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Preoperative MR Tractography For Functional Risk Assessment in Pediatric Subcortical Supratentorial Tumors

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Abstract

Pediatric subcortical supratentorial tumors represent a complex group of intracerebral neoplasms characterized by heterogeneous clinical presentation and variable relationships with functionally significant white matter pathways. Conventional magnetic resonance imaging provides important anatomical information; however, its ability to assess the functional-topographic organization of subcortical white matter remains limited. To evaluate the clinical and radiological features of pediatric subcortical supratentorial tumors and to determine the diagnostic value of MR tractography in assessing tumor relationships with functionally significant white matter pathways during preoperative planning. This retrospective study included 100 pediatric patients with subcortical supratentorial tumors who underwent standard magnetic resonance imaging and diffusion tensor MR tractography before surgical treatment. Clinical presentation, conventional MRI characteristics, tractographic patterns of tumor-white matter interaction, intraoperative findings, and postoperative neurological outcomes were analyzed comparatively. A control group of 20 neurologically healthy pediatric subjects was additionally evaluated to characterize normal tractographic anatomy. Conventional MRI demonstrated considerable variability in tumor morphology, contour characteristics, perifocal edema, and mass effect across different subcortical localizations, limiting the reliability of standard anatomical assessment. MR tractography revealed a broad spectrum of tumor-tract relationships, including tract displacement, deformation, thinning, and partial involvement. Moderate tract displacement represented the most frequent tractographic pattern. More severe tractographic abnormalities were associated with a progressively higher incidence of persistent postoperative neurological deficits. Tractographic findings demonstrated high concordance with intraoperative observations, confirming the clinical relevance of preoperative tractographic assessment. MR tractography provides clinically significant functional-topographic information that cannot be reliably obtained using conventional MRI alone. Integration of tractographic analysis into preoperative evaluation may improve surgical planning and facilitate more accurate assessment of functional risk in children with subcortical supratentorial tumors.

Keywords: Pediatric brain tumors; subcortical supratentorial tumors; magnetic resonance imaging; diffusion tensor imaging; MR tractography; white matter pathways; pediatric neurosurgery; functional-topographic assessment.

Introduction

Pediatric subcortical supratentorial tumors remain one of the most challenging categories of intracerebral neoplasms in pediatric neurosurgery because of their heterogeneous anatomical localization and close relationship with functionally significant white matter pathways [1]. Unlike deeply located lesions, subcortical tumors are frequently characterized by superficial localization within the hemispheric white matter combined with variable proximity to eloquent cortical and subcortical structures, which substantially complicates preoperative topographic assessment and surgical planning. Even within the same lobar region, these tumors may demonstrate markedly different clinical presentation, radiological appearance, and patterns of interaction with adjacent neural pathways [2].

Conventional magnetic resonance imaging remains the

standard method for preoperative evaluation of pediatric brain tumors and provides essential information regarding tumor size, morphology, perifocal changes, and mass effect. However, standard MRI primarily reflects anatomical and structural characteristics of the lesion and does not allow reliable assessment of the internal spatial organization of subcortical white matter or the degree of involvement of functionally significant tracts. In clinical practice, tumors with similar MRI appearance may demonstrate fundamentally different relationships with major conducting pathways, leading to substantial variability in surgical risk and postoperative neurological outcomes [3, 4]. These limitations become particularly important in pediatric patients, where preservation of neurological function represents a critical component of surgical treatment.

Recent advances in diffusion tensor imaging and MR tractography have expanded the possibilities of functional-topographic assessment in neuro-oncology [5]. Tractography enables in vivo visualization of white matter pathways and allows evaluation of tract displacement, deformation, thinning, or partial involvement by the tumor process. Several studies have suggested that tractographic analysis may improve preoperative planning and facilitate safer surgical approaches in eloquent brain regions [6, 7]. Nevertheless, the role of MR tractography in the evaluation of pediatric subcortical supratentorial tumors remains insufficiently standardized, while the relationship between tractographic findings, intraoperative observations, and postoperative neurological outcomes continues to require further clarification.

The aim of the study was to evaluate the clinical and radiological features of pediatric subcortical supratentorial tumors and to determine the diagnostic value of MR tractography in assessing tumor relationships with functionally significant white matter pathways during preoperative planning.

Methods

This retrospective observational study included 100 pediatric patients with subcortical supratentorial brain tumors who underwent preoperative neuroimaging assessment and subsequent surgical treatment. All patients were treated at a specialized neurosurgical center during the study period. The study population consisted of children with intracerebral tumors localized within the subcortical white matter of the cerebral hemispheres, including frontal, parietal, temporal, occipital, and perisylvian regions. Patients with infratentorial tumors, extra-axial lesions, multicentric neoplasms, or incomplete neuroimaging data were excluded from the analysis.

All patients underwent standard preoperative magnetic resonance imaging followed by diffusion tensor imaging with MR tractography. Conventional MRI assessment included evaluation of tumor localization, contour characteristics, internal structure, presence of cystic and solid components, perifocal edema, and mass effect. Attention was paid to topographic relationships between the tumor and surrounding cortical and subcortical structures.

MR tractography was used to assess the spatial relationships between the tumor and functionally significant white matter pathways. Tractographic analysis included evaluation of tract displacement, deformation, thinning, preservation of tract continuity, and partial involvement of conducting pathways within the zone of tumor growth. According to tractographic findings, the relationships between tumors and white matter tracts were classified into the following categories: absence of contact with conducting pathways, contact without tract deformation, moderate displacement of tracts, deformation and thinning of tracts, and partial tract involvement.

Tractographic findings were subsequently compared with intraoperative observations and postoperative neurological outcomes. Intraoperative assessment focused on confirmation of spatial relationships between the tumor and surrounding white matter structures identified during preoperative tractography. Functional outcome evaluation was based on postoperative neurological examination with assessment of persistent neurological deficit after surgical treatment.

For comparative analysis, a control group consisting of 20 neurologically healthy pediatric subjects without structural brain pathology was additionally evaluated using MR tractography to characterize normal tractographic anatomy of subcortical white matter pathways.

Statistical analysis was performed using standard descriptive methods. Quantitative data were presented as absolute values and percentages. The distribution of tractographic patterns, MRI characteristics, intraoperative findings, and postoperative outcomes was analyzed comparatively across different subcortical localizations.

Results

Analysis of clinical and radiological characteristics demonstrated substantial heterogeneity of subcortical supratentorial tumors in children even within the same anatomical region. Epileptic onset predominated in temporal and perisylvian tumors, whereas focal neurological deficits were more frequently observed in parietal and occipital localizations. Standard MRI revealed marked variability in tumor morphology, including differences in contour definition, internal structure, perifocal edema, and mass effect. Heterogeneous structure and pronounced perifocal changes were identified in many patients irrespective of lobar localization, limiting the diagnostic specificity of conventional MRI findings during preoperative assessment.

At the same time, tractographic analysis demonstrated considerable variability in tumor relationships with functionally significant white matter pathways. Preservation of tract integrity without deformation was observed only in a limited number of patients, whereas various degrees of tract displacement, deformation, thinning, and partial involvement predominated in the study cohort. More severe tractographic alterations were most frequently identified in temporal and perisylvian subcortical tumors, indicating higher functional complexity of these regions (table 1).

Table 1. Clinical and radiological characteristics of pediatric subcortical supratentorial tumors

PARAMETER	FINDINGS
Total number of patients	100
Frontal localization	32 (32.0%)
Parietal localization	21 (21.0%)
Temporal localization	27 (27.0%)
Occipital localization	11 (11.0%)
Perisylvian localization	9 (9.0%)
Epileptic onset	Predominantly temporal and perisylvian tumors
Focal neurological deficits	More frequent in parietal and occipital tumors
Heterogeneous tumor structure	Predominant MRI pattern
Pronounced perifocal edema	Frequently observed
Significant mass effect	Detected in more than half of patients
Infiltrative or indistinct tumor margins	Common in temporal and perisylvian tumors

Comparison of tractographic findings with intraoperative observations demonstrated a high degree of concordance between preoperative MR tractography and surgical anatomy. Moderate tract displacement represented the most frequent tractographic pattern. More advanced changes, including tract deformation, thinning, and partial involvement, were associated with increased frequency of persistent postoperative neurological deficits. In contrast, patients without tract involvement or with preserved tract configuration generally demonstrated favorable postoperative functional outcomes (table 2).

Table 2. Tractographic patterns and postoperative functional outcomes

Tractographic pattern	Patients, n (%)	Persistent neurological deficit, n (%)
No contact with white matter tracts	16 (16.0%)	1 (1.0%)
Contact without tract deformation	19 (19.0%)	2 (2.0%)
Moderate tract displacement	34 (34.0%)	8 (8.0%)
Tract deformation and thinning	21 (21.0%)	9 (9.0%)
Partial tract involvement	19 (19.0%)	10 (10.0%)

Overall, the frequency of persistent postoperative neurological deficits increased progressively with greater severity of tractographic abnormalities. The highest rate of unfavorable functional outcomes was observed in patients with tract deformation, thinning, and partial tract involvement. These findings indicate that MR tractography provides clinically significant information regarding functional relationships between subcortical tumors and white matter pathways that cannot be reliably identified using conventional MRI alone.

Discussion

The present study demonstrated that pediatric subcortical supratentorial tumors are characterized by substantial clinical and radiological heterogeneity, which limits the reliability of conventional topographic assessment based solely on anatomical localization and standard MRI findings. Even within the same lobar region, tumors showed marked variability in clinical presentation, contour characteristics, perifocal changes, and relationships with surrounding white matter structures. These findings support the concept that conventional MRI provides predominantly morphological information and does not adequately reflect the functional organization of subcortical white matter pathways [8, 9].

One of the most important observations of the study was the absence of a stable relationship between standard MRI characteristics and the severity of tractographic alterations. Tumors with similar radiological appearance frequently demonstrated different patterns of interaction with functionally significant conducting pathways, ranging from simple displacement to deformation, thinning, and partial tract involvement [10]. This finding highlights the limitations of traditional anatomical landmarks during preoperative planning, particularly in pediatric patients with subcortical lesions located near eloquent brain regions.

MR tractography provided additional functional-topographic information that could not be obtained using conventional MRI alone. The method allowed visualization of the internal spatial organization of white matter pathways and enabled assessment of the degree of tract involvement by the tumor process [11]. Moderate tract displacement represented the most common tractographic pattern, whereas deformation, thinning, and partial tract involvement were associated with more complex anatomical relationships and increased functional risk. These findings are consistent with recent reports

emphasizing the growing role of diffusion tractography in pediatric neuro-oncological surgery and functional preservation strategies.

The study also demonstrated a clinically relevant association between the severity of tractographic abnormalities and postoperative neurological outcomes [12]. Patients without tract involvement or with preserved tract configuration generally had favorable postoperative functional status, whereas more severe tractographic changes were associated with a progressively higher frequency of persistent neurological deficits. This gradation suggests that tractographic assessment may have prognostic value in addition to its anatomical role during surgical planning. In practical terms, visualization of tract deformation or partial involvement may help identify patients with increased functional vulnerability before surgery.

An additional important finding was the high degree of concordance between tractographic data and intraoperative observations. In most cases, preoperative tractographic patterns corresponded to the actual anatomical relationships identified during surgery, supporting the clinical reliability of MR tractography in the evaluation of pediatric subcortical tumors. This correspondence is particularly important in children, where maximal tumor resection must be balanced against preservation of neurological function and long-term quality of life [13, 14].

Several limitations of the present study should be acknowledged. The study had a retrospective single-center design and included heterogeneous tumor localizations within the supratentorial subcortical region. Quantitative diffusion metrics were not analyzed, and tractographic assessment was based primarily on qualitative evaluation of pathway configuration and involvement. In addition, the study focused mainly on structural tractographic patterns without detailed analysis of specific functional tracts. Further prospective studies with quantitative diffusion analysis and long-term neurological follow-up may provide additional information regarding the prognostic significance of tractographic findings in pediatric neuro-oncology.

Conclusion

Pediatric subcortical supratentorial tumors demonstrate pronounced clinical and radiological heterogeneity, which substantially limits the diagnostic reliability of conventional anatomical and MRI-based assessment during preoperative planning. Standard magnetic resonance imaging provides important morphological information regarding tumor localization and structural characteristics; however, it does not adequately reflect the spatial relationships between the tumor and functionally significant white matter pathways. MR tractography allows detailed visualization of subcortical conducting pathways and enables identification of different patterns of tumor-tract interaction, including displacement, deformation, thinning, and partial tract involvement. The severity of tractographic abnormalities was associated with postoperative neurological outcomes and demonstrated high concordance with intraoperative findings, indicating the clinical relevance of tractographic assessment in pediatric neurosurgical practice. Integration of MR tractography into the preoperative evaluation of pediatric subcortical supratentorial tumors may improve functional-topographic assessment, facilitate surgical planning, and contribute to more accurate prediction of neurological risk during tumor resection.

References

1. Acta Neurochirurgica Foley R., Boop F. Tractography guides the approach for resection of thalamopeduncular tumors // Acta Neurochirurgica. 2017. Vol. 159, No. 9. P. 1597-1601.

2. Brain Structure and Function Vergani F., Sarubbo S., Yang J.Y. Debate: is tractography accurate enough to be used to inform surgery? // Brain Structure and Function. 2025. Vol. 230, No. 5. Art. 81.

3. Neuro-Oncology Hu J., Bao H., Liu X. et al. Glioma-white matter tract interactions: a diffusion magnetic resonance imaging-based 3-tier classification and its clinical relevance // Neuro-Oncology. 2025. Vol. 27, No. 7. P. 1888-1898.

4. Journal of Neurosurgery Zhang W., Ille S., Schwendner M. et al. Tracking motor and language eloquent white matter pathways with intraoperative fiber tracking versus preoperative tractography adjusted by intraoperative MRI-based elastic fusion // Journal of Neurosurgery. 2022. Vol. 137, No. 4. P. 1114-1123.

5. Neurosurgical Focus Xiao X., Kong L., Pan C. et al. The role of diffusion tensor imaging and tractography in the surgical management of brainstem gliomas // Neurosurgical Focus. 2021. Vol. 50, No. 1. Art. E10.

6. Brain Structure and Function Chong S.T., Yang J.Y., Lin C.P. Understanding tractography in edematous brain regions: challenges and solutions // Brain Structure and Function. 2025. Vol. 230, No. 5. Art. 64.

7. Brain Structure and Function Dubois J., Grotheer M., Yang J.Y. et al. Small brains but big challenges: white matter tractography in early life samples // Brain Structure and Function. 2025. Vol. 230, No. 4. Art. 58.

8. Neurology Guberman G.I., Balasubramaniam N., Wilson L. et al. Diffusion MRI tractography to reduce risks of postoperative neurologic deficits: a systematic review and meta-analysis // Neurology. 2025. Vol. 105, No. 9. P. e214145.

9. Clinical Neurophysiology Jung J., Rajwani K., Mirallave-Pescador A. et al. Functional cortical mapping and structural subcortical anatomy predicts intra-operative speech arrest: a nTMS-tractography study // Clinical Neurophysiology. 2025. Vol. 179. Art. 2110995.

10. Journal of Neurosurgery Zhang W., Ille S.,

Schwendner M. et al. Tracking motor and language eloquent white matter pathways with intraoperative fiber tracking versus preoperative tractography adjusted by intraoperative MRI-based elastic fusion // Journal of Neurosurgery. 2022. Vol. 137, No. 4. P. 1114-1123.

11. Neuro-Oncology Hu J., Bao H., Liu X. et al. Glioma-white matter tract interactions: a diffusion magnetic resonance imaging-based 3-tier classification and its clinical relevance // Neuro-Oncology. 2025. Vol. 27, No. 7. P. 1888-1898.

12. Brain Structure and Function Vergani F., Sarubbo S., Yang J.Y. Debate: is tractography accurate enough to be used to inform surgery? // Brain Structure and Function. 2025. Vol. 230, No. 5. Art. 81.

13. Journal of Neurosurgery: Case Lessons Yuan-Mou Yang J., Cottier R., Beare R. et al. Advanced tractography-guided laser ablation of a perirolandic long-term epilepsy-associated tumor: illustrative case // Journal of Neurosurgery: Case Lessons. 2024. Vol. 8, No. 15. CASE24139.

14. Acta Neurochirurgica Foley R., Boop F. Tractography guides the approach for resection of thalamopeduncular tumors // Acta Neurochirurgica. 2017. Vol. 159, No. 9. P. 1597-1601.