Diffusion tensor imaging for mild traumatic brain injury

Diffusion tensor imaging can be used to predict recovery in mTBI patients. Unlike computed tomography or conventional magnetic resonance imaging, DTI is sensitive to microstructural axonal injury, the neuropathology that is thought to be most responsible for the persistent cognitive and behavioral impairments that often occur after mTBI. Through the use of newer DTI analysis techniques such as automated region of interest analysis, tract-based voxel-wise analysis, and quantitative tractography, researchers have shown that frontal and temporal association white matter pathways are most frequently damaged in mTBI and that the microstructural integrity of these tracts correlates with behavioral and cognitive measures. Future longitudinal DTI studies are needed to elucidate how symptoms and the microstructural pathology evolve over time. Moving forward, large-scale investigations will ascertain whether DTI can serve as a predictive imaging biomarker for long-term neurocognitive deficits after mTBI that would be of value for triaging patients to clinical trials of experimental cognitive enhancement therapies and rehabilitation methods, as well as for monitoring their response to these interventions [1)].

Mild Traumatic brain injury (mTBI) is a signature wound in military personnel, and repetitive mTBI has been linked to age-related neurodegenerative diseases that affect white matter (WM) in the brain. However, findings of injury to specific white matter tracts have been variable and inconsistent. This may be due to the heterogeneity of mechanisms, etiology, and comorbid disorders related to mTBI. Non-negative matrix factorization (NMF) is a data-driven approach that detects covarying patterns (components) within high-dimensional data. Bouchard et al. applied NMF to Diffusion-weighted magnetic resonance imaging data from military Veterans with and without a self-reported TBI history. NMF identified 12 independent components derived from fractional anisotropy (FA) in a large dataset (n = 1,475) gathered through the ENIGMA (Enhancing Neuroimaging Genetics through Meta-Analysis) Military Brain Injury working group. Regressions were used to examine TBI- and mTBI-related associations in NMF-derived components while adjusting for age, sex, post-traumatic stress disorder, depression, and data acquisition site/scanner. They found significantly stronger age-dependent effects of lower FA in Veterans with TBI than Veterans without in four components ($q < 0.05$), which are spatially unconstrained by traditionally defined WM tracts. One component, occupying the most peripheral location, exhibited significantly stronger age-dependent differences in Veterans with mTBI. They found NMF to be powerful and effective in detecting covarying patterns of FA associated with mTBI by applying standard parametric regression modeling. The results highlight patterns of WM alteration that are differentially affected by TBI and mTBI in younger compared to older military Veterans [2)].

DTI and MRS have been at the forefront of research as a result of their noninvasiveness and ease of acquisition, and hence it is thought that the use of these neuroimaging modalities has the potential to aid clinical decision making and management, including guiding return-to-play protocols [3)].

1)

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2)

Bouchard HC, Sun D, Dennis EL, Newsome MR, Disner SG, Elman J, Silva A, Velez C, Irimia A, Davenport ND, Sponheim SR, Franz CE, Kremen WS, Coleman MJ, Williams MW, Geuze E, Koerte IK, Shenton ME, Adamson MM, Coimbra R, Grant G, Shutter L, George MS, Zafonte RD, McAllister TW, Stein MB, Thompson PM, Wilde EA, Tate DF, Sotiras A, Morey RA. Age-dependent white matter disruptions after military traumatic brain injury: Multivariate analysis results from ENIGMA brain injury. Hum Brain Mapp. 2022 Mar 15. doi: 10.1002/hbm.25811. Epub ahead of print. PMID: 35289463.

3)

Dimou S, Lagopoulos J. Toward Objective Markers of Concussion in Sport: A Review of White Matter and Neurometabolic Changes in the Brain after Sports-Related Concussion. J Neurotrauma. 2014 Jan 23. [Epub ahead of print] PubMed PMID: 24266534.