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Functional Neurocognitive Imaging (fNCI): A Diagnostic Tool for Assessing Concussion Neuromarker Abnormalities and Treating Post-Concussion Syndrome in Mild Traumatic Brain Injury Patients

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Abstract : Purpose: Pathological dysregulation of Neurovascular Coupling (NVC) caused by mild traumatic brain injury (mTBI) is the predominant source of chronic post-concussion syndrome (PCS) symptomology. fNCI has the ability to localize dysregulation in NVC by measuring blood-oxygen-level-dependent (BOLD) signaling during the performance of fMRI-adapted neuropsychological evaluations. With fNCI, 57 brain areas consistently affected by concussion were identified as PCS neural markers, which were validated on large samples of concussion patients and healthy controls. These neuromarkers provide the basis for a computation of PCS severity which is referred to as the Severity Index Score (SIS). The SIS has proven valuable in making pre-treatment decisions, monitoring treatment efficiency, and assessing long-term stability of outcomes. Methods and Materials: After being scanned while performing various cognitive tasks, 476 concussed patients received an SIS score based on the neural dysregulation of the 57 previously identified brain regions. These scans provide an objective measurement of attentional, subcortical, visual processing, language processing, and executive functioning abilities, which were used as biomarkers for post-concussive neural dysregulation. Initial SIS scores were used to develop individualized therapy incorporating cognitive, occupational, and neuromuscular modalities. These scores were also used to establish pre-treatment benchmarks and measure post-treatment improvement. Results: Changes in SIS were calculated in percent change from pre- to post-treatment. Patients showed a mean improvement of 76.5 percent (σ= 23.3), and 75.7 percent of patients showed at least 60 percent improvement. Longitudinal reassessment of 24 of the patients, measured an average of 7.6 months post-treatment, shows that SIS improvement is maintained and improved, with an average of 90.6 percent improvement from their original scan. Conclusions: fNCI provides a reliable measurement of NVC allowing for identification of concussion pathology. Additionally, fNCI derived SIS scores direct tailored therapy to restore NVC, subsequently resolving chronic PCS resulting from mTBI.

Keywords : concussion, functional magnetic resonance imaging (fMRI), neurovascular coupling (NVC), post-concussion syndrome (PCS)
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