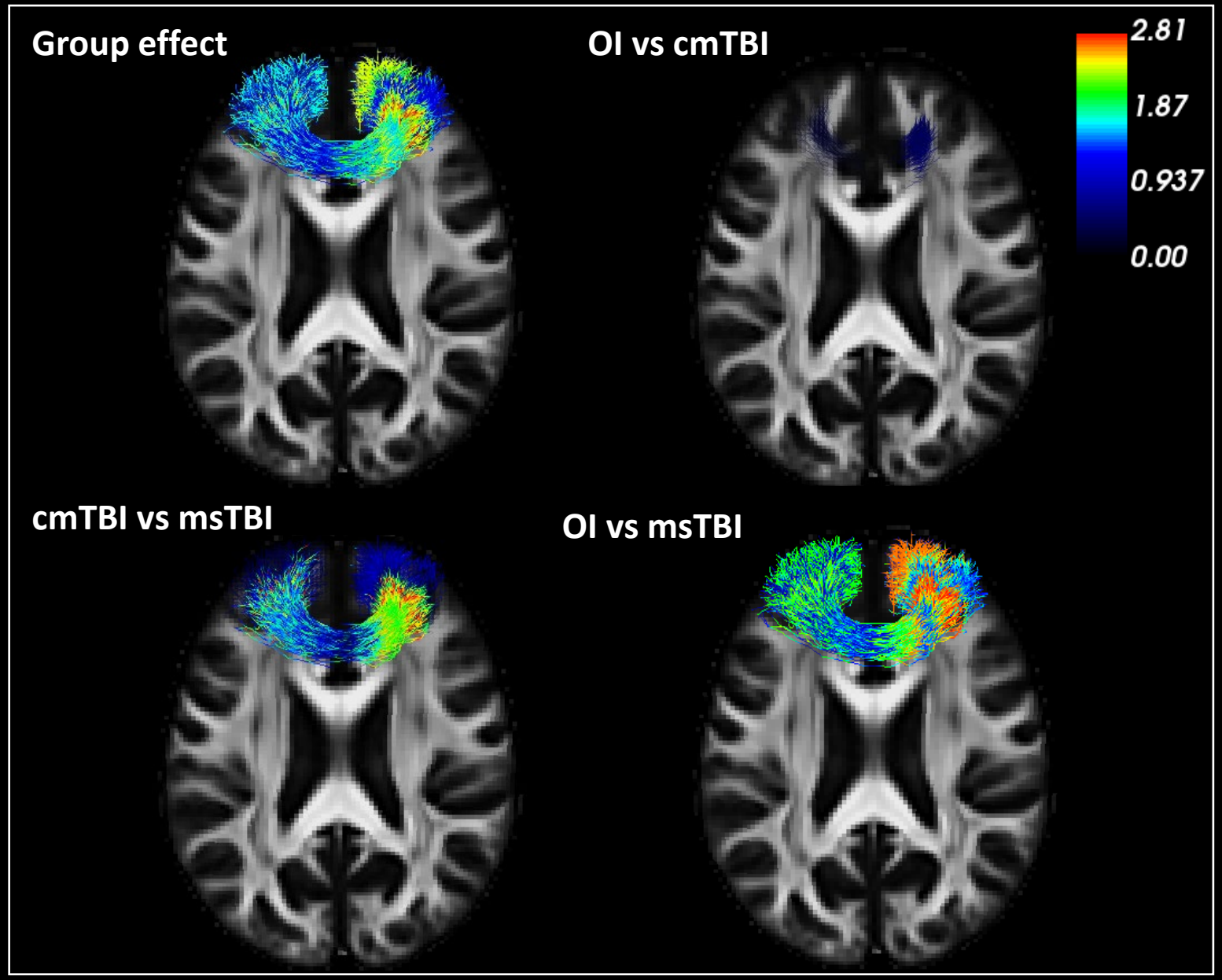


Figure 1. Left: Significant group differences in FA on areas of the central body of the CC (F=2.15, p<.04). msTBI differed with less FA from OI (t=2.51, p<.02), and cmTBI (t=2.01, p<.04). **Right:** Significant group differences in MD on regions of the central body of the CC (F=3.35, p<.03; F=2.29, p<.03).



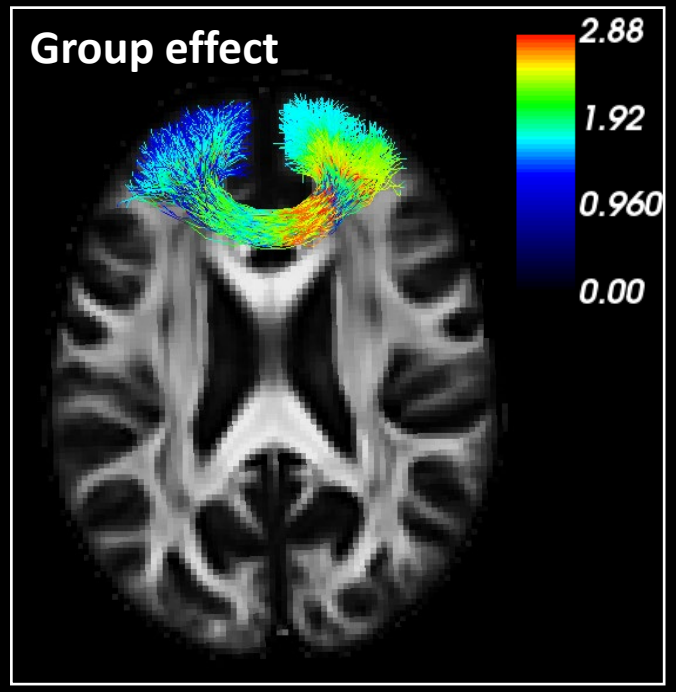
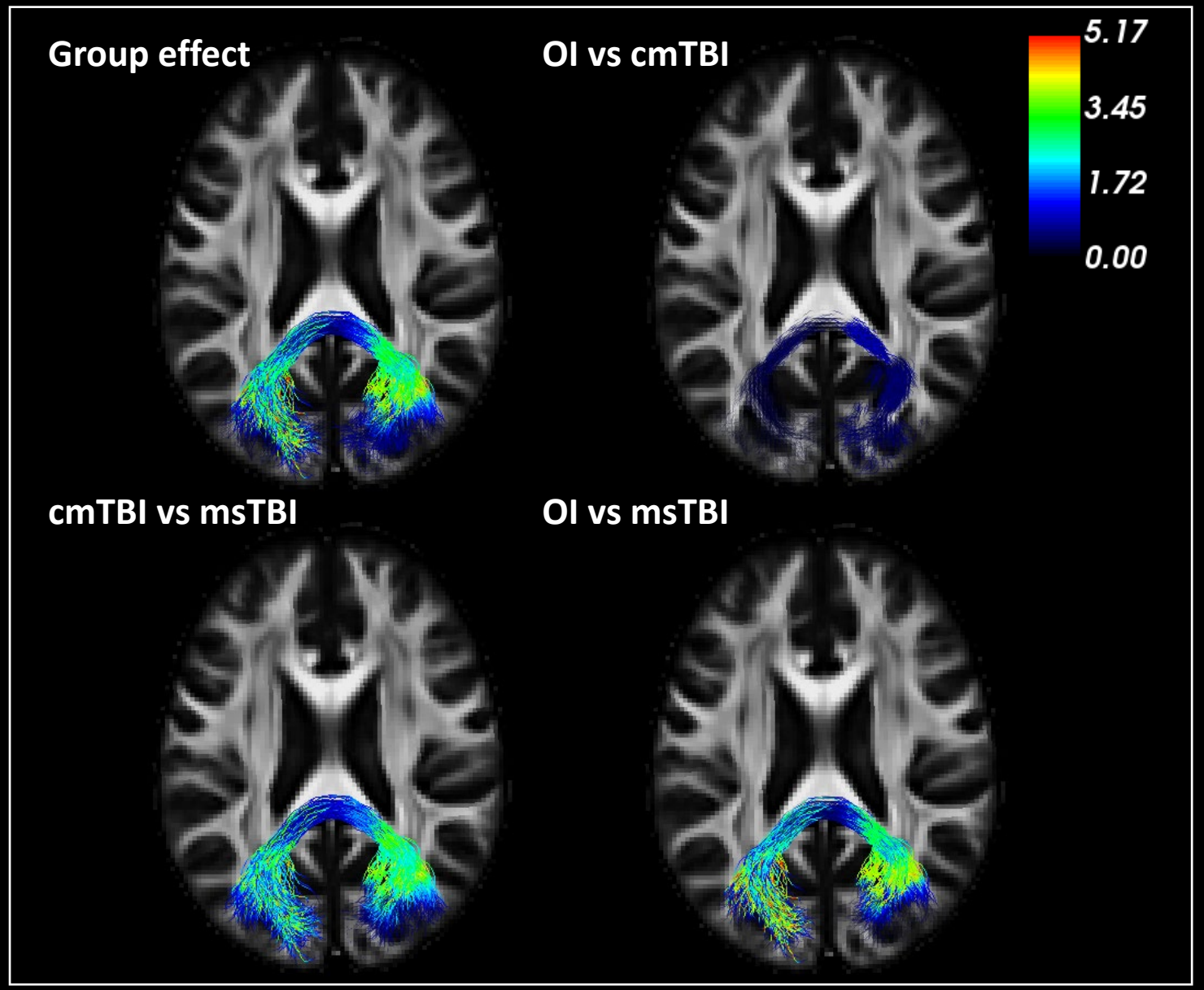


Figure 2. Left: Significant group differences in FA on regions of the genu of the CC (F=2.51, p<.05). msTBI differed with less FA from OI (t=2.80, p=.005) and cmTBI (t=2.08, p<.02; t=2.36, p<.03)**. Right:** Significant group differences in MD on regions of the genu of the CC (F=2.36, p<.01; F=2.88, p<.03).



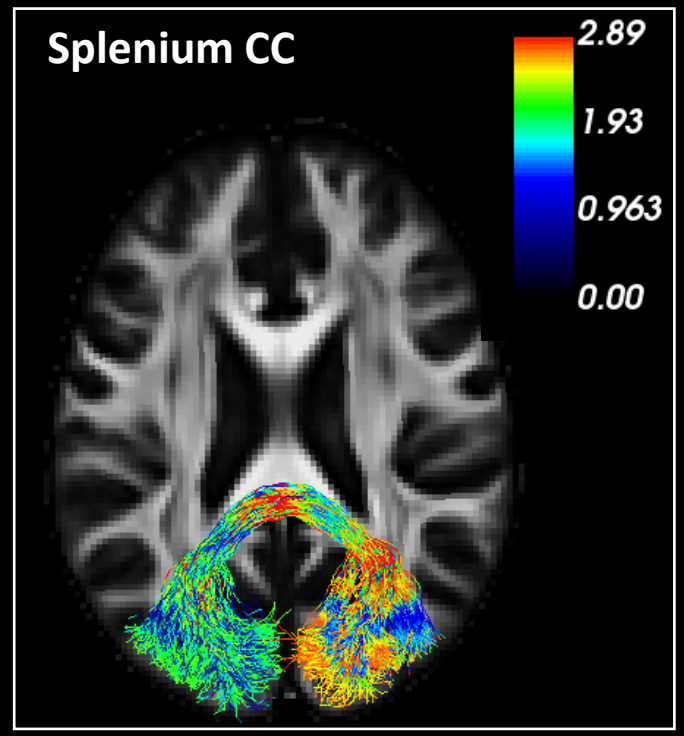


Figure 3. Left: Significant group differences in FA on regions of the splenium of the CC (F=5.14, p=.005; F=3.13, p<.02). msTBI differed with less FA from OI (t=5.16, p<.01; t=2.85, p<.04), and cmTBI (t=4.66, p=.001). **Right:** Significant group differences in MD on regions of the splenium of the CC (F=2.88, p<.04).

So What?

- We found overall **group differences** in white matter integrity in areas of the **Corpus Callosum**
- msTBI group differed from **both** cmTBI and OI groups and may have **sustained damage** even years after injury
- Help in treatment and recovery

How could this manifest in behavior and executive function?

Further Analysis

- Relationship between **white matter integrity** and **behavior**
  - Abstract accepted for a poster presentation at Society for Neuroscience 2023
- Does **white matter integrity** differ among groups during a **spatial working memory** task?
  - Current undergraduate research thesis
- Incorporate this pipeline in ongoing and/or completed studies

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Thank you

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