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Idiopathic Brain Herniations in Children: Clinical and Radiologic Correlations from a Retrospective Series

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Abstract

Objective

Idiopathic brain herniations (IBH) are rare structural anomalies characterized by the protrusion of normal brain parenchyma into adjacent dural or venous compartments in the absence of trauma, surgery, mass effect, or intracranial hypotonia. Their clinical relevance in pediatric patients is not well understood. The aim of this study is to investigate the MRI characteristics and clinical associations of IBH in a pediatric population.

Materials and methods

We retrospectively analyzed 19 pediatric patients diagnosed with IBH on brain MRI at a tertiary radiology center between 2021 and 2025. Exclusion criteria included secondary herniation, systemic or congenital disease and poor image quality. Two board-certified neuroradiologists independently reviewed MRI findings, including herniation localization, laterality, and associated signal changes. Clinical data were extracted from patient records. Statistical analyzes were performed to evaluate correlations between hernias and neurological symptoms.

Results

The most frequent herniation site was the precuneal gyrus (52.6%), followed by the temporal lobe (36.8%). Temporal IBH was significantly associated with clinical seizures ($p = 0.0009$), whereas precuneus herniations were generally asymptomatic or associated with headache and dizziness. In two temporal IBH cases, MR venography revealed filling defects in the transverse sinus that mimicked venous thrombosis but proved to be benign. No significant correlation was found between IBH and age or gender of the patients.

Conclusion

Idiopathic brain herniations in children are not always incidental and may be associated with site-specific neurologic symptoms, particularly seizures in temporal hernias. Recognizing their imaging patterns is important to avoid misdiagnosis and unnecessary treatment. Awareness of IBH can improve diagnostic accuracy in pediatric neuroimaging practice.

Introduction

Idiopathic brain herniations (IBD) are rare disorders in childhood and their etiology is not fully understood. They are described in the literature as very rare, mostly on a case-by-case basis. In IBD, normal brain tissue expands into the extradural space. The herniating brain tissue is structurally normal and no signal changes are seen on magnetic resonance imaging (MRI). Early diagnosis and appropriate treatment are crucial to prevent potential neurological damage [1–4]. In this study, we retrospectively reviewed pediatric cases diagnosed with IBD on MRI scans of the brain over a five-year period and examined the MRI features, concomitant clinical findings, and other MRI findings.

Materials and methods

This retrospective study included nineteen patients evaluated between January 2021 and January 2025 in a tertiary radiology department with a radiologic diagnosis of IBH. The study was approved by the institutional ethics committee and conducted in accordance with the Declaration of Helsinki. The present study is a retrospective study for which the ethics committee for non-invasive clinical research of our university granted its approval on May 17, 2023 (decision no. 2023-05/33).

Patient group

Our retrospective study included 19 patients under 18 years of age diagnosed with IBD by evaluating pediatric brain MRI scans in the PACS system between 2019 and 2024. Patients were excluded if they were older than 17 years, had artifacts that prevented evaluation, had missing or insufficient MRI data, had a secondary brain hernia, had venous and cerebrospinal fluid perfusion disorders, had undergone previous cranial surgery, and had systemic disease. Patients with missing or insufficient MRI data or MRI findings that could not be optimally evaluated due to artifacts were also excluded.

MRI protocol and evaluation

MRI protocol and evaluation
All MRI examinations of the brain were performed with a 1.5 Tesla scanner (Magnetom Aera, Siemens, Erlangen, Germany) according to a standard protocol for pediatric brain imaging. Sequences included axial and coronal T2-weighted fast spin echo (FSE), axial T1-weighted spin echo, axial fluid-attenuated inversion recovery (FLAIR), diffusion-weighted imaging (DWI), and sagittal 3D T1-weighted volumetric gradient echo sequence. In addition, axial inversion recovery (IR) sequences were performed in selected cases to enhance the contrast between gray and white matter and improve the detection of subtle cortical abnormalities and parenchymal herniation margins. When clinically indicated, 3D T1-weighted post-contrast imaging was performed after intravenous administration of a gadolinium-based contrast agent.

All images were independently reviewed by two board-certified neuroradiologists with more than 10 years of experience who were blinded to the patients' clinical data. The radiologists assessed the presence, location, and laterality of IBHs along with concomitant findings such as an adjacent venous sinus impression, parenchymal signal changes, or mass effect. IBH was defined as focal protrusion of brain tissue into adjacent dural or venous compartments in the absence of trauma, mass effect, surgery, or intracranial hypotension. All disagreements between the reviewers were resolved by consensus. The patient flowchart of the study is shown in Fig. 1.

Statistical analysis

Descriptive statistics, group comparisons and multivariate analyzes were carried out in the study. The chi-square test was used to assess the relationships between gender and IBD types, age groups and IBD types, and clinical findings and IBD types. Spearman correlation test was used to assess the correlation between age and IBD localization. A p-value of < 0.05 was considered statistically significant.

Results

The mean age of the nineteen patients with IBD detected by MRI was 8.6 years, with a range of 1–17 years. Nine (47.4%) of the cases were female and 10 (52.6%) were male. Of the nineteen cases, the IBD was localized precuneal in 10 cases (Fig. 2), temporal in 7 cases (Fig. 3), lingual in 1 case (Fig. 4), and occipital in 1 case (Fig. 5). The most common herniation site was the precuneus, seen in 10 cases (52.6%), followed by the temporal lobe in 7 cases (36.8%). Lingual and occipital herniations were observed in only one patient each (5.3%). Five (50%) of the cases of precuneus herniation were male and five (50%) were female. Of the unilateral precuneal IBD cases, one (20%) was left-sided and four (80%) were right-sided. Five (50%) of the precuneal IBD cases were bilateral, two of which were male and three of which were female. Five (71%) of the temporal IBD cases were male and two (29%) were female. All of these cases were unilateral. Five (71%) of the unilateral cases were left-sided and two (29%) were right-sided. In the male temporal IBD cases, three (42) IBD cases were on the left side and two cases were on the right side. In female patients with temporal IBD, the IBD was located on the right side in one patient and on the left side in one patient. In the female patient with lingual IBD, the lesion was bilateral. In the male patient with occipital IBD, the lesion was on the left side and appeared to be depressed into the inner plate of the occipital bone. The gender, location and lateralization findings of the patients are shown in Fig. 6. Of the precuneus IBD patients, 1 (13%) had headache, 4 (50%) had convulsions, and 3 (37%) had headache and dizziness. Six (85%) of the temporal IBD patients had

clinical seizures. Three (43%) of the temporal IBD patients had headaches and 2 (28%) had mental retardation and speech delay. MR venography of two patients with herniation of the left temporal lobe showed a filling defect in the left transverse sinus due to IBD. In addition, one patient with left-sided IBD had a large arachnoid cyst in the right hemisphere. The patient with lingual IBD had bilateral strabismus and distichiasis. The patient with occipital IBD had tinnitus and vertigo. The distribution of clinical findings in the patients is shown in Fig. 7.

No significant relationship was found between gender and IBD types (p: 0.194). No significant correlation was found between age groups and IBD types (p: 0.622). A statistically significant association was found between clinical findings and IBD types (p: 0.0009). No significant association was found between age and IBD localization (p: 0.65). The results of the statistically tested relationships are summarized in Table 1.

Discussion

This study is the largest in the literature showing the prevalence and clinical and imaging features of IBD at various anatomic sites in the pediatric age group. While these findings are often discovered incidentally, their clinical significance has not been adequately evaluated due to their subtle imaging features and often nonspecific symptomatology, especially with the increasing use of MRI in pediatrics. As most previous publications are limited to single case reports or very small series, little data is available on the prevalence, typical localizations and clinical correlations in children. Our retrospective analysis of 19 pediatric patients represents one of the largest case series to date and suggests that IBDs, particularly at specific sites, may not be entirely benign or incidental. It is noteworthy that temporal lobe herniations were strongly associated with clinical seizures, which were observed in 6 of 7 cases (85.7%). This observation supports the hypothesis that herniated temporal cortex may serve as a structural substrate for epileptogenesis, possibly due to focal cortical distortion, altered neuronal connectivity, or venous congestion in the adjacent transverse sinus.

Various factors, including tumors, trauma, hydrocephalus, ischemia, and infection, may play a role in the etiology of cerebral hernia. Idiopathic brain hernias (IBD) are rare structural abnormalities characterized by focal protrusion of normal brain parenchyma into adjacent dural or venous sinus compartments in the absence of trauma, surgery, mass effect, or intracranial hypotonia. The pathophysiology of IBD is not fully understood, but several possible factors have been discussed in the literature. Proposed mechanisms include congenital or acquired dural weakness, focal CSF flow alterations, meningeal discontinuities, or increased local pressure gradients near venous structures. Some studies suggest that localized dural and dural dilation defects that occur during meningeal embryogenesis may be responsible for focal brain parenchymal herniation. Changes in cerebrospinal fluid pressure can also cause abnormal displacement of brain tissue. Repeated microtrauma can lead to structural changes in brain tissue that predispose to IBD. Variations in the tentorial angle have been identified as an anatomical feature that may predispose to localized displacement of the parenchyma. In addition, it is hypothesized that increased CSF resistance at certain anatomic sites may generate sufficient force to cause cerebral herniation into the vulnerable sinus compartments, particularly in developing children's brains with their more flexible dura mater. The etiology of IBH is likely multifactorial and involves a combination of developmental, hemodynamic, and mechanical factors [1–7].

In the current literature, most cases of IBD are discovered incidentally. They are often discovered during MRI scans of the brain performed for epilepsy or other neurological symptoms. This suggests that IBD is generally asymptomatic. However, in some cases it has been associated with symptoms such as epilepsy, trigeminal neuralgia, chronic headaches and narcolepsy, indicating the need for further investigation to confirm this link [2–7].

Since computed tomography (CT) does not provide as good soft tissue contrast as MRI, its diagnostic value in IBD is limited. MRI is the most important imaging technique in the diagnosis of IBD. It can also assess the dynamics of cerebrospinal fluid flow [2–6].

Cases of temporal IBD associated with untreatable epilepsy have been reported in the literature and it is noted that careful investigation should be carried out in children with new onset or refractory seizures [8]. Another important imaging feature

noted in our study was the presence of transverse sinus filling defects in all patients with temporal IBD. This finding poses a diagnostic challenge as it can mimic dural venous sinus thrombosis on MR venography. Various publications in the literature emphasize the importance of recognizing herniation of the parenchyma into the venous sinus as a normal variant or benign protrusion in order to avoid misdiagnosis and the unnecessary use of anticoagulants. In our series, no patient had other imaging or clinical signs of venous thrombosis, and the casts were smooth, well-defined, and symmetrical, typical features of benign IBD. In our cohort, precuneous herniations were most frequently observed (52.6%). Although less symptomatic than temporal IBDs, a subset of patients reported headaches and dizziness. These symptoms may be due to venous congestion, local cortical irritation, or even incidental comorbidities. In contrast, lingual and occipital herniations observed in isolated cases were asymptomatic, suggesting that the location of the herniation plays a central role in the clinical presentation. This anatomic-clinical correlation has not been extensively addressed in previous literature, and our results provide valuable evidence for this debate. Importantly, we found a statistically significant correlation between the location of IBD and presenting symptoms ($p = 0.0009$), suggesting that these lesions may have site-specific neurological consequences. This finding challenges the traditional notion that IBD is a purely incidental finding and emphasizes the need for radiologists to be cautious when evaluating such abnormalities, especially in symptomatic patients. Although IBD can mimic other pathologies (e.g., neoplasms, venous thrombosis, encephalocele), careful consideration of its location, shape, signal characteristics, and clinical context can help avoid misinterpretation.

Koç et al. [1] reported two cases of pediatric IBD in 2014. The first case was a hernia of the left inferior temporal gyrus in a 12-year-old boy and the second case was a hernia of the right precuneus gyrus in a 6-year-old boy. Both cases were discovered by chance during MRI examinations for suspected epilepsy. In 2018, Romero and Vieira [2] discovered a herniation of the precuneus gyrus into the quadrigeminal sphincter in an 8-year-old girl during an MRI scan following mild head trauma. Düzkalır et al. [3] reported that 50% of patients with idiopathic herniation of the cuneal gyrus have congenital malformations, and that half of these cases have concomitant posterior fossa abnormalities. However, we excluded cases with congenital anomalies associated with IBD because we believed that the presence of congenital anomalies could contribute to brain herniation. It has been suggested that precuneus herniation may affect the visual field because the cuneus region protrudes from the visual field [4]. In our cases of precuneus herniation, no specific visual field symptoms were observed. The precuneus is a structure in the posterior medial part of the parietal lobe with extensive cortical and subcortical connections. Functionally, it plays a role in complex integrative functions such as visual-spatial imagination, sensorimotor processing and consciousness. These extensive connections and functional diversity can make it difficult to associate the precuneus region with neurological symptoms.

In 2013, Çoban et al. [4] reported on a patient who presented with vertigo and was found to have herniation of the temporal lobe into the transverse sinus on MRI. In this case, the diagnosis was also confirmed by MR venography. Yadav et al. [9] reported a 21-year-old male patient with a focal herniation of the parenchyma of the left temporal lobe into the left transverse sinus. In this case, the patient had recurrent seizures and headaches despite taking antiepileptic drugs. In their study of 21 cases, Battal et al. [10] found herniation of the inferior temporal gyrus into the transverse sinus in 9 patients. In our study, seizures were observed in 5 out of 6 (83%) patients with temporal herniation. If a filling defect in the transverse sinus is detected in patients undergoing MRI of the brain due to seizures, IBD should be considered in the differential diagnosis in addition to granulation of the arachnoid membrane and sinus thrombosis.

In 2017, Seok et al. [7] discovered a unilateral herniation of the lingual gyrus into the quadrigeminal cistern on MRI in a 56-year-old woman who presented with a headache. This herniated gyrus segment had a signal intensity similar to that of the brain parenchyma. In our study, the herniation of the lingual gyrus was bilateral and the patient presented clinically with strabismus and distichiasis.

In their study of 21 cases, Battal et al. [10] found herniation of the occipital lobe into the occipital bone in three cases. Two of these cases were on the right side and one on the left side. In our case, the occipital lobe appeared to be herniated into the inner plate of the occipital bone.

There are also case series in the literature with brain herniation into the arachnoid granulation. In our study, there were no cases of herniation into the arachnoid granulation. A summary of the cases of IBD reported in the literature and a comparison with the present study are summarized in Table 2.

One of the greatest strengths of this study is the relatively large pediatric sample size for such a rare entity. To our knowledge, this is one of the most comprehensive single studies on idiopathic brain herniations in children. The study design allowed for systematic MRI review by two independent and experienced pediatric neuroradiologists, reducing interobserver variability and ensuring consistent interpretation. In addition, statistical analysis revealed a significant correlation between the location of herniation and clinical symptoms, providing new insights into the clinical significance of these lesions. In contrast to previous literature based primarily on random case reports, our study provides structured data on the anatomic distribution, symptom patterns, and imaging features in a pediatric cohort. This makes our findings valuable for improving diagnostic awareness and radiologic interpretation of IBD in clinical practice.

However, this study has several important limitations that should be considered. First, the retrospective design inherently limits the ability to control for all clinical variables and introduces potential bias due to incomplete or missing data. Second, the relatively small sample size — limited to 19 pediatric patients due to the rarity of idiopathic brain hernia (IBH) — limits the statistical power and generalizability of the results. Third, the lack of functional imaging techniques such as electroencephalography (EEG) or functional MRI (fMRI) prevents a direct assessment of the epileptogenic potential of the herniations, especially in cases of temporal lobe associated with seizures. Fourth, the lack of long-term follow-up data prevents an assessment of the natural history, progression, or potential long-term consequences of IBH in pediatric patients. Finally, the lack of a healthy control group limits comparative analysis, and the interpretation of correlations between hernia features and clinical symptoms should therefore be treated with caution.

Future studies, especially prospective, multicenter studies with larger patient cohorts, standardized imaging protocols, and functional correlates (e.g., EEG, fMRI), are needed to determine the true prevalence, natural history, and clinical impact of IBD. In clinical practice, the identification of IBD as a possible cause of neurological symptoms (especially seizures) in children can change management and prevent unnecessary diagnostic procedures or interventions.

Conclusion

Idiopathic brain herniations are often overlooked as incidental findings, but can be of considerable clinical relevance — especially when the temporal lobe is affected. Our study provides new evidence of a strong association between the location of herniation and neurological symptoms in the pediatric population. Recognizing these subtle imaging findings and understanding their potential significance may prevent misdiagnosis and avoid unnecessary interventions. Future prospective, multicenter studies with functional imaging and long-term clinical follow-up are essential to fully elucidate the significance of these abnormalities.

Declarations

Author Contribution

M.A., N.B. and S.A. wrote the main manuscript, tables and figures. All authors reviewed the manuscript.

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Tables

Table 1: Statistical correlation between gender, age, clinical findings, type and localization of the idiopathic brain herniations.

Tested Relationship	Chi-square/Spearman R	p-value	Significance (p<0.05)
Gender - Herniation Types	3.28	0.194	No
Ages groups - Herniation Types	2.63	0.622	No
Clinical symptoms - Herniation Types	26.40	**0.0009***	**Yes**
Age- Herniation Localization	0.12	0.65	No

Table 2. Summary of reported idiopathic brain herniation cases in the literature compared with the present study

Author/Year	Study type	Population	No. of Cases	Age Range	Herniation site(s)	Clinical Findings	Key Remarks
Koç et al., 2014	Case report	Pediatric	2	6-12 y	Temporal (1), Precuneus (1)	Epilepsy (both)	First pediatric cases reported; incidental MRI finding
Romero&Vieira, 2018	Case report	Pediatric	1	8y	Precuneus	Head trauma (incidental finding)	Precuneus herniation into quadrigeminal cistern
Düzkalır et al., 2024	Retrospective series	Pediatric	14	1-17y	Cuneus	50% with congenital malformations	MRI-based evaluation; possible embryologic origin
Çoban et al., 2013	Case report	Adult	1	40y	Temporal	Vertigo	Temporal encephalocele into transverse sinus
Yadav et al., 2020	Case report	Adult	1	21y	Temporal	Seizures, headache	Refractory epilepsy; transverse sinus involvement
Battal et al., 2016	Retrospective series	Pediatric+Adult	21	12-68y	Temporal, Occipital, Precuneus	Variable	43% temporal lobe involvement; possible venous sinus variants
Seok et al., 2017	Case report	Adult	1	56y	Lingual	Headache	Unilateral lingual herniation
Present study	Retrospective series	Pediatric	19	1-18y	Precuneus (10), Temporal (7), Lingual (1), Occipital (1)	Seizures, headache, dizziness	Largest pediatric IBH series; significant correlation between site and symptoms

Figures

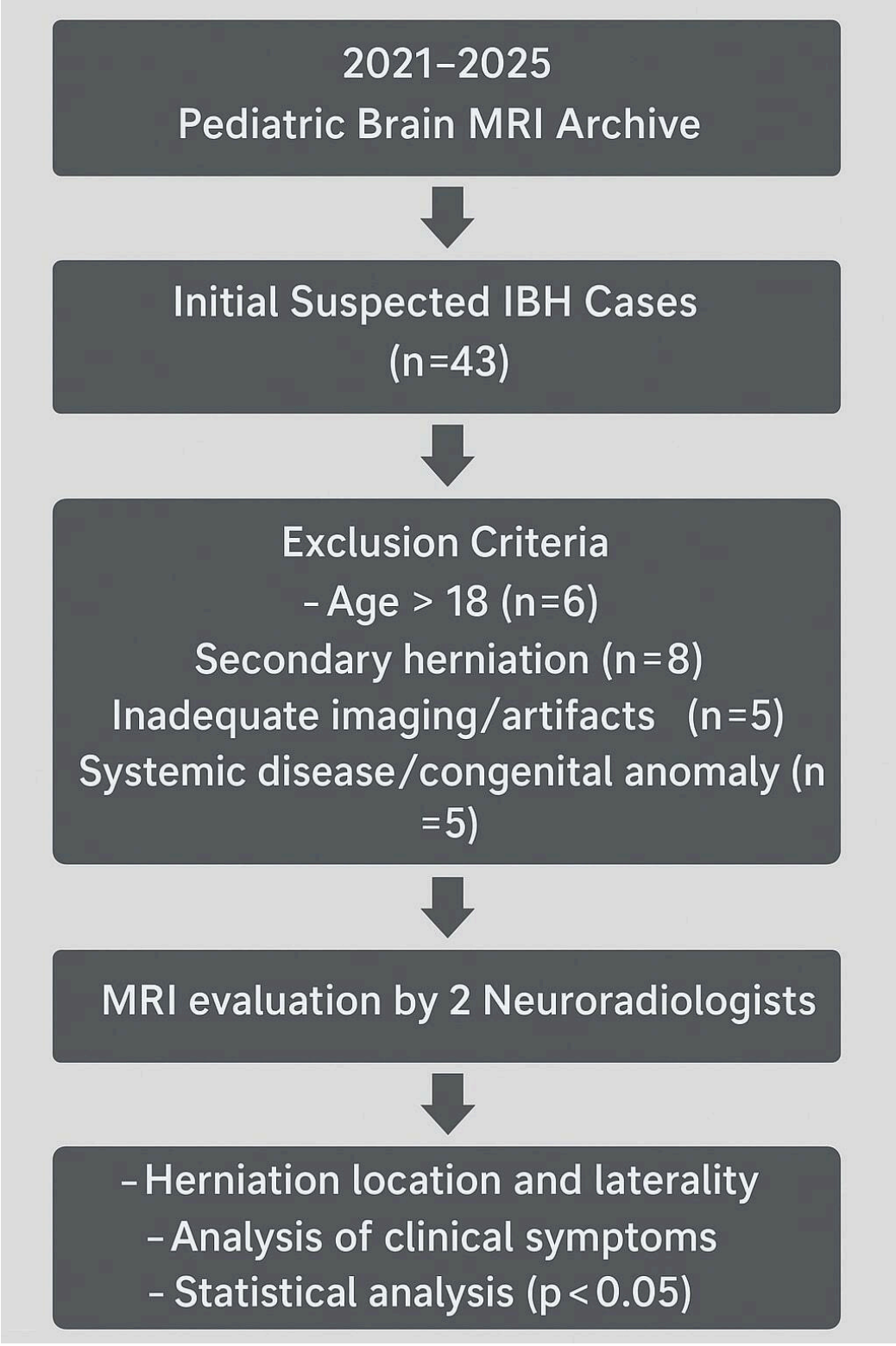


Figure 1

Flowchart illustrating the patient selection process for the study.

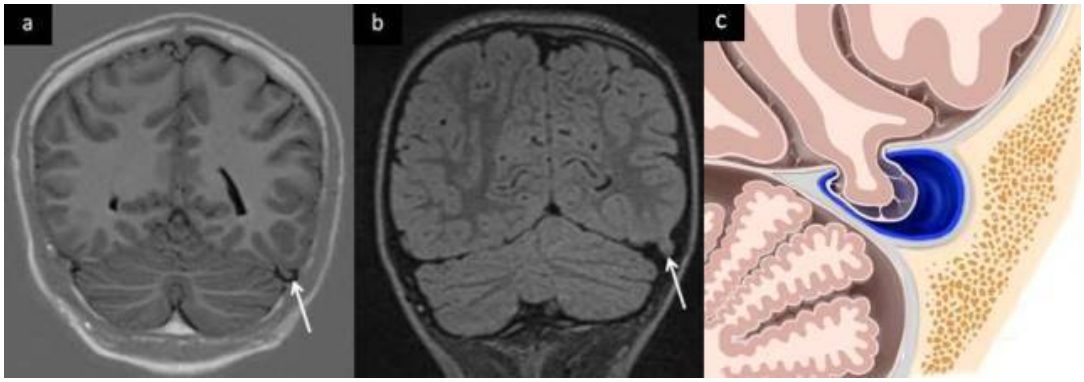


Figure 2

Seven-year-old boy. Axial T2W (a) and sagittal T1W (b) MR images showing herniation of the right precuneal gyrus (white arrows). (c) Schematic drawing of herniation of the right precuneal gyrus.

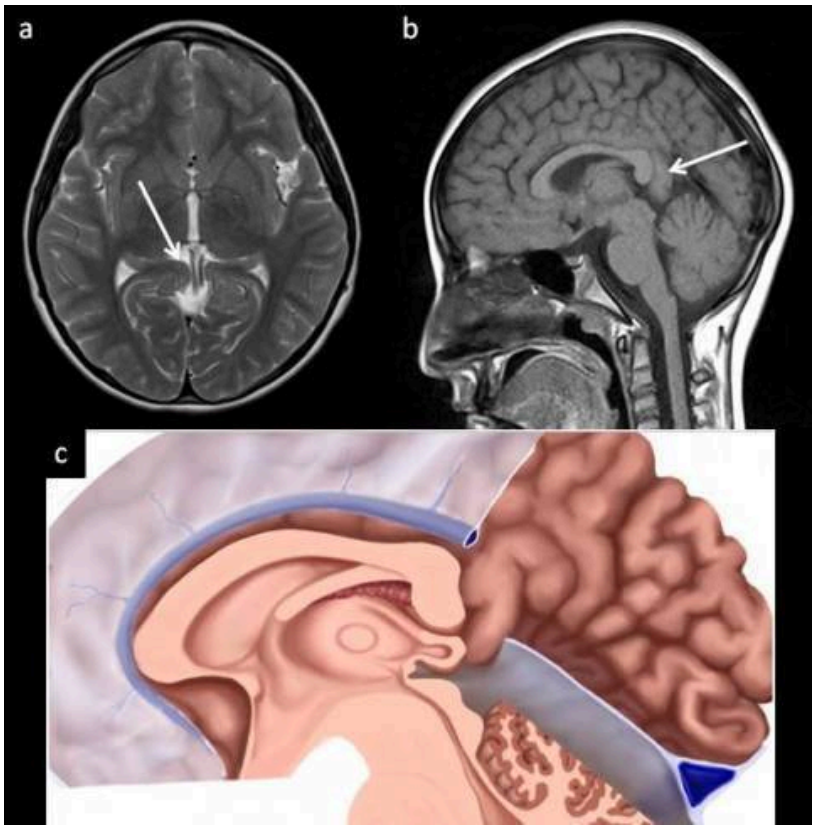


Figure 3

Eight-year-old boy. Coronal T1W inversion recovery (a) and coronal FLAIR MR images (b) show a focal brain herniation in the lower part of the left temporal lobe (white arrows). (c) Schematic drawing of the idiopathic focal temporal herniation.

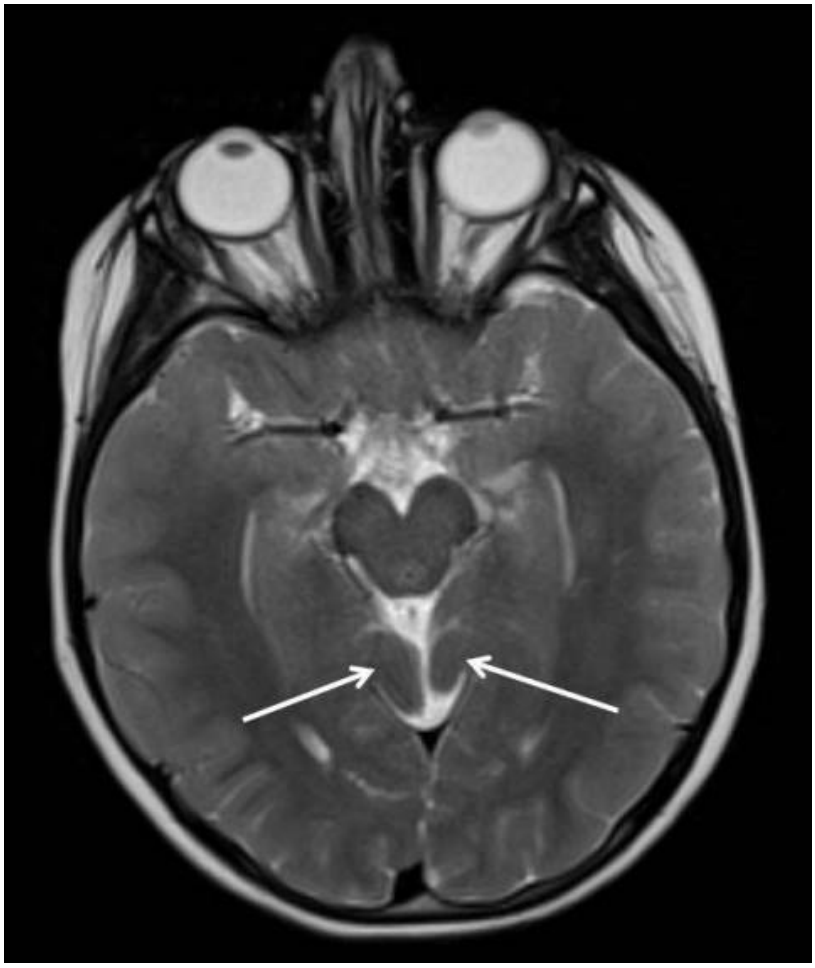


Figure 4

Five-year-old girl. Axial T2W MR image showing herniation of the bilateral lingual gyrus (white arrows).

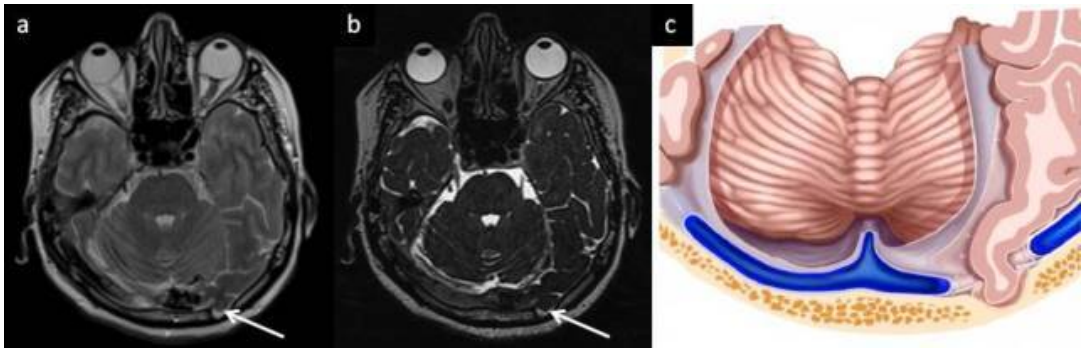


Figure 5

Seventeen-year-old boy. Axial (a) T2W and (b) CISS MR images showing focal herniation of the left occipital lobe into calvarium. (c) Schematic drawing of focal herniation of the left occipital lobe.

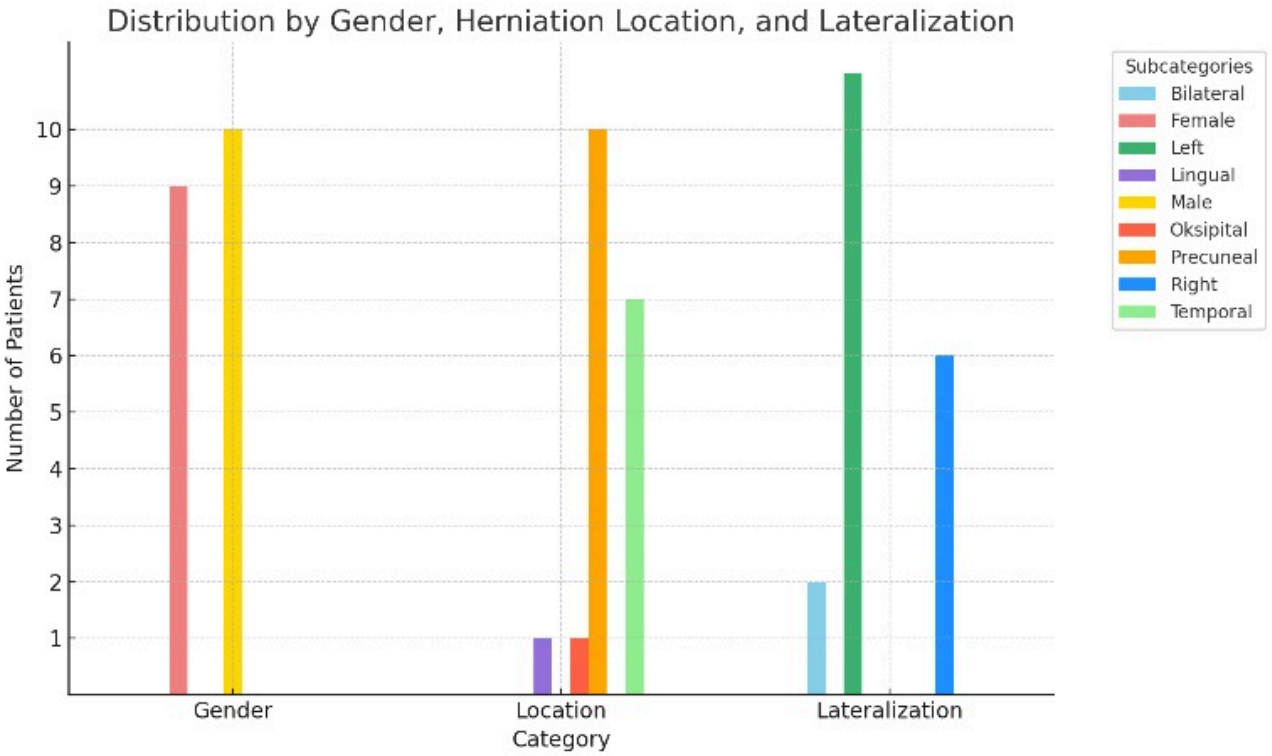


Figure 6

Distribution by gender, site of herniation and lateralization.

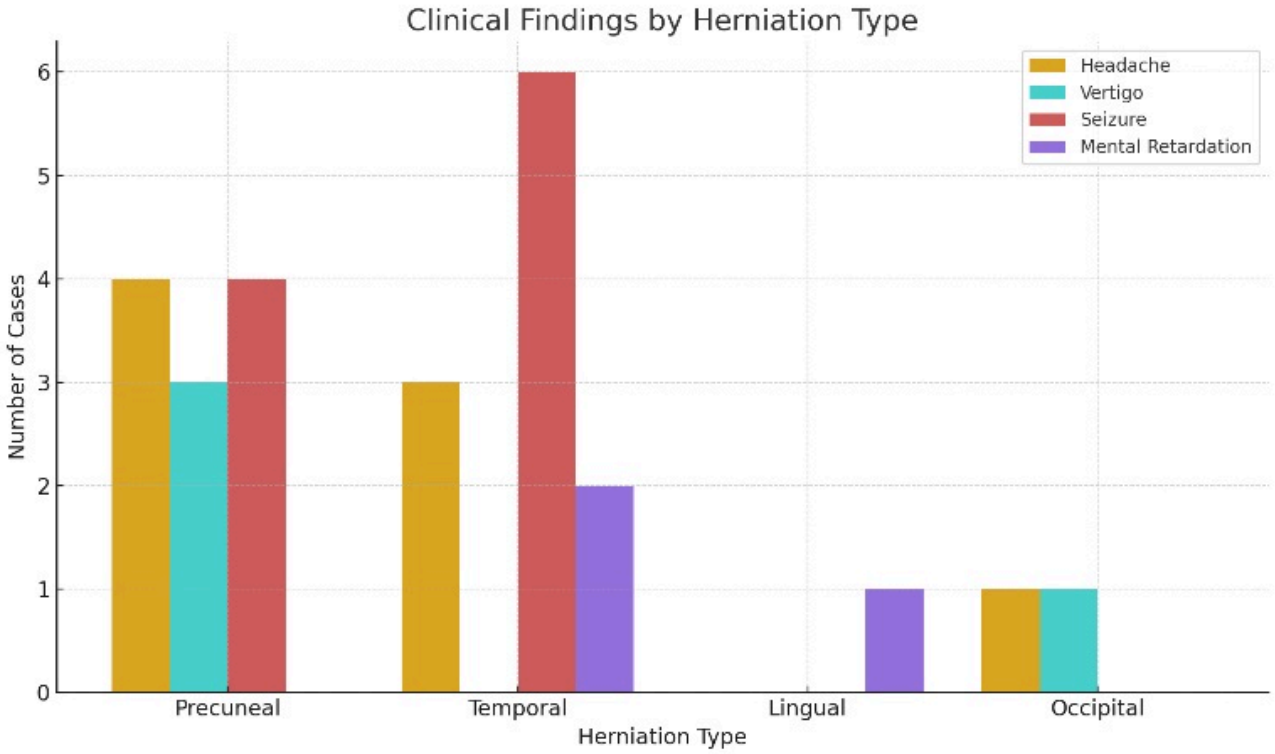


Figure 7

Clinical findings according to herniation types.