Purpose: To characterize therapy-induced changes in normal-appearing brainstems of childhood brain tumor patients by serial diffusion tensor imaging (DTI).

Methods: We analyzed sequential DTI of 20 brain tumor patients, aged 4-23 years, with normal-appearing brainstems included in the radiation treatment fields. Prescribed tumor doses ranged from 54 to 59.4 Gy. Parametric maps of fractional anisotropy (FA) and apparent diffusion coefficient (ADC) were computed and registered to three-dimensional radiation dose data. Volumes of interest included corticospinal tracts, medial lemnisci, and the pons. Serving as an age-related benchmark for comparison, DTI studies from 20 healthy volunteers, aged 6-25 years, were included in the analysis.

Results: The median DTI follow-up was 3.5 years (range, 1.6-5.0 years). The median mean dose to the pons was 56 Gy (range, 7-59 Gy). Three distinctive patterns of temporal changes in FA and ADC were observed in the pons: (1) a stable or normal developing time trend similar to those observed in healthy children, (2) initial deviation from normal with subsequent recovery, (3) progressive deviation without evidence of complete recovery. In this group of patients without severe brainstem necrosis, maximal decline in FA often occurred 1.5 to 3.5 years after the start of radiation therapy. A full recovery time trend could be observed within 4 years. Patients with incomplete recovery often had a larger decline in FA within the first year. Radiation dose alone did not predict long-term recovery patterns.

Conclusions: Longitudinal DTI analysis revealed variation among individual patients in diffusion properties of brainstems reflecting therapy-induced white matter injury and recovery. Early response in brainstem anisotropy may serve as an indicator of the recovery time trend over 5 years following radiation therapy. Attention should be given to patients with pronounced early changes since DTI suggested their recovery was slower and less complete than other patients.

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