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Characterizing long-term neurocognitive outcomes through diffusion tensor imaging in childhood brain tumor survivors

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Abstract

Background: Diffusion tensor imaging (DTI) can probe the longitudinal microstructural integrity and development of the brain. This study characterizes the relationship between long-term neurocognition and changes in fractional anisotropy (FA) and mean diffusivity (MD) of the corpus callosum and hippocampus in childhood brain tumor survivors.

Methods: Patients diagnosed with a brain tumor at < 18 years of age with ≥ 2 neurocognitive assessments retrospectively paired with DTI were eligible. Multi-trajectory modeling clustered patients into distinct neurocognitive trajectories based on intelligent quotient, processing speed index and working memory. Linear mixed models were used to determine whether patient clusters were associated with change in MD and FA. Patient clusters were compared to healthy subjects.

Results: From 2014 to 2022, 68 patients with 464 neurocognitive assessments paired with DTI and 80 healthy subjects were included. Multi-trajectory modeling identified two patient clusters: (1) low-performance, with declining scores below the normative mean, and (2) normal-performance. Compared to the low-performance group, the normal-performance group demonstrated greater increase in FA and greater decrease in MD within the corpus callosum and hippocampus, respectively. This pattern was consistent across multiple white matter tracts, highlighting global differences between the groups. Directional change of FA and MD observed in healthy subjects mirrored that of the normal-performance group, but was opposite to that of the low-performance group.

Conclusion: Compared to the normal performance group, the low-performance group demonstrated reduced white matter microstructural integrity and higher mean diffusivity in the hippocampus over time, opposite to what is observed in normally developing children. This suggests aberrant neurodevelopment may contribute to late neurocognitive impairment.

Keywords: brain tumor; diffusion tensor imaging; neurocognitive impairment.