Test-Retest and Inter-Reader Reliability of Semi-Automated Atlas-Based Analysis of Diffusion Tensor Imaging Data in Acute Cervical Spinal Cord Injury in Adult Patients

[1]D Peterson , [1]D Hippe , [1]A Rutman , [1]A Wilson , [1]J Jarvik , [1]W Cohen , [2]F Chokshi , [1]M Mossa-Basha
[1]University of of Washington, Seattle, WA, [2]Emory University School of Medicine, Atlanta, GA

Purpose

Diffusion Tensor Imaging (DTI) is an emerging tool for the evaluation of acute traumatic cervical spinal cord injury (SCI)[1,2]. Deriving useful measures from DTI of the spinal cord with hand-drawn ROIs can be labor-intensive and may be prone to bias and poor reliability. In this work, we developed and evaluated the test-retest reliability of a semi-automated spinal DTI analysis pipeline in the setting of acute traumatic cervical SCI.

Materials and Methods

***Participants*:** 30 patients with clinical suspicion of acute traumatic cervical SCI

Imaging: Two separate axial DTI scans during the same imaging session, separated by patient removal and repositioning. A STIR image was also collected.

Processing: The raw diffusion weighted images were used as input into an analysis pipeline that uses the Spinal Cord Toolbox for atlas-based parcellation of spinal cord images[3,4]. Single-point manual seeds were placed to identify three spinal levels on the STIR image. All manual steps were repeated with another reader after minimal training.

Measures: Mean Diffusivity (MD) and Fractional Anisotropy (FA) metrics within 13 bilateral atlas regions, as well as Gray Matter (GM) and White Matter (WM) ROIs were extracted across spinal levels.

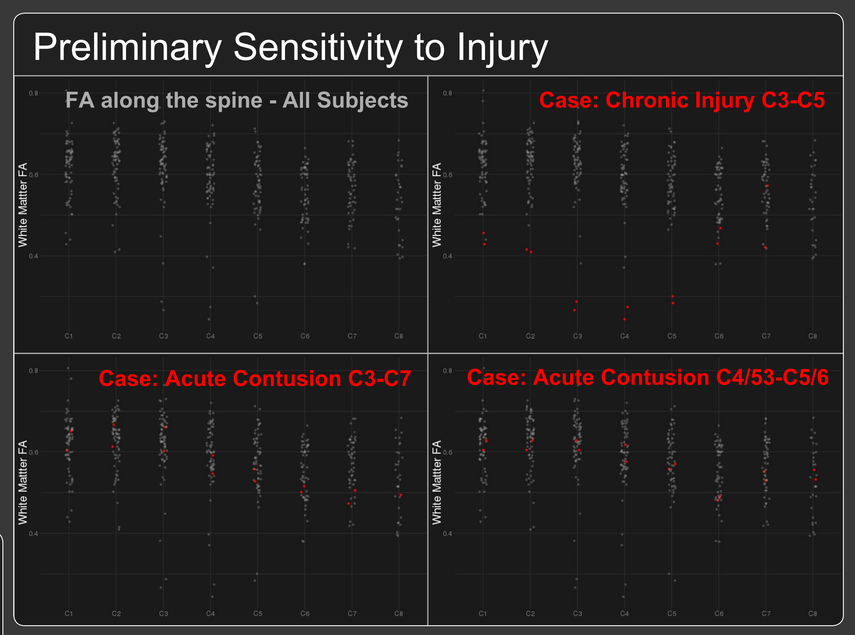
Analysis: Reliability was assessed by intraclass correlation coefficient (ICC) values, with ICC > 0.6 taken as a threshold of good reliability.

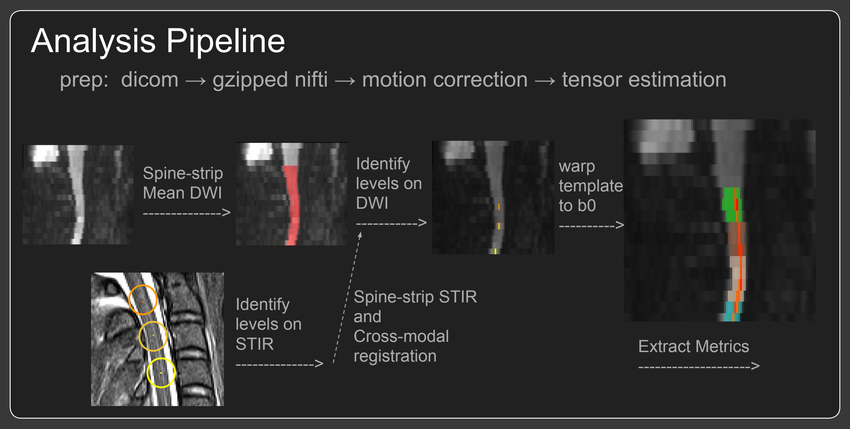
Results

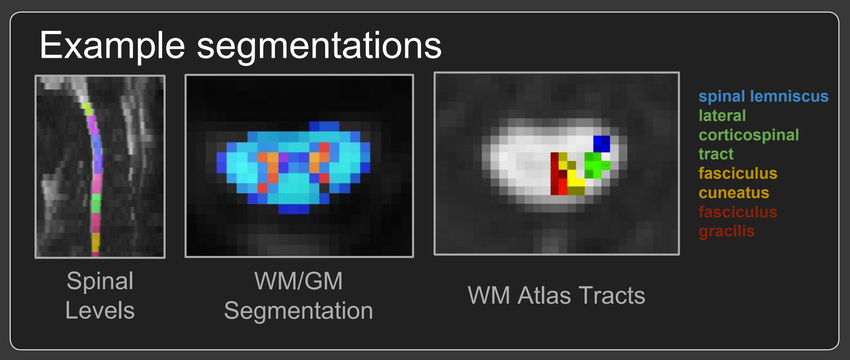
- FA and MD metrics within WM and GM all had ICC > 0.6 (0.83 for GM FA, 0.93 for WM FA, 0.66 for GM MD, and 0.64 for WM MD).
- FA within individual tracts showed good or better reliability in 10 out of a total of 13 atlas tracts.
- Inter-reader reliability was good or better across all structures and measures, and 0.7 or greater for all FA measures.
- Qualitative assesment of metrics indicates sensitivity to level and extent of injury

Intraclass Correlation:
0.21-0.40 - fair 0.41-0.60 - moderate
0.61-0.80 - good 0.81-1.00 - excellent

	Scan-Rescan		Inter-Reader	
	FA	MD	FA	MD
White Matter	0.93	0.86	0.90	0.93
Grey Matter	0.83	0.66	0.95	0.88
Ventral white matter tracts	0.72	0.75	0.88	0.90
Ventral reticulospinal tract	0.47	0.57	0.73	0.82
Ventral corticospinal tract	0.56	0.69	0.76	0.81
Lateral vestibulospinal tract	0.58	0.62	0.81	0.87
Spino-olivary tract	0.68	0.74	0.87	0.87
Tectospinal tract	0.69	0.58	0.88	0.85
Lateral white matter tracts	0.84	0.71	0.92	0.78
Ventral spinocerebellar tract	0.72	0.72	0.83	0.81
Ventrolateral reticulospinal tract	0.69	0.66	0.81	0.83
Spinal lemniscus	0.78	0.67	0.91	0.84
Rubrospinal tract	0.66	0.56	0.81	0.65
Lateral corticospinal tract	0.80	0.69	0.88	0.75
Dorsal white matter tracts	0.80	0.71	0.89	0.80
Fasciculus cuneatus	0.79	0.70	0.89	0.79
Fasciculus gracilis	0.75	0.66	0.86	0.77







Conclusions

- Atlas-based parcellation of spinal DTI data shows good to excellent test-retest reliability, particularly for FA and for WM measures
- Spinal tract-specific diffusion metrics are especially reliable within the larger tracts.
- The required manual step introduces minimal variability in the extracted metrics.

References

[1]Cheran S, Shanmuganathan K, Zhuo J, et al. Correlation of MR diffusion tensor imaging parameters with ASIA motor scores in hemorrhagic and nonhemorrhagic acute spinal cord injury. J Neurotrauma 2011;28(9):1881-1892.
[2]Mulcahey MJ, Samdani A, Gaughan J, et al. Diffusion tensor imaging in pediatric spinal cord injury: preliminary examination of reliability and clinical correlation. Spine 2012;37(13):E797-803.
[3]De Leener B, Levy S, Dupont SM, Fonov VS, Stikov N, Louis Collins D, Callot V, CohenAdad J. SCT: Spinal Cord Toolbox, an opensource software for processing spinal cord MRI data. Neuroimage 2016
[4]Fonov VS, Le Troter A, Taso M, et al. Framework for integrated MRI average of the spinal cord white and gray matter: the MNI-Poly- AMU template. NeuroImage 2014;102 Pt 2:817-827.

correspondence: djpeters@uw.edu, mossab@uw.edu