Diffusion Tensor Imaging Tractography for traumatic brain injury

DTI techniques are sensitive for TBI at the group level only and there is insufficient evidence that DTI plays a role at the individual level. We conclude by discussing future directions in DTI research in TBI including the role of machine learning in the pattern classification of TBI [1)].

DTI parameters, assessed at approximately day 12 after injury, correlated with mortality at 6 months in patients with severe TBI or aSAH. Similar patterns were found for both TBI and aSAH patients. This supports a potential role of DTI as early endpoint for clinical studies and a predictor of late mortality [2)].

Mild traumatic brain injury

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 [3)].

Despite enormous research interest in diffusion tensor and kurtosis imaging (DTI; DKI) following mild traumatic brain injury (MTBI), it remains unknown how diffusion in white matter evolves post-injury and relates to acute MTBI characteristics.

This prospective cohort study aimed to characterize diffusion changes in white matter the first year after MTBI. Patients with MTBI (n=193) and matched controls (n=83) underwent 3T MRI within 72 hours and 3- and 12-months post-injury. Diffusion data were analyzed in three steps: (1) voxel-wise comparisons between the MTBI- and control group were performed with tract-based spatial statistics at each time point; (2) clusters of significant voxels identified in (1) were evaluated longitudinally with mixed effect models; (3) the MTBI group was divided into (A) complicated (with macrostructural findings on MRI) and uncomplicated MTBI, (B) long (1-24 hours) and short (< 1 hour) post-traumatic amnesia (PTA), and (C) other and no other concurrent injuries, to investigate if findings in (1) were driven mainly by aberrant diffusion in patients with a more severe injury. At 72 hours, voxel-wise comparisons revealed significantly lower fractional anisotropy (FA) in one tract and significantly lower mean kurtosis (Kmean) in 11 tracts in the MTBI- compared to control group. At 3 months, the MTBI group had significantly higher mean diffusivity in 8 tracts compared to controls. At 12 months, FA was

significantly lower in 4 tracts and Kmean in 10 tracts in patients with MTBI compared to controls. There was considerable overlap in affected tracts across time, including the corpus callosum, corona radiata, internal and external capsule, and cerebellar peduncles. Longitudinal analyses revealed that the diffusion metrics remained relatively stable throughout the first year after MTBI. The significant group*time interactions identified were driven by changes in the control- rather than the MTBI group. Further, differences identified in step 1 did not result from greater diffusion abnormalities in patients with complicated MTBI, long PTA, or other concurrent injuries, as standardized mean differences in diffusion metrics between the groups were small (0.07±0.11) and non-significant. However, follow-up voxel-wise analyses revealed that other concurrent injuries had effects on diffusion metrics, but predominantly in other metrics, and at other time points, than the effects observed in the MTBI versus control group analysis. In conclusion, patients with MTBI differed from controls in white matter integrity already 72 hours after injury. Diffusion metrics remained relatively stable throughout the first year after MTBI and were not driven by deviating diffusion in patients with a more severe MTBI [4].

1)

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2)

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3)

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4)

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