High-Definition Fiber Tractography in Evaluation and Surgical Planning of Thalamopeduncular Pilocytic Astrocytomas in Pediatric Population: Case Series and Review of Literature

Emrah Celtikci[1,2], Pinar Celtikci[1], David Tiago Fernandes-Cabral[1], Murat Ucar[3], Juan Carlos Fernandez-Miranda[1], Alp Ozgun Borcek[4]

■ OBJECTIVE: **Thalamopeduncular tumors (TPTs) of childhood present a challenge for neurosurgeons due to their eloquent location. Preoperative fiber tracking provides total or near-total resection, without additional neurologic deficit. High-definition fiber tractography (HDFT) is an advanced white matter imaging technique derived from magnetic resonance imaging diffusion data, shown to overcome the limitations of diffusion tensor imaging. We aimed to investigate alterations of corticospinal tract (CST) and medial lemniscus (ML) caused by TPTs and to demonstrate the application of HDFT in preoperative planning.**

■ METHODS: **Three pediatric patients with TPTs were enrolled. CSTs and MLs were evaluated for displacement, infiltration, and disruption. The relationship of these tracts to tumors was identified and guided surgical planning. Literature was reviewed for publications on pediatric thalamic and TPTs that used diffusion imaging.**

■ RESULTS: **Two patients had histologic diagnosis of pilocytic astrocytoma. One patient whose imaging suggested a low-grade glioma was managed conservatively. All tracts were displaced (1 CST anteriorly, 2 CSTs, 1 ML anteromedially, 1 ML medially, and 1 ML posteromedially). Literature review revealed 2 publications with 15 pilocytic astrocytoma cases, which investigated CST only. The condition of sensory pathway or anteromedial displacement of the CST in these tumors was not reported previously.**

■ CONCLUSIONS: **Displacement patterns of the perilesional fiber bundles by TPTs are not predictable. Fiber tracking, preferably HDFT, should be part of preoperative planning to achieve maximal extent of resection for longer survival rates in this young group of patients, while preserving white matter tracts and thus quality of life.**

INTRODUCTION

Thalamopeduncular tumors (TPTs) are a rare form of supratentorial neoplasm of the childhood. Due to their anatomically challenging location, these lesions were considered unresectable half a century ago,[1-4] but recent advances in imaging and neuronavigation systems have allowed neurosurgeons to consider aggressive surgical resection.

Management of TPTs of childhood is still a matter of debate among neurosurgeons. There is an evolving body of literature suggesting that greater extent of resection of low-grade gliomas provides longer survival rates in both adults and children.[5-8] Therefore maximal tumor resection is favored but at the expense of potentially increasing surgical morbidity.[2,9-13] Previous authors have reported the use of diffusion tensor imaging (DTI)-based

Key words
- Diffusion tensor imaging
- High-definition fiber tractography
- Pediatric
- Pilocytic astrocytoma
- Thalamopeduncular

Abbreviations and Acronyms
CST: Corticospinal tract
DSI: Diffusion spectrum imaging
DTI: Diffusion tensor imaging
HDFT: High-definition fiber tractography
ML: Medial lemniscus
MRC: Medical Research Council
MRI: Magnetic resonance imaging
ROI: Region of interest
TPT: Thalamopeduncular tumor
WHO: World Health Organization

From the [1]Department of Neurological Surgery, University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania, USA; and [2]Division of Pediatric Neurosurgery, Department of Neurosurgery, [3]Division of Pediatric Neurosurgery, Department of Radiology, and [4]Division of Pediatric Neurosurgery, Department of Neurosurgery, Gazi University Faculty of Medicine, Besevler, Ankara, Turkey

To whom correspondence should be addressed: Emrah Celtikci, M.D. [E-mail: drceltikci@gmail.com]

Citation: World Neurosurg. (2017) 98:463-469.
http://dx.doi.org/10.1016/j.wneu.2016.11.061

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

1878-8750/$ - see front matter © 2016 Elsevier Inc. All rights reserved.

fiber tracking before and during surgery in order to facilitate increasing the extent of resection while preserving perilesional eloquent fiber bundles,[14-18] including cases of TPTs.[19,20] However, DTI has several limitations such as inability to resolve crossing fibers, susceptibility to partial volume artifacts, and difficulties defining the origin and termination of fibers.[21,22] Advanced diffusion imaging techniques, such as high-definition fiber tractography (HDFT), have been introduced to increase the accuracy and reliability of structural white matter mapping.[23-25]

In this study, HDFT was performed to identify and describe the location, trajectory, and relationship of the corticospinal tract (CST) and medial lemniscus (ML) to the mass lesions located in the thalamopeduncular region of pediatric patients. We propose that this valuable information has the potential to improve surgical planning by enhancing a better understanding and more accurate depiction of the ideal edges of resection in order to preserve perilesional fiber tracts. Besides contributing to the existing literature with 3 additional cases, we present 2 cases of thalamopeduncular pilocytic astrocytoma with anteromedial displacement of the CST, which has not been reported previously. Also, we investigated the surgical anatomy of the sensory pathway, which has not been reported before.

MATERIAL AND METHODS

Three consecutive pediatric patients with TPTs referred to Gazi University Faculty of Medicine, Division of Pediatric Neurosurgery, between 2012 and 2015 were enrolled. The Institutional Review Board approved this study, and written consents of patients' guardians were obtained before the study.

Image Acquisition and Reconstruction

All patients were screened to rule out any contraindication to magnetic resonance imaging (MRI). Diffusion data were acquired using a 3-Tesla Magnetom Verio (Siemens, Erlangen, Germany) with a 32-channel coil. Total scan time was 34 minutes and included a 25-minute diffusion spectrum imaging (DSI) scan (repetition time = 3439 milliseconds, echo time = 150 milliseconds, multiband acceleration factor = 3, voxel size = 2.4 mm^3, field of view = 231 × 231 mm) and 257 noncollinear gradient directions with a maximum *b* value of 7000 seconds/mm^2, followed by a 9-minute T1-weighted structural scan (repetition time = 2200 milliseconds, echo time = 3.58 milliseconds, voxel size = 1.0 mm^3). The diffusion data were reconstructed using a generalized q-sampling imaging method to model an orientation distribution function in each brain voxel.[26]

Fiber Tracking

Fiber tracking was performed by 3 experts in the field who were blinded to the results from each other. DSI Studio (dsi-studio.labsolver.org) was used to visualize the CST and ML using a generalized deterministic tractography method.[27] For CST reconstruction a region of interest (ROI) was placed bilaterally over the precentral gyrus as a seed using the Talairach atlas available in the software; additionally, a complementary ROI was placed axially on the middle third of the pons. An ML pathway was obtained by placing an ROI over the paramedian pontomedullary area posterior to the CST and medial to the olivary complex; a second ROI was placed over the primary sensory area.[28] These ROIs were kept constant across subjects. Fiber tracking was initiated from the whole brain seed using all orientations present within a voxel until 100,000 streamlines were detected. To maximize the detection of the studied tracts, the following parameters were kept constant across the 2 scans: maximum turning angle of 60°, step size of 0.5 mm, smoothing 0.8, and a length constraint of 100–200 mm. All fibers terminating outside the trajectory of the involved tracts were deleted.

We described the affected tracts as being "displaced" when a change in location or direction due to mass effect by the lesion was identified, using the contralateral unaffected side as a comparison.[24,29,30] Presence of tracts coursing through the tumor bulk was described as infiltration, whereas disruption was defined as the discontinuation of the fiber bundle. All decisions were made in consensus by the 3 fiber tracking experts.

Clinical Assessment

Neurologic examinations were performed using the House-Brackmann Facial Nerve Grading System and Medical Research Council (MRC) Scale for Muscle Strength.[31,32] Pathologic specimens were evaluated referring to the 2007 World Health Organization (WHO) Classification of Tumors of the Central Nervous System.[33]

RESULTS

Two patients had a histologically proven low-grade astrocytoma diagnosis compatible with pilocytic astrocytoma (WHO grade I). One patient's MRI findings (including MRI spectroscopy and MRI perfusion scans) suggested a low-grade glioma of the thalamopeduncular region, and the guardians did not approve surgery. All of the reconstructed tracts were displaced, and none were found to be infiltrated or disrupted.

Case 1

A 4-year-old female patient was referred to our clinic with the disability of not being able to walk for 7 months. She had a left-sided hemiparesis (MRC 4/5). MRI revealed a well-defined, intra-axial, right-sided thalamopeduncular mass lesion with scant contrast enhancement suggesting low-grade glioma. There was no obvious peripheral edema. Preoperative HDFT showed anteromedially displaced right CST and posteromedially displaced right ML (Figure 1). The patient underwent image-guided surgery using intraoperative MRI. Following a right temporoparietal craniotomy, we performed a transcortical approach through the middle temporal gyrus. Intraoperative MRI guidance was used twice. An intraoperative pathologic specimen was evaluated as low-grade glioma. In order to prevent additional damage to the right CST, a residual mass of 9 mm in diameter was left in the right cerebral peduncle (see Figure 1). In the early postoperative period (24 hours), her left hemiparesis worsened, especially in the lower extremity (MRC 2/5). Two weeks later, the patient was discharged to a rehabilitation facility with improved left hemiparesis (MRC 3/5). After 6 months of physical therapy she was able to ambulate independently. A 2-year follow-up MRI scan showed residual tumor that was radiologically stable;

Download English Version:

https://daneshyari.com/en/article/5634953

Download Persian Version:

https://daneshyari.com/article/5634953

Daneshyari.com