Diffusion Tensor Imaging of Tract Involvement in Children with Pontine Tumors

BACKGROUND AND PURPOSE: Conventional MR imaging permits subcategorization of brain stem tumors by location and focality; however, assessment of white matter tract involvement by tumor is limited. Diffusion tensor imaging (DTI) is a promising method for visualizing white matter tract tumor involvement supratentorially. We investigated the ability of DTI to visualize and quantify white matter tract involvement in pontine tumors.

METHODS AND MATERIALS: DTI data (echo-planar, 1.5T) were retrospectively analyzed in 7 patients with pontine tumors (6 diffuse, 1 focal), 4 patient controls, and 5 normal volunteers. Fractional anisotropy (FA) and apparent diffusion coefficient (ADC) were calculated from the diffusion tensor in 6 regions of interest: bilateral corticospinal tracts, transverse pontine fibers, and medial lemnisci. Relationships between FA and ADC values and results of the neurologic examinations were evaluated.

RESULTS: The corticospinal tracts and transverse pontine fibers were affected more often than the medial lemnisci. The DTI parameters (FA and ADC) were significantly altered in all tracts of patients with pontine tumors (P < .05), compared with those values in the control groups. A marginally significant (P = .057) association was seen between the severity of cranial nerve deficit and decreased FA.

CONCLUSION: DTI provided superior visualization and quantification of tumor involvement in motor, sensory, and transverse pontine tracts, compared with information provided by conventional MR imaging. Thus, DTI may be a sensitive measure of tract invasion. Further prospective studies are warranted to assess the ability of DTI to delineate tumor focality and improve risk stratification in children with pontine tumors.

Diffuse pontine tumors comprise a group of malignant tumors with a much poorer prognosis than that of focal brain stem tumors. Pontine tumors account for about 15% of pediatric brain tumors and comprise approximately 20%–30% of posterior fossa tumors. Histopathologically, these diffuse pontine tumors are usually differentiated WHO grade II fibrillary astrocytomas or WHO grade III anaplastic astrocytomas at diagnosis and are known to infiltrate between normal axonal fibers. Although the appearance of focal brain stem tumors and that of diffuse brain stem tumors typically differ by conventional MR imaging, distinguishing focal from diffuse involvement is sometimes imprecise. The discovery of a method that distinguishes these 2 types of tumors is valuable because the treatment and prognosis for the brain stem tumors are substantially different. On T2-weighted MR images, focal tumors are typically well marginated, often enhance, may be exophytic, and occupy <50% of the axial diameter of the brain stem, whereas diffuse tumors are poorly marginated, rarely enhance, occupy more than 50% of the axial diameter of the brain stem, lack an exophytic component, and commonly engulf the basilar artery.

Conventional MR imaging has demonstrated prognostic value in the treatment of brain stem tumors, but white matter appears homogeneous on MR images; therefore, this method cannot precisely define essential aspects of tract location, displacement, or invasion. In contrast, diffusion tensor imaging (DTI) detects anisotropic diffusion, thereby allowing the visualization of major fiber tracts in the brain stem. Thus, DTI may provide information about tumor involvement in white matter tracts. Recent work on the application of DTI in supratentorial tumors has explored quantitative values of the apparent diffusion coefficient (ADC) and fractional anisotropy (FA) to characterize tumors, peritumoral involvement of tracts, and the appearance of tumor-altered white matter tracts. On the basis of these studies, DTI has become an important component of preoperative evaluation and treatment planning for patients with supratentorial tumors in certain institutions.

Current management of suspected focal lesions in the brain stem involves stereotactic biopsy or resection, depending on the location and size of the tumor. Surgical options have an acceptable but real risk and are essential in determining therapy for focal brain stem lesions. To our knowledge, we recently reported the first application of DTI for surgical planning in cervico- and pontomedullary tumors.

We report a study in which we tested the hypothesis that invasion of corticospinal, transverse pontine, and medial lemniscal tracts by pontine tumors can be demonstrated by DTI data showing reduced FA and elevated ADC values. We compare and contrast the differences when using DTI between the single patient with a focal tumor and those patients with more diffuse pontine tumors. Additionally, we evaluate the correlation between the degree of tract invasion and neurologic deficits.
Methods

Patient Demographics
DTI data were analyzed in a retrospective study of 3 groups. The experimental group consisted of 6 patients with diffuse pontine tumors and 1 with a focal pontine tumor. The mean age of the patient group was 7.7 years (range, 6–15 years). The second group consisted of 4 patients with cancer, who served as patient controls. The mean age of this group was 16.5 years (range, 12–20 years), and the sites and types of primary tumor were prostatic rhabdomyosarcoma, noncerebral metastatic melanoma, pineal glioma, and parafalcine Rosai-Dorfman histiocytic lesion. Patients from these 2 groups underwent MR imaging and DTI procedures at St. Jude during 2002–2003. The third group consisted of 5 healthy adult volunteers who were nonasymptomatic graduate students and MR imaging technicians, whose ages ranged from 21 to 37 years. Clinical data were obtained by chart review, as approved by the institutional review board.

Conventional MR Imaging
MR imaging was performed on a 1.5T Siemens Symphony scanner (Siemens Medical Solutions, Malvern, Pa) by using a quadrature head coil. Conventional imaging included the following: fast low-angle shot T1-weighted images (TR/TE, 165–218/4 ms; field of view [FOV], 158 × 210; section thickness, 5/0-mm gap; matrix, 256 × 256; number of excitations [NEX], 2 in the sagittal, axial, and coronal planes; axial double-echo T2-weighted images (TR/TE, 4000–6000/16–109 ms; FOV, 210 × 210; section thickness, 5/0-mm gap; matrix, 512 × 512; NEX, 2; and axial fluid-attenuated inversion recovery images (TR/TE/TI, 9000–10,000/112/2400 ms; FOV, 158 × 210; section thickness, 5/0-mm gap; matrix, 144 × 256; NEX, 2.

Diffusion Tensor Imaging
Diffusion-weighted echo-planar images were acquired with a double spin-echo sequence15 (FOV, 230 × 230 × 200 mm; TR/TE, 10 000/100 ms; 4 acquisitions per series). Diffusion encoding was applied along 6 noncollinear directions (b = 1000), and 1 image was acquired without diffusion encoding. Image acquisitions were realigned by using the realignment tools within Statistical Parametric Mapping (SPM99, Wellcome Institute of Neurology, London, UK). Diffusion tensors were calculated by using the SPM diffusion toolbox software developed for SPM99 software.16 FA, ADC, and eigenvector maps were calculated (Figs 1 and 2). To aid in the visualization of the fiber tracts, we used an RGB-orientation color map to demonstrate fiber shape and direction.17 FA and ADC were evaluated in 6 regions of interest hand drawn under the supervision of experienced neuroradiologists (K.J.H., J.W.L.). The regions of interest were drawn around the bilateral corticospinal tracts, transverse pontine fibers, and medial lemnisci at the level of the middle cerebellar peduncles. Analyses of the DTI data were performed by authors blinded to the results of the patient’s neurologic evaluation.

Both conventional MR images (axial pre- and postcontrast T1-weighted and T2-weighted) and color-coded DTI maps were analyzed for obvious tract disturbance and areas of hemorrhage or necrosis. We used regions of interest of the white matter tracts on the color maps to obtain quantitative FA and ADC values. We also used corresponding T2-weighted images at the level of the middle cerebellar peduncles and adapted criteria developed by Witwer et al10 to classify fiber tracts into 1 of 5 categories: normal, displaced, edematous, infiltrated, or destroyed. In contrast to the study of Witwer et al, we did not use a contralateral “normal” brain image as a control because diffuse pontine tumors were most often bilateral. We also gathered quantitative ADC data for more in-depth analysis of white matter involvement, though we did not use that information to determine tract involvement, as per the adapted criteria of Witwer et al. Instead, we used the appearance and locations of the corticospinal, transverse pontine, and median lemniscal tracts on the FA image and color maps.

Classification of Tract Involvement
Quantitative FA and ADC values from the volunteer group were used to define normal anisotropy and location of the tracts. Abnormal tracts displayed high signal intensity on T2-weighted images. “Displaced tracts” were defined as those that maintained normal anisotropy but were in abnormal locations, had an abnormal orientation on the color-coded map, or both. “Edematous tracts” were those that maintained normal anisotropy and orientation but demonstrated high signal intensity on T2-weighted images. “Infiltrated tracts” were those that demonstrated reduced anisotropy but were still identifiable on color-coded maps. “Disrupted tracts” were those that had markedly reduced anisotropy and no identifiable tracts on the color-coded map. Quantitative ADC and FA values from each region of interest in the pontine tumor group were compared with those values from the same region of interest in the patient and volunteer control groups.

Evaluation of Neurologic Deficits
We retrospectively reviewed the neurologic evaluations performed on each patient with pontine tumor before the MR imaging examination. Neurologic information for motor and cranial nerve findings were complete in all 7 patients, though sensory information was present in only 3 patients. DTI region of interest analysis was blinded to neurologic findings. Neurologic deficits were classified into 4 categories: corticospinal (assessment of motor strength, muscle tone, and reflexes), cranial nerve, sensory, and ataxia. The severity of deficit within each category (except sensory) was also graded as follows: ab-
sent if no deficit was present; mild if neurologic deficit resulted in no loss of function of the limb or, in the case of cranial nerves, <50% loss of function; moderate if neurologic deficit resulted in loss of function that restricted activity or, in the case of cranial nerves, >50% loss of function; and severe if there was marked loss of function prohibiting activity and complete paralysis in the case of cranial nerves. Sensory deficits were graded as absent if not present, mild if noted by the examiner only, moderate if the patient reported with no loss of function, and severe if loss of sensation affected function of the limb as well. Correlation analyses were then performed to determine whether the neurologic deficit scores were associated with the quantitative DTI measurements of the corresponding anatomic structures.

Statistical Analysis
The exact Kruskal-Wallis test was performed, and if a pair-wise comparison was necessary, the exact Wilcoxon-Mann-Whitney test was also used. All tests were performed by using StatXact five software (Cytel Software Corp, Cambridge, Mass), which was implemented by using SAS version 9.1 (SAS Institute, Inc, Cary, NC). A P value of ≤ .05 was considered statistically significant for the 3-group comparisons, and a P value of ≤ .0167 (ie, .05/3) was considered statistically significant for pair-wise comparisons. We combined data from the 2 control groups and compared the combined data with those from the pontine tumor group. Also, we combined datasets of the 2 lower grades (absent and mild) from individual neurologic deficit categories and compared the combined data with those from the moderate/severe grade of the same deficit by using the exact Wilcoxon-Mann-Whitney test; a P value of ≤ .05 was considered statistically significant for these comparisons.

Results

Conventional MR Imaging Evaluation
Tumors ranged in size. The axial dimensions ranged from 2.6 to 4.6 cm (median, 3.3 cm; mean, 3.2 cm), and the anteroposterior dimensions ranged from 1.8 to 4.7 cm (median, 3.6 cm; mean, 3.6 cm). One diffuse tumor had enhancement surrounding a region of necrosis. Tumors were moderately to severely hypointense on T1-weighted images and moderately to severely hyperintense on T2-weighted images. The focal tumor had both a nonenhancing infiltrative component and an enhancing exophytic component. Tumor mass effect was minimal (n = 4), mild (n = 1), or moderate (n = 2). Only 1 patient had hydrocephalus at the time of imaging, but another patient had previously received a shunt. No tumor hemorrhage or metastatic disease was detected (Table 1).

Neurologic Evaluation
Various combinations of the following symptoms were experienced by the 7 patients with pontine tumors at time of imaging: long tract signs (n = 3), cranial nerve deficits (n = 5), and ataxia (n = 4) (Table 3). Sensory involvement was noted as normal in 3 patients and not recorded in the evaluations of the other 4.

DTI Evaluation
Evaluation of the DTI color maps revealed several patterns of tumor infiltration. Overall, the diffuse pontine tumors appeared to expand the transverse pontine components and, to a lesser extent, the corticospinal tracts (Fig 2). In 3 patients with diffuse pontine tumors, at least 1 corticospinal tract was so infiltrated that both the corticospinal and corticobulbar components were visible (Fig 3A). The corticospinal tracts were displaced (n = 3) or remained in their expected locations (n = 3) with various degrees of expansion. In 1 patient, the left corticospinal tract was diminished in size and appeared slightly isotropic. In 5 of 6 patients, the sensory tracts (including the medial lemnisci and multiple cranial nerve nuclei) were posteriorly displaced, often thinned, and draped over the substance of the tumor; however, the color map of those tracts indicated that they maintained their anisotropy (Table 1). In contrast, the single focal tumor had both a slightly expanded lateral component involving a nondisplaced left corticospinal tract and an exophytic component outside the motor tracts (Fig 3B).

White Matter Tract Involvement
In accordance with the criteria listed in the Methods section, we classified the status of the white matter tracks in each region of interest by using their appearance on T2-weighted images, the color maps, and FA values. The corticospinal tracts and transverse pontine fibers were more often infiltrated or destroyed than were the medial lemnisci (Table 2).
Quantitative DTI Analysis

Median FA and ADC values of the pontine tumor cohort at the 6 regions of interest were compared with those in both control groups. The 3-way comparisons revealed that FA values of all 6 tracts were significantly decreased, and ADC values were significantly increased in patients with pontine tumors (Fig 4). In the pair-wise comparisons, the FA values of the pontine tumor group significantly differed from those in the patient controls in the following regions of interest: bilateral corticospinal tract, bilateral transverse pontine, and left medial lemniscus (Fig 4A). A marginal difference was observed in the ADC values of the left corticospinal and bilateral transverse pontine tracts (Fig 4B) and in the FA value of the right medial lemniscus. Interestingly, despite the differences in age and prior therapies in the patient control group, there was no significant difference in any of the regions of interest between the patient control and volunteer groups; only a marginal difference was observed in the ADC value of the right medial lemniscus. Consequently, a pair-wise comparison of data from the pontine tumor cohort and the combined control groups demonstrated significant differences in FA and ADC measures in all 6 regions of interest.

Although we attempted to determine whether there was a correlation between the severity of neurologic deficits in the patients with pontine tumors and the median FA and ADC values of their corticospinal, transverse pontine, and sensory tracts, this analysis was limited by the small sample size because the neurologic examination data were gathered retrospectively and sensory data were incomplete. Despite these limitations, the comparison of severity of cranial nerve deficits with the average FA value of the transverse pontine tract showed a marginal difference (P = .057), which could be clinically significant. We compared data from patients with normal or mild cranial nerve deficits with those from patients with moderate/severe cranial nerve deficits. We performed a similar comparison by using data from patients with normal or mild ataxia and those with severe ataxia. There was no significant difference in any comparison.

Discussion

We describe quantitative and significantly altered DTI measurements (FA and ADC) in the brain stem tracts of 7 patients with pontine tumors (P < .05), compared with those values in the 2 control groups. Pontine tumors comprise approximately 15% of pediatric brain tumors, and the most common subtype of pontine tumor is diffuse pontine glioma. Most children with apparent diffuse pontine gliomas die of the disease within 18 months of diagnosis, despite contemporary radiation therapy and chemotherapy. The current principal diagnostic technique for pontine tumors is MR imaging, and there are several key grading systems that use MR imaging findings to classify brain stem tumors by location and focality. There is still debate in the literature about whether the presence of enhancement is a useful prognostic sign; however, there is no question that patients with focal tumors, as seen on conventional T2-weighted images, benefit from information obtained from the stereotactic biopsy.

A certain percentage of patients with focal pontine tumors have lower-grade histology; hence, they also have different treatment options and prognoses. Lesniak et al found that of 57 patients with enhancing brain stem tumors who were surgical candidates, 60% had low-grade histology (30 juvenile pilocytic astrocytoma, 3 ganglioglioma, and 1 oligoglioma), and 40% had higher-grade histology (12 glioblastoma multiforme, 10 fibrillary astrocytoma, and 1 primitive neuroectodermal tumor). Both location and focality as defined by MR imaging have substantial prognostic significance. The probability of 5-year overall survival of patients with tumors of the midbrain ranged from 72% to 100%; that of patients with tumors of the pons was 18%; that of patients with tumors of the medulla ranged from 50% to 64%; and that of patients with focal tumors ranged from 56% to 100%. The 5-year overall survival rate of patients with diffuse brain stem tumors ranged from 18% to 20%. Six of our 7 patients had classic diffuse pontine tumors, as determined by imaging; 1 patient had a focally invasive tumor with an enhancing exophytic component.

The general imaging features of diffuse and focal pontine tumors have been well described in the literature. We used quantitative DTI to explore the relationships between the involvement of the corticospinal, transverse pontine, and medial lemnisci brain stem tracts in 7 patients with pontine tumors (6 diffuse, 1 focal) with various degrees of invasion. Our analysis revealed both qualitative differences in the DTI color maps and statistically significant differences in the FA and ADC values of these tracts when compared with those of the 2 control groups. Therefore, DTI shows promise in furthering our understanding of the effects of brain stem tumors on nearby white matter tracts.

Stieltjes et al recently used the brain stem as a model to evaluate the ability of quantitative DTI to assess densely packed well-known fiber tracts in 6 healthy adults. They iden-
Table 1: Comparison of conventional MR imaging and diffusion tensor imaging measures in 7 pediatric patients with pontine tumors

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Location</th>
<th>Size (cm)</th>
<th>T1W</th>
<th>T2W</th>
<th>Enhancement</th>
<th>Focality</th>
<th>Necrosis</th>
<th>Mass Effect</th>
<th>Hydrocephalus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Midbrain/pons</td>
<td>4.6 × 3.6</td>
<td>Hypo</td>
<td>Hyper</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Moderate</td>
<td>Shunt in place</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Pons</td>
<td>3.0 × 3.4</td>
<td>Hypo</td>
<td>Hyper</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Minimal</td>
<td>No</td>
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<tr>
<td>3</td>
<td>Pons</td>
<td>2.8 × 3.1</td>
<td>Hypo</td>
<td>Hyper</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Minimal</td>
<td>No</td>
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<tr>
<td>4</td>
<td>Pons</td>
<td>3.2 × 4.3</td>
<td>Sev hypo</td>
<td>Sev hyper</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Minimal</td>
<td>No</td>
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<tr>
<td>5</td>
<td>Pons</td>
<td>3.8 × 4.5</td>
<td>Sev hypo</td>
<td>Sev hyper</td>
<td>Surrounding necrosis</td>
<td>No</td>
<td>Yes*</td>
<td>Moderate</td>
<td>Mild</td>
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<td></td>
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</tr>
<tr>
<td>6</td>
<td>Pons</td>
<td>3.9 × 4.7</td>
<td>Sev hypo</td>
<td>Sev hyper</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Mild</td>
<td>No</td>
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</tr>
<tr>
<td>7</td>
<td>Pons</td>
<td>1.6 × 1.0</td>
<td>Hypo</td>
<td>Hyper</td>
<td>Minimal focal</td>
<td>Yes</td>
<td>No</td>
<td>Minimal</td>
<td>No</td>
</tr>
</tbody>
</table>

**Note:**—hypo indicates hypointense; hyper, hyperintense; sev, severe; exp, expansion; CB, corticobulbar tracts; displ, displacement.

* The necrotic region measured 2.2 × 2.5 cm.

† This patient’s tumor had an exophytic component that measured 1.0 × 0.8 cm.
versely correlated with tumor cellularity. This finding contrib-

uted another diagnostic aspect of tumor characterization. Al-

though we did not examine the boundaries of the diffuse tumors,
our finding that the tracts of the patients with pontine tumors had
infiltrated or destroyed than were the medial lemnisci. This finding supports the common clinical triad of pre-
sent in regions of the brain that appear abnormal on con-

ventional MR images.

In our study, the patterns of diffuse tumor involvement in
6 patients with pontine tumors were similar by conventional imaging, but their patterns of tract involvement were quite varied by DTI. As one would expect, the color map showed evidence of diffuse infiltration of the corticospinal and trans-
verse pontine tracts. We noted bilateral enlargement of the
corticospinal and transverse pontine tracts in many patients
but frequent apparently random displacement of the individ-
ual corticospinal tracts and posterior displacement of the me-

Table 3: Neurologic deficits in 7 pediatric patients with pontine tumors

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Neurologic Deficit (Grade* and Location)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Corticospinal Tracts</td>
</tr>
<tr>
<td>1</td>
<td>Mild (left)</td>
</tr>
<tr>
<td>2</td>
<td>Mild (right)</td>
</tr>
<tr>
<td>3</td>
<td>Absent</td>
</tr>
<tr>
<td>4</td>
<td>Absent</td>
</tr>
<tr>
<td>5</td>
<td>Absent</td>
</tr>
<tr>
<td>6</td>
<td>Mild (bilateral), worse on left</td>
</tr>
<tr>
<td>7</td>
<td>Absent</td>
</tr>
</tbody>
</table>

Note:—N/A indicates not available.

* Deficits were classified into 2 grades: absent/mild, and M/S, moderate/severe.


tified the corticospinal tracts; the superior, medial, and infe-
rior cerebellar peduncles; and the medial lemnisci and evalu-
ated their FA and ADC values. In our study, not only were
these white matter tracts clearly seen in patients with pontine
tumors, but also substantial differences in the FA and ADC
values were found in a comparison of the patient and the con-
trol groups. Certainly the mean corticospinal tracts and me-
dial lemnisci FA values and standard deviations for our patient
control and volunteer groups compared favorably with data
published by Stieltjes el al.

Sinha et al2 explored the regional mean diffusivity (ADC)
values of high-grade gliomas in 9 adults. They found clear quanti-
tative differences in ADC values of different tissues; the highest
ADC was observed in the necrotic tumor core, followed by edem-
atous brain, enhancing tumor core, enhancing tumor margin,
and normal brain. A recent study comparing quantitative ADC
values between 3 basic histopathologic pediatric tumor types
(low-grade gliomas, embryonal tumors, and nonembryonal
high-grade tumors) in 12 patients demonstrated that ADC is in-
versely correlated with tumor cellularity.4 This finding contrib-
utes another diagnostic aspect of tumor characterization.

Although stereotactic biopsy of suspected focal tumors has
acceptable risks, attempted partial resections of low-grade tu-
mors for tumor debulking and decompression can result in
serious outcomes. Lesniak et al2 argued that despite the obvi-
ous benefits of careful resection of benign lesions, surgery has
serious risks. Whereas most of the patients experienced im-
provement in neurologic deficits after their surgical proce-
dure, significant morbidity was described (ie, 17.5% experi-
enced moderate disability; 3.5%, severe disability; and 1.7%,
vegetative state). We found that DTI (including color maps)
provides a wealth of information that, until now, has not been
available in surgical planning for patients with pontine tu-
mors. It remains to be seen whether DTI can further our un-

Table 2: Color map assessment of diffusion tensor images of brainstem white matter tracts in 7 pediatric patients with pontine tumors

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Corticospinal Tracts</th>
<th>Transverse Pontine Tracts</th>
<th>Medial Lemnisci</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D/I</td>
<td>I</td>
<td>D</td>
</tr>
<tr>
<td>2</td>
<td>I</td>
<td>X/I</td>
<td>D</td>
</tr>
<tr>
<td>3</td>
<td>I</td>
<td>I</td>
<td>D/I</td>
</tr>
<tr>
<td>4</td>
<td>I</td>
<td>X/I</td>
<td>D/I</td>
</tr>
<tr>
<td>5</td>
<td>X/I</td>
<td>X/I</td>
<td>I</td>
</tr>
<tr>
<td>6</td>
<td>I</td>
<td>X/I</td>
<td>N/I</td>
</tr>
<tr>
<td>7</td>
<td>I</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

* The condition of the tracts was classified as follows: D, displaced; E, edematous; I, infiltrated; N, normal; X, destroyed.

Table 2: Color map assessment of diffusion tensor images of brainstem white matter tracts in 7 pediatric patients with pontine tumors

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<thead>
<tr>
<th>Patient No.</th>
<th>Corticospinal Tracts</th>
<th>Transverse Pontine Tracts</th>
<th>Medial Lemnisci</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D/I</td>
<td>I</td>
<td>D</td>
</tr>
<tr>
<td>2</td>
<td>I</td>
<td>X/I</td>
<td>D</td>
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<tr>
<td>3</td>
<td>I</td>
<td>I</td>
<td>D/I</td>
</tr>
<tr>
<td>4</td>
<td>I</td>
<td>X/I</td>
<td>D/I</td>
</tr>
<tr>
<td>5</td>
<td>X/I</td>
<td>X/I</td>
<td>I</td>
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<tr>
<td>6</td>
<td>I</td>
<td>X/I</td>
<td>N/I</td>
</tr>
<tr>
<td>7</td>
<td>I</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

* The condition of the tracts was classified as follows: D, displaced; E, edematous; I, infiltrated; N, normal; X, destroyed.
understanding of tract displacement and infiltration and facilitate surgical planning in patients with known focal lesions.

DTI technology is under rapid development, and the functional and clinical significance of the diffusion properties of brain tissue are unknown. Tropine et al (2004) demonstrated that DTI may not reliably distinguish tumor infiltration from vasogenic edema in supratentorial gliomas and glioblastomas. Nimsky et al (2005) discovered that though pre- and intraoperative DTI fiber tracking in supratentorial gliomas was possible, there was striking white matter tract shift, and intraoperative DTI fiber tracking in supratentorial gliomas. Subject groups included patients with pontine tumors, patient control (PAT), and healthy volunteer (VOL) groups.

Fractional anisotropy (FA).

Fig 4. Graphs show diffusion tensor imaging parameters for major white matter tracts in the brain stem. A, Fractional anisotropy (FA). B, Apparent diffusion coefficient (ADC). Data are shown for the corticospinal (CS, blue bars), transverse pontine (TP, red bars), and medial lemnisci (ML, yellow bars). Subject groups included patients with pontine tumors, patient control (PAT), and healthy volunteer (VOL) groups.

Conclusion

To our knowledge, this study is the first to evaluate the quantitative DTI measures of FA and ADC in pediatric patients with diffuse and focal pontine tumors and in those with “normal” brain stem, as determined by conventional MR imaging. Our results indicate that DTI analysis can delineate tract invasion and displacement. These tools may help to better discriminate between diffuse and focal brain stem tumors in the future and may be useful for guiding surgical biopsies. DTI analysis also shows promise of providing quantitative measures of risk stratification, prognosis, and treatment response. We conclude that the results from this retrospective study support the expansion of this research in a large prospective study in pediatric patients with pontine tumors.

References