The Use of Diffusion Tensor Metrics and Tractography in Differentiating Between Infiltrating and Well-circumscribed Tumors of the Posterior Fossa

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INTRODUCTION: Diffusion tensor imaging (DTI) and tractography has been demonstrated to provide a method for characterizing the anatomic tracts within the brain and brainstem. The purpose of this study is to determine if diffusion tensor metrics including fractional anisotropy (FA), mean diffusivity (MD), longitudinal (E^{long}) and transverse (E^{trans}) eigenvalues as well as fiber tractography of brainstem white matter tracts are useful in distinguishing between infiltrating and well-circumscribed tumors of the posterior fossa.

MATERIALS AND METHODS: A review of patients with posterior fossa tumors who underwent preoperative MRI with DTI was performed. Histopathologic data were collected. MRI images of the brain were reviewed by a blinded observer. Images were obtained on a standard head coil at 1.5T with diffusion tensor imaging using a single-shot echo planar imaging sequence (TR/TE/SL: 4000/99/5, 128x128 matrix, 240x240 FOV) obtained in 6 directions at a b value of 1000s mm^{-2}. Diffusion tensor images were post-processed using a Siemens Leonardo workstation and Siemens/MGH DTI taskcard.

Conventional MR images were reviewed. FA color-maps were used to localize brainstem white matter tracts: medullary pyramids, pontine corticospinal tracts, transverse pontine fibers, medial lemniscus/central tegmental tracts, brachium pontis, and cerebral peduncles. Using regions of interest, FA, MD, as well as E^{long} and E^{trans} eigenvalues were measured in each visualized white matter tract. Fiber tractography was performed.

Patients were divided into two groups based on tumor type: infiltrating tumors and well-circumscribed tumors. Unequal-variance t tests were used to compare groups in terms of DTI measures.

RESULTS*:* We studied 36 patients with posterior fossa tumors: 16 infiltrating tumors (15 brainstem glioma, 1 CNS sarcoma) and 20 well-circumscribed lesions (10 JPA, 4 ependymoma, 2 medulloblastoma, 2 hemangioblastoma, 1 choroid plexus papilloma, and 1 epidermoid). There were 18 males and 18 females with average age of 16.2 years. Comparison was made to 29 controls.

Both patient groups had elevated MD, decreased FA, elevated E^{long}, and elevated E^{trans} compared to controls ($p<0.05$) in multiple brainstem white matter tracts with T2 prolongation. In the corticospinal tracts with T2 prolongation, MD was higher ($p=0.006$), FA was lower ($p=0.003$), and E^{trans} was higher ($p=0.008$) in patients with infiltrating tumors compared with well-circumscribed tumors. A similar trend was observed in the transverse pontine fibers ($p=0.06$). No difference was detected in E^{long} measures between patient groups.

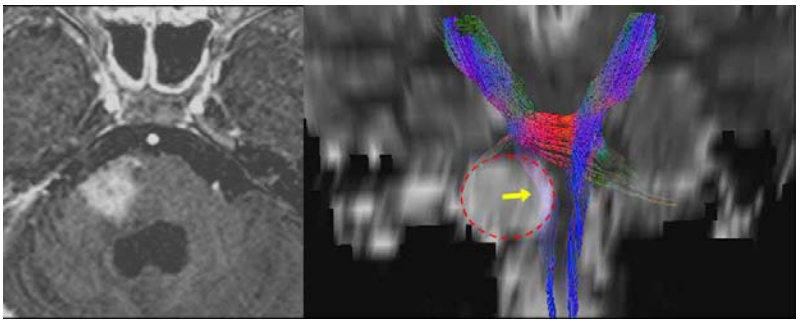

Figure 1. Post-contrast T1 weighted image demonstrates an enhancing mass lesion in the right pons. Coronal tractography image shows the mass (outlined in red) displacing but not disrupting the right corticospinal tract (arrow) in this biopsy proven ependymoma.

In normal appearing white matter (NAWM), there was lower MD in the corticospinal tracts ($p=0.02$) in patients with infiltrating tumors compared to those with well-circumscribed tumors. There was also higher FA in the corticospinal tracts ($p=0.02$), cerebral peduncles ($p=0.007$), and brachium pontis ($p=0.004$). There was no difference between metrics obtained in NAWM in patients and controls.

Using tractography, circumscribed lesions such as JPA tended to displace brainstem fiber tracts, whereas brainstem gliomas tended to disrupt them (Figure 1).

CONCLUSION: Within brainstem white-matter tracts in patients with posterior fossa tumors, tensor metrics are abnormal. Differences in metrics exist between infiltrating tumors and well-circumscribed tumors, in areas of T2 signal abnormality and in NAWM. Fiber tracts also tend to be more disrupted in patients with infiltrating tumors.

Our findings support the notion that NAWM in patients with infiltrating tumors is abnormal. DTI is a useful technique to characterize tumors of the posterior fossa and may provide an *in vivo* method to differentiate tumoral infiltration from edema.