INTRODUCTION

Brainstem lesions require one of the most difficult procedures for neurosurgeons. Surgery includes high risks. The relationship between the lesion and the white matter tracts, difficulty for the choice of the approach, length of the approach trajectory or the size of the lesion determines the risk increment\(^2\). Conventional MRI, functional MRI and magneto-encephalography (MEG) with neuronavigation combination are worthwhile in eloquent brain area lesions treatment. However white matter appears homogeneous on MR images, so these methods can not define white matter tracts localizations\(^1\). Recently, DTI- based fiber
tracking is very popular in neurosurgical practice, because it can visualize white matter tract involvement for the preoperative surgical planning and can show the most noninvasive and safe pathways to reach the brainstem lesions\(^{(1)}\). Thus provide us a better protection of the neurologic functions. Major White matter tracts can not be sacrificed just like eloquent cortical brain areas. DTI can differentiate and identify major white matter tracts. It can also reveal the fiber widening caused by edema or tumor infiltration. DTI can show the clue of course displacement or interruption of white matter tracts which surround the lesion\(^{(1,2)}\). To our knowledge, in brainstem lesions, surgery decision should be given with DTI assistance.

**CASE PRESENTATION**

**Case 1**

A five-year-old girl was admitted to our hospital with a 1 month history of ataxia, nausea, vomiting and a progressive motor loss on four extremities. Neurologic examinations revealed bilateral severe sensory loss with left side dominance. Motor strength for upper and lower extremities on both sides was found grade 3 according to the Medical Research Council Scale of 0-5\(^{(3)}\). Uvula was deviated to the right side and she had dysphasia. On MRI examination; a hyperintense mass (35x34 mm in size) (in T2-weighted series) localized centrally in ponto-mesencephalic junction was seen (Figure 1a). The mass was seen slightly hypointense in T1-weighted series and showed ring-like contrast enhancement. DTI-based fiber tractography (Figure 1b) was performed to determine the anatomical relationship between brainstem lesion and the adjacent eloquent fiber tracts. On fiber tractography images, right corticospinal tracts were displaced laterally by the centrally localized mass. Right medial lemniscus was compressed and displaced to the right far lateral aspect of pons. Left medial lemniscus was seen in normal localization. Surgical pathway and surgical entry point of the midbrain was determined under the tractography. Mesencephalon was incised on the left side of the posterior median line with bipolar forceps. Coagulation and ultrasonic aspiration weren't used any time on the surgery. Tumor was soft, pale and homogenous which was easily aspirated and gross-total removed by the Yasargil Type Controlled aspiration system (Figure 1c). Slight neurological deterioration just after the surgery was observed. The pathology of the tumor was diffuse fibrillary astrocytoma. Rehabilitation was performed and she was discharged in better condition than first admittance.

*Figure 1a: T2 weighted sagittal MRG sequence showing pons lesion.*
Case 2

A 33-year-old male patient with Neurofibromatosis Type 1 disease was admitted with progressive headache complaint for one year. The contractions on the right side of his mouth with approximately 1 minute duration and diplopia for one month were present. Neurological examination revealed bilateral abducens nerve paralysis, quadriplegiasis of grade 4 and loss of glossopharyngeal reflex. On MRI examination, a huge mass was observed. It was centrally localized in pons with hyperintense signal characteristics on T2-weighted series. On contrast enhanced T1-weighted series tumor showed a heterogenous enhancement pattern. On fiber tractography images; tumor was characterized with a highly invasive pattern and tracts fibers were seen mostly within the mass with a scattered appearance. Poor members of fibers were...
also observed in and around tumor due to the probable destruction of myelin sheets of fibers. A safe surgical approach path couldn't be found and case was accepted as inoperable. Radiation therapy was given but he died in 9 months.

**Case 3**

A 12-year-old girl with complaints of diplopia and difficulty in swallowing for one month was admitted to the neurosurgery department. MRI examination revealed a midbrain-pontine glioma. Gastrostomy catheter and tracheotomy cannula were placed. On T2-weighted MRI series a hyperintense mass which is centrally localized in pons was observed. On contrast enhanced T1-weighted series tumor showed clear enhancement pattern. Fiber tractography showed a displacement of the corticopontine and corticospinal tracts anteriorly and laterally in both sides. Medial lemniscus fibers were also compressed by the mass and were displaced posteriorly. On the surgery; tumor was juicy. It was easily aspirated. After the surgery, tracheotomy was closed in two months and she also started to eat solid foods. The pathology was anaplastic astrocytoma. Postoperative MRI showed subtotal removing of the tumor. She deteriorated 9 months later and she died in a year.

**Case 4**

A 42-year-old male patient with complaints of gait disturbance and diplopia was admitted to our department. On MRI examination a lobulated pons mass (28x36 mm in size) with slightly hyperintense signals in T2-weighted series and no contrast enhancement was observed. On fiber tractography images, anterior displacement of the corticopontine and corticospinal tracts was present. Pontine crossing tracts were displaced to right lateral side of pons and right medial lemniscus fibers were compressed by the mass. Surgery was planned and pons was incised posteriorly by bipolar cautery. Tumor was aspirated and removed by biopsy forceps. The patient was good condition in early postoperative period. The pathology was diffuse fibrillary astrocytoma.

**DISCUSSION**

DTI is an improved technique of diffusion-based imaging which permits a non-invasive measuring of free water diffusion as a function of spatial location(1,4). The calculated diffusion tensor describes the amount and the degree of anisotropy as well as its directionality(5). Fiber tracking obtained from diffusion anisotropy data also gives information about the integrity and connectivity patterns of white matter tracts(6) and has been used for visualization of white matter tracts and their relation with brain tumor(9). Preoperative DTI data were analyzed in 4 patients with brainstem lesions. Surgery decision was given by neurosurgeons and radiologists according to the DTI. In three cases, white matter tractography (WMT) showed safe pathways through the lesion so surgery decision was given. Postoperative WMT truly revealed the preserved WM tracts (Figure 1c).

Diffusion tensor imaging reveals useful information about the white matter entireness. The water content and the diffusion changes of water in the brain tissue gives us much more information than MRI about the structural changes due to different cerebral tumors(7,8). Therefore, there are many hypothesis defending that DTI can distinguish the type of the tumor and delineate the extension of the tumoral infiltration(7,8).

Brainstem surgery is very difficult. Surgeon mustn't use ultrasonic aspirator and bipolar coagulation. Surgical area is small, pathway is long and the target found in eloquent area is far. Aspiration system, small and sharp biopsy punches are necessary for tumor excision. In our cases, one of them was decided as inoperable through the DTI findings. Other 3 patients were operated. One patient died one year
after the surgery. Other two patients are still alive, but follow up time are still short (18 months and 6 months).

In this study, we used WMT and DTI to evaluate the relations between the mass lesions of brainstem and surrounded white matter fibers for surgery decision. This non invasive technique guided us to find out a safe pathway in three of four cases to reach the lesion. In all cases, surgery decision should be discussed in detailed with neuroradiologists.

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