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ORIGINAL ARTICLE

A new imaging entity consistent with partial ectopic posterior pituitary gland: report of six cases

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Abstract

Background Abnormal posterior pituitary development including ectopic location has been associated with endocrine manifestations of anterior pituitary dysfunction.

Objective We describe an unreported clinical and radiologic entity we call partial ectopic posterior pituitary for which associated endocrine consequences are not known.

Materials and methods We selected pediatric head MRI examinations from 2005 to 2017 based on the finding of a double midline sellar and suprasellar bright spot on T1-weighted sequence. Medical history, physical examination, pituitary hormonal profile and bone age evaluation were extracted from the medical record of the selected patients. An experienced pediatric neuroradiologist reviewed head MRIs, which were performed on 3-tesla (T) magnet and included at least sagittal T1-weighted imaging centered on the sella turcica obtained with and without fat suppression.

Results In six cases, two midline bright spots were identified on T1-weighted sequences obtained both with and without fat suppression. While one spot was located at the expected site of the neurohypophysis in the posterior sella, the second one was in the region of the median eminence, suggesting partial ectopic posterior pituitary gland. Growth hormone deficiency, either isolated (n=1) or combined with thyroid stimulating hormone deficiency (n=1) was found. None of the children had clinical signs of posterior pituitary dysfunction.

Conclusion We describe an unreported imaging entity suggesting partial ectopic posterior pituitary gland in six children. Anterior pituitary hormone deficiencies might be detected in those children and long-term follow-up could provide additional information on the development of other pituitary hormone deficiencies.

Keywords Children · Ectopic · Endocrine · Growth hormone · Magnetic resonance imaging · Pituitary gland · Posterior pituitary

Introduction

Abnormal posterior pituitary gland development has been associated with a migration defect or caused by neurodegeneration of the hypothalamic nuclei. Developmental abnormality of the posterior pituitary can lead to an ectopic posterior pituitary at the median eminence or along the pituitary stalk, with partial or complete pituitary stalk agenesis [1]. Pituitary stalk interruption syndrome is defined by an absent or thin pituitary stalk, a hypoplastic anterior pituitary gland

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and an ectopic posterior pituitary. Ectopic posterior pituitary has been associated with isolated growth hormone deficiency, multiple pituitary hormone deficiency, and hyperprolactinemia, but normal posterior pituitary function [1–3]. Genetic or idiopathic etiologies might be at play in these developmental abnormalities and might have a common origin. A genetic cause is likely one of the explanations for ectopic posterior pituitary [4, 5].

Although two reports exist of a patient with two apparent ectopic bright spots in aberrant locations [6, 7], to our knowledge the coexistence of an orthotopic and an ectopic neurohypophysis as an anatomical variant of this entity has not been reported in the literature. We report six pediatric cases where a normal posterior pituitary gland, a continuous stalk and a normal infundibulum are present in addition to an ectopic neurohypophysis in the infundibulum or at the floor of the 3rd ventricle, seen on head MRI. We named it partial ectopic posterior pituitary gland. We propose that partial ectopic posterior pituitary gland is a variant of ectopic posterior pituitary syndrome.

Materials and methods

Six pediatric cases from the McGill University Health Centre, Montreal, QC, Canada, were collected and stored prospectively from 2005 to 2017, based only on MRI findings. Image acquisition was done using a 3-tesla (T) magnet. Because head imaging was done for various reasons, different protocols were used; however they all included sagittal T1-weighted sequences with and without fat suppression, with repetition time/echo time/inversion time (TR/TE/TI) 650–2000/7.1–33/1,000 ms, echo train length 3–9, flip angle 140–150°, field of view (FOV) 180×180 mm/140×140 mm, slice thickness 2 mm, matrix 256×192; and coronal thin T2-W sequence with fat suppression, TR/TE 3,000/97 ms, echo train length 17, flip angle 150°, FOV 140×140 mm, slice thickness 2 mm, and matrix 320×224, centered on the sella turcica.

Images were assessed at the time they were performed and reviewed during this manuscript preparation by a pediatric neuroradiologist (C.S.-M., with 25 years of experience) for the size of the pituitary gland, presence and thickness of the pituitary stalk, size and location of the ectopic supernumerary bright spot (Figs. 1, 2, 3, 4, 5 and 6), and any associated brain malformations (Figs. 7, 8, 9, 10, 11 and 12). Craniocaudal and anteroposterior diameters of the ectopic bright spot were taken in the sagittal midline view.

We retrospectively extracted medical history, physical examination findings and hormonal evaluation from the medical records. Height and weight were measured in a digital balance and a calibrated stadiometer. Z-scores were calculated based on the World Health Organization growth charts [8]. Hormonal laboratory work was performed. Growth hormone (GH) deficiency was defined by peak GH level <5.0 mcg/L on two stimulation testing (clonidine 5 mcg/kg and L-arginine 0.5 g/kg). Children older than 8 years received estrogen

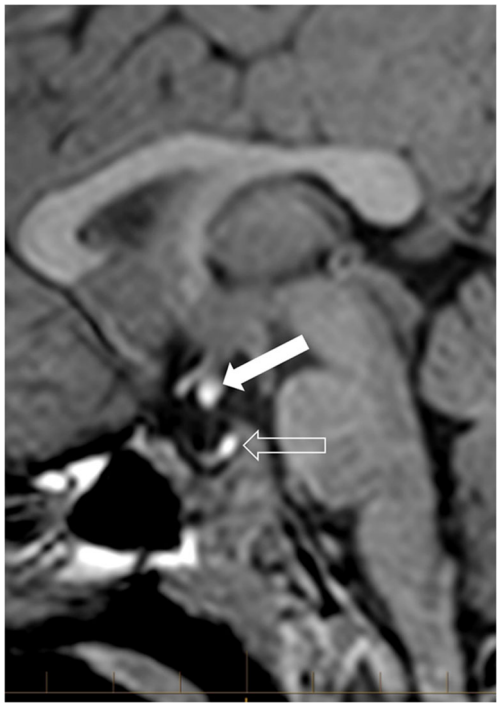

Fig. 1 Case 1, a boy age 4 years 6 months. T1-weighted fat-saturated sagittal midline MR head image shows a second and ectopic T1 bright spot in the midline at the infundibulum (*solid arrow*). A T1 bright spot also appears in the sella (*open arrow*)

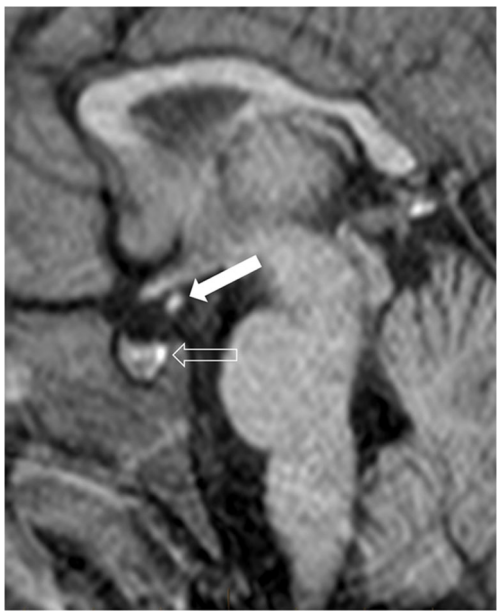

Fig. 2 Case 2, a girl age 2 years 3 months. T1-weighted fat-saturated sagittal midline MR head image shows a second and ectopic T1 bright spot in the midline at the proximal pituitary stalk (*solid arrow*). A T1 bright spot is also in the sella (*open arrow*)

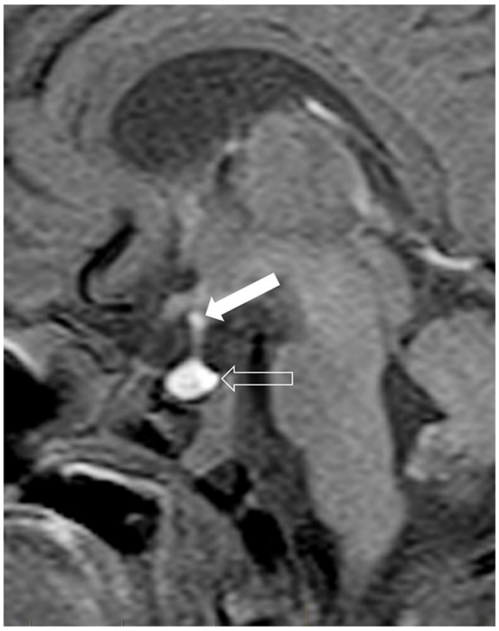

Fig. 3 Case 3, an 8-day-old boy. T1-weighted fat-saturated sagittal midline MR brain image shows a second and ectopic T1 bright spot in the midline at the infundibulum (*solid arrow*). A T1 bright spot is also in the sella posterior to the physiological-for-age hyperintense pituitary gland (*open arrow*)

priming for two consecutive nights prior to GH testing. Bone age was interpreted by comparison with Greulich and Pyle standards [9].

The ethics committee of the McGill University Health Centre, Montreal, QC, Canada, approved this study.

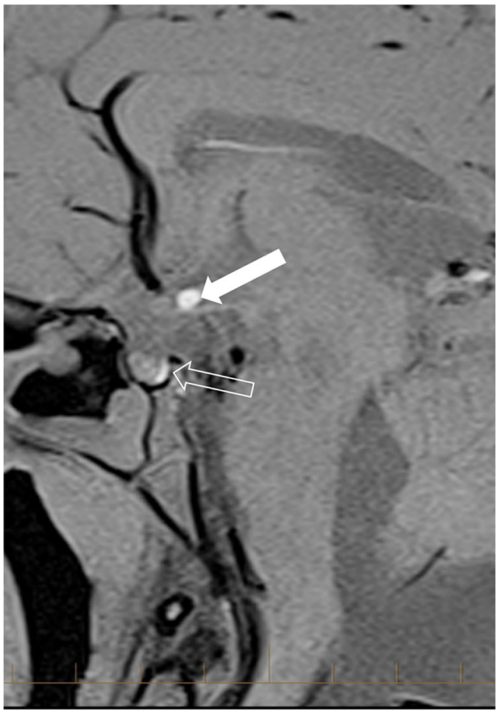

Fig. 5 Case 5, a girl age 7 years 4 months. T1-weighted fat-saturated sagittal MR brain midline image shows a second and ectopic T1 bright spot posterior and cranial to the optic chiasm (*solid arrow*). A T1 bright spot also appears in the sella (*open arrow*)

Results

All case descriptions and hormonal evaluation are summarized in Table 1 and all MRI findings in Table 2. Important

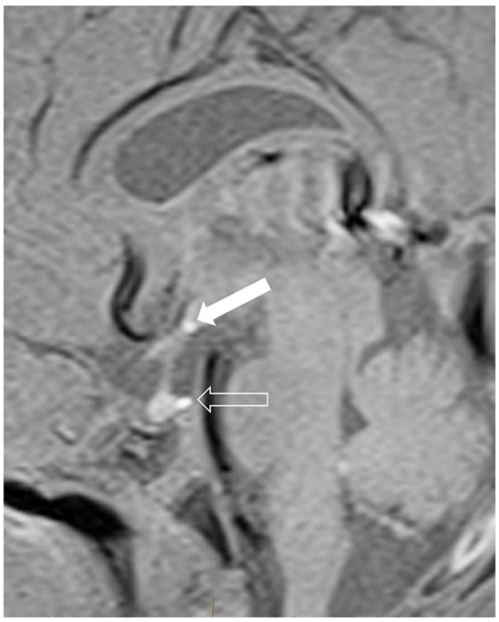

Fig. 4 Case 4, a 14-day-old girl. T1-weighted fat-saturated sagittal midline MR head image shows a second and ectopic T1 bright spot on the midline above the optic chiasm (*solid arrow*). A T1 bright spot is also in the sella (*open arrow*)

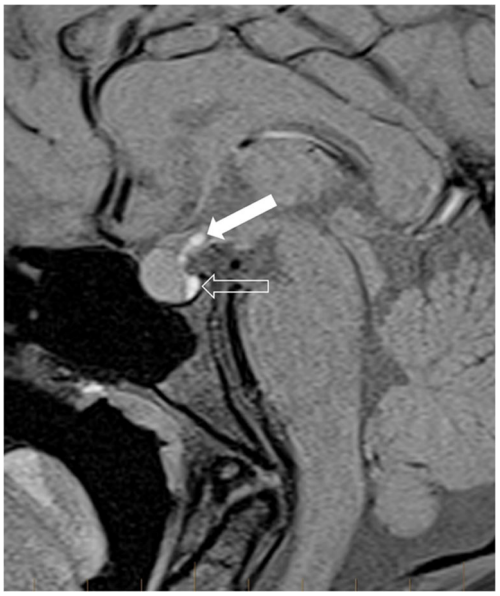

Fig. 6 Case 6, a girl age 14 years 10 months. T1-weighted fat-saturated sagittal midline head MR image shows a second and ectopic T1 bright spot bilobed at the infundibulum and along the stalk (*solid arrow*). A T1 bright spot also appears in the sella (*open arrow*)

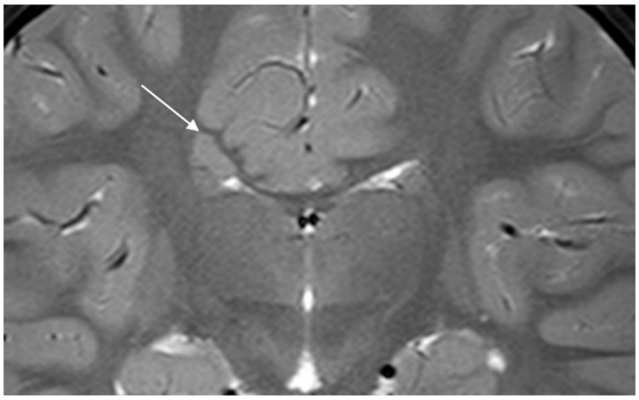

Fig. 7 Case 1, a boy age 4 years 6 months. T2-weighted coronal MR brain image shows bilateral periventricular nodular heterotopia of gray matter (*arrow*)

complementary information is briefly described in the case sections.

Case 1

A boy age 4 years 6 months, born at term, small for gestational age (2.7 kg), from a mother with insulin-dependent gestational diabetes, presented to the pediatric endocrinology clinic with short stature. Mid-parental height was 172.1 cm (–0.54 standard deviation [SD]). His height and weight were tracking below the 0.1st percentile, and at the time of the consultation, height was 88 cm (–4.2 SD) and weight was 11 kg (–3.5 SD). Pituitary imaging was obtained after growth hormone stimulation testing confirmed growth hormone deficiency (Figs. 1 and 7).

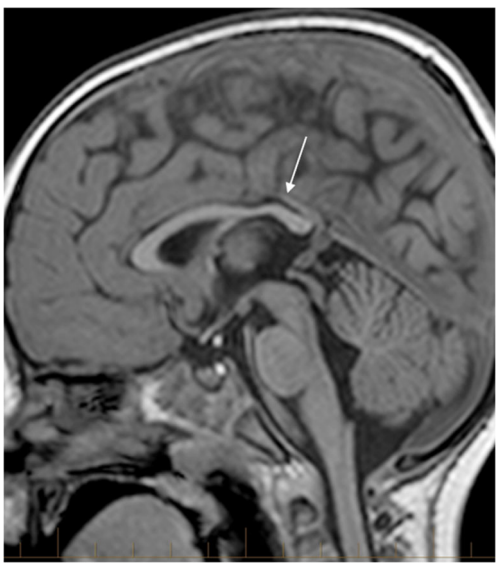

Fig. 8 Case 2, a girl age 2 years 3 months. T1-weighted sagittal MR brain image shows dysmorphic splenium of the corpus callosum (*arrow*)

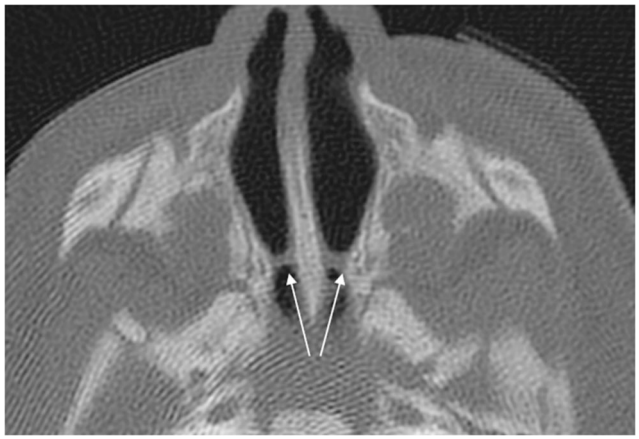

Fig. 9 Case 3, an 8-day-old boy. Unenhanced CT head axial bone windows image shows bilateral choanal atresia (*arrows*)

Case 2

A girl age 2 years 3 months, born at term and small for gestational age (2.78 kg), was referred for motor development delay. She had dysmorphic features and generalized hypotonia. Her height was 78.1 cm (–3 SD) and her weight was 10.2 kg (–1.4 SD). She had a normal 46,XX karyotype. Pituitary MRI was obtained as part of the investigation for the dysmorphic features (Figs. 2 and 8).

Case 3

An 8-day-old boy, born at $35^{6/7}$ weeks of gestation with a birth weight of 2.34 kg, was diagnosed with CHARGE syndrome (coloboma, heart defects, atresia choanae, growth retardation, genital abnormalities, and ear abnormalities) with no genetic testing done for *CHD7* mutation. He was referred because of abnormal findings on head MRI, obtained as part of the investigation of CHARGE syndrome. His mother had insulin-dependent gestational diabetes and polyhydramnios (Figs. 3, 9 and 10).

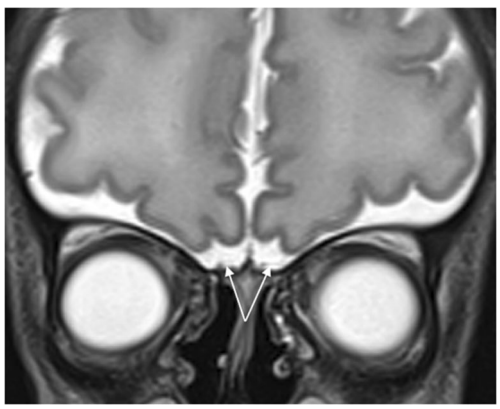

Fig. 10 Case 3, an 8-day-old boy. T2-weighted coronal MR head image shows bilateral absence of the olfactory bulbs (*arrows*)

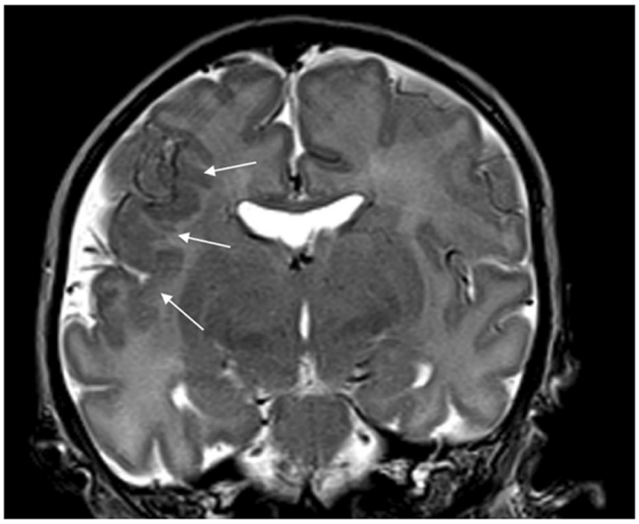

Fig. 11 Case 4, a 14-day-old girl. T2-weighted coronal MR brain image shows perisylvian polymicrogyria (*arrow*)

Case 4

A 19-day-old girl, born at 37 weeks of gestation weighing 2.84 kg, was admitted at 9 days of age for severe respiratory failure from respiratory syncytial virus bronchiolitis complicated with hypotension, septic shock, metabolic acidosis and neonatal seizures with encephalopathy. No hypoglycemia was noted. Head MRI was obtained as part of the investigation for the encephalopathy (Figs. 4 and 11).

Case 5

A girl age 7 years 4 months, born at term weighing 3.4 kg, presented with short stature. Mid-parental height was 163.5 cm (0.7 SD; 58th percentile). An arachnoid brain cyst was noted on gestational ultrasound. She had a shunt placed for hydrocephalus as a neonate and was diagnosed with autism spectrum disorder early in life. No hypoglycemia was noted. She had a history of well-controlled seizures on topiramate. Her height was tracking below the 0.1st percentile for growth, and at the time of the consultation her height was 101 cm (–3.9 SD) and weight was 16.6 kg (–2.3 SD). Dermatological examination revealed no café-au-lait spots. Thyroid was of normal size and consistency on palpation. She had a 46,XX karyotype. Pituitary imaging was obtained after growth hormone stimulation testing confirmed growth hormone deficiency (Figs. 5 and 12).

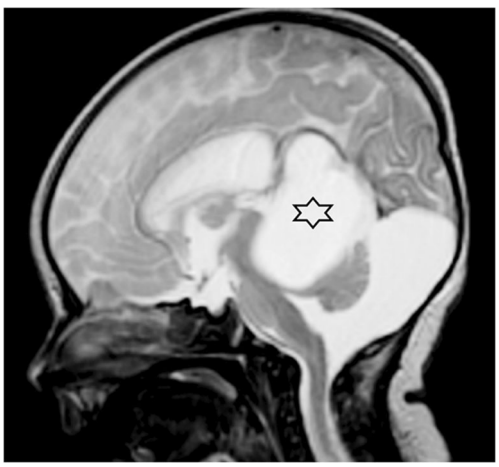

Fig. 12 Case 5, a girl age 7 years 4 months. T2-weighted sagittal head MR image obtained in perinatal period shows a large arachnoid cyst of the quadrigeminal plate (*star*)

Case 6

A girl age 14 years 10 months presented with asymptomatic bilateral optic nerve swelling diagnosed during an annual eye examination. She was a healthy teenager, doing well at school, with no history of hypoglycemia, polydipsia or polyuria. She had a normal growth velocity during infancy and teenage years and had her menarche at 12 years old with regular menses since then. Her height was 152 cm (–1.4 SD) and weight was 48.2 kg, with a body mass index of 21 kg/m^2 (+0.1 SD). Laboratory results showed normal pubertal hormones (luteinizing hormone [LH]: 4.5 IU/L [normal range: 2.5–16.3 IU/L], follicle stimulating hormone [FSH]: 2.9 IU/L [normal range: 1.2–18.5 IU/L] and estradiol: 582 pmol/L [normal range: 0–407.3 pmol/L]). Head MRI was obtained as part of the investigation for optic nerve swelling (Fig. 6).

Imaging specifications

All cases were characterized by the presence of two midline bright spots on the thin focused T1-weighted sequences obtained twice, without and with fat-suppression technique. One bright spot was located at the normal expected site of the neurohypophysis in the posterior sella and was preserved in signal intensity compared to the anterior pituitary gland. An additional ectopic focus of high signal intensity appeared on T1-weighted imaging and did not lose its bright signal on fat-suppressed imaging. This ectopic bright spot was in the region of the midline median eminence and infundibulum or along the normal-appearing pituitary stalk above the sella turcica, posterior to and close to the optic chiasm.

In all of the cases, the ectopic bright spot was small and measured 1.9–3.6 mm craniocaudally and 1.0–2.4 mm anteroposteriorly. It did not exert any mass effect on the adjacent structures including the optic pathways, the cavernous sinuses and the circle of Willis. None of the cases was associated with cystic, solid or enhancing tissue to the ectopic midline bright spot. The anterior pituitary gland was normal in signal and thickness in five cases and preserved in signal but thinned with pronounced upward concavity of the sellar diaphragm in one case. An intact pituitary stalk was present

Table 1 Summary of clinical and laboratory findings of the six children with partial ectopic posterior pituitary

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Age at diagnosis	4y6m	2y3m	8 days	19 days	7y4m	14y10m
Gender	Male	Female	Male	Female	Female	Female
Clinical presentation	Short stature	Poor growth, developmental delay, strabismus	CHARGE syndrome	ONH	Short stature, autism	Incidental bilateral optic nerve swelling
Dysmorphic features	None	Short nose, prominent ears, small chin, large forehead, shorter right leg	Small ears, jaw and nose, hypertelorism	None	None	None
TSH/f-T4 (mU/L/pmol/L)	2.19/12.5	2.6/11.4	4.36/NA	1.18/*7.6*	*5.1/7.7*	1.75/11.1
Cortisol level (nmol/L)	319 (random)	Not performed	678 (random)	522 (random)	741.5 (peak[a])	519 (random)
GH peak on stimulation test (μg/L)	*3.7*	NA	NA	NA	*1.8*	NA
Bone age[b]	3y (–2 SD/13 m) CA: 4y6m	3–12 m (<–2 SD/9.3 m) CA: 2y3m	NA	NA	6y10m (–2 SD/20.5 m) CA: 8y	NA
Endocrine symptoms	GHD	None	None	None	GH and TSH deficiency	None

CA chronological age, *CHARGE* coloboma, heart defects, atresia choanae, growth retardation, genital abnormalities, and ear abnormalities, *f-T4* free thyroxine (normal range: 8–18 pmol/L), *GH* growth hormone, *GHD* growth hormone deficiency, *m* months, *NA* not available, *ONH* optic nerve hypoplasia, *SD* standard deviations, *TSH* thyroid stimulating hormone (normal range: 0.4–4.4 mIU/L), *y* years; abnormal laboratory values are italicized

[a] Peak on adrenocorticotropin hormone (ACTH) stimulation test. Growth hormone (GH) deficiency was defined by peak GH level <5.0 mcg/L on stimulation testing (clonidine 5 mcg/kg and L-Arginine 0.5 g/kg); cortisol level (morning), normal range: 120–535 nmol/L

[b] Greulich and Pyle standards

and continuous in all six cases, either thinned (n=3) or normal (n=3) in thickness compared to the adjacent optic chiasm.

Associated brain MRI abnormalities were found in five of our six patients. These included midline anomalies with dysmorphic splenium of the corpus callosum, absence of olfactory bulbs, absent septum pellucidum, and arachnoid cyst of the quadrigeminal plate (Figs. 8, 10, 11 and 12). Off midline, gray matter anomalies were found including one child with bilateral periventricular nodular heterotopia and one with perisylvian polymicrogyria (Figs. 7 and 11).

Discussion

We report on six children with a combination of an ectopic suprasellar T1 bright spot and a normally located neurohypophysis with a preserved stalk, which we presume corresponds to a partial ectopia of the neurohypophysis, a condition that, to our knowledge, has not been reported previously. The majority of the children did not have an endocrine abnormality to date, while one had isolated growth hormone deficiency, and another had combined thyroid stimulation hormone and

Table 2 Summary of head MRI findings

Case	Location of PEPP	Size (mm)[a]	Stalk	Anterior pituitary	Associated findings
1	Midline in the infundibulum	2.0×2.0	Normal	Hypoplasia	Periventricular nodular heterotopia of gray matter
2	Proximal in pituitary stalk	1.9×1.3	Thin distally	Normal	Dysmorphic posterior corpus callosum
3	Midline in the infundibulum	1.4×1.0	Normal	Normal	Optic nerve hypoplasia, agenesis of olfactory bulbs, inferior vermian hypoplasia, small bilateral colobomas
4	Midline above the optic chiasm	1.5×1.0	Normal	Normal	Polymicrogyria, agenesis of the septum pellucidum, optic nerve hypoplasia
5	Posterior and cranial above the optic chiasm	3.6×2.4	Thin	Normal	Arachnoid cyst of the quadrigeminal plate and hydrocephalus
6	Bilobed at the infundibulum and along the stalk	2.6×1.6	Normal	Normal	None

[a] Measurements are in craniocaudal x anteroposterior diameters taken in the sagittal plane

PEPP partial ectopic posterior pituitary

growth hormone deficiency. The others presented with CHARGE syndrome, motor developmental delay and septo-optic dysplasia.

Head MRI is the gold standard radiologic method for evaluating the hypothalamic–pituitary axis [10]. An additional T1-bright spot was incidentally found on MR imaging of the brain for children being investigated for various reasons. Although there is a wide differential diagnosis for T1 hyperintensities on MRI, it can be narrowed with the aid of additional sequences, location and clinical manifestations. Lipid, protein, metallic substances, methemoglobin and calcifications are all bright on T1-weighted imaging [11, 12]. However, we deduced that the additional bright spot on T1 in our cases was most likely an additional and ectopic focus of the posterior pituitary gland for the following reasons. First, fat-containing lesions were excluded on fat-suppressed images. Second, although primary and metastatic melanomas have been described in the sellar and suprasellar region, the age, lack of clinical manifestations, and stability over time all made the possibility of a melanoma unlikely [13, 14]. Metallic deposition could also be excluded based on dedicated susceptibility or T2* sequences available in Case 4. Third, methemoglobin transforms with time into hemichromes, which lose their paramagnetic properties and do not appear bright on T1-W imaging. Three of our six cases had subsequent imaging, long after the timeline of methemoglobin degradation, in which the lesion remained bright on T1. Finally, regarding the possibility of calcifications, two children (Cases 3 and 5) had a CT scan that confirmed the additional T1 bright spot was not a focus of calcification (images not shown). For the remaining cases, one child (Case 4) had susceptibility-weighted imaging that was negative for calcifications (images not shown), and all of the children had at least one MRI including an echoplanar imaging diffusion sequence on which the bright T1 spot did not create any susceptibility artifact. We considered a Rathke cleft cyst as a cause of proteinaceous high T1 signal but the lack of an intracystic nodule, which is a common MR feature, and stability over time made this diagnosis less likely, although possible [15].

In addition to the typical location of an ectopic neurohypophysis [16–18], five of the six children in our series had other anomalies that have been described [18–20], some genetically linked to pituitary stalk interruption syndrome [7, 16]. For example, foci of gray matter heterotopia, dysmorphic corpus callosum, optic nerve agenesis and polymicrogyria were found in four of our patients.

A genetic cause could be a likely explanation for the partial ectopic posterior pituitary gland. Although we did not perform any genetic tests in our patients, several genes including *PROP1, IFT172, LHX4, HESX1, OTX2* and *SOX3* are well known to be involved in the ectopic posterior pituitary development [5, 21–23]. While these genetic causes of ectopic posterior pituitary are usually associated with anterior pituitary hormone deficiencies, only two of our cases presented with such endocrine abnormalities. On the other hand, phenotypes of these mutations are variable, with some patients only manifesting pituitary hormone deficiencies in adulthood [24]. Further, children with genetic forms of ectopic posterior pituitary who do not have associated hormone deficiencies might be insufficiently ascertained because they are not diagnosed unless incidentally if brain imaging is obtained for an unrelated reason.

Genetic defects in proteins associated with anatomical pituitary gland development have been implicated in the development of ectopic posterior pituitary such as the gene encoding the signaling molecule HSEX1. This gene has also been associated with septo-optic dysplasia and periventricular heterotopia where homozygous mutations were associated with more severe phenotypes compared to heterozygotes. It has also been suggested that a heterozygous mutation in the *Hsex1* gene, where some of the protein causes normal posterior pituitary location but not enough leads to an additional ectopic neurohypophysis, could be implicated in a phenotype similar to our cases [7]. Additionally, holoprosencephaly genes have been implicated in pituitary stalk interruption syndrome; these include sonic hedgehog (*SHH*), transforming growth factor–beta induced factor (*TGIF*) and GLI-Kruppel family member 2 (*GLI2*). Mutations in G-protein-coupled receptors or proteins that interact with the *SHH* receptor have also been postulated to affect midline development with variable penetrance. Therefore, our cases could also be explained based on the allocation of pituitary stalk interruption syndrome in the holoprosencephaly spectrum where heterozygous mutations or environmental factors might affect protein levels encoded by these genes in a way that induction of normal neurohypophysis development is incomplete, such that an ectopic pituitary also exists [16].

The uninterrupted stalk in all cases might explain the fact that only two children in this series had endocrine manifestations. Chen et al. [25] reported only one patient with isolated growth hormone deficiency and one with multiple pituitary hormone deficiencies in 14 patients with ectopic posterior pituitary and normal stalk. In fact, pituitary stalk agenesis and ectopic posterior pituitary are specific markers of permanent isolated growth hormone deficiency [26].

We hypothesize that partial ectopic posterior pituitary gland is an extremely rare cause of hormone deficiencies in children but nevertheless should be considered in children presenting with such findings on MRI. El Sanharawi et al. [27] described 29 patients with sporadic ectopic posterior pituitary on MRI, and none of them had partial ectopic posterior pituitary gland. The Pfizer International Growth Database (KIGS) study analyzed 15,043 MRIs from children with growth hormone deficiency, and 6.8% had ectopic posterior pituitary with no reports of partial ectopic posterior pituitary gland [28]. In 2017, a German study described 29 patients

with ectopic posterior pituitary found on MRI from 2010 to 2014, and none of them had partial presentation [27].

CHARGE syndrome is an autosomal-dominant syndrome with a variable combination of coloboma of the eye, heart malformations, choanal atresia, growth and development retardation, and genital and ear abnormalities [29]. Pituitary hormone deficiency is a feature of CHARGE syndrome. The association of CHARGE syndrome with congenital hypopituitarism and ectopic posterior pituitary was reported in 2013 [30]; however no patient with CHARGE syndrome was reported to have a partial ectopic posterior pituitary. On the other hand, only 30% of septo-optic dysplasia cases present with the complete septo-optic dysplasia triad (optic nerve hypoplasia, midline abnormalities and hypothalamic-pituitary endocrine deficiencies) [31]. Ferran et al. [32] described five cases of children with septo-optic dysplasia and short stature, four of them with ectopic posterior pituitary, none with the partial presentation. The presence of ectopic posterior pituitary can predict the association of septo-optic dysplasia with pituitary hormone deficiency [33]. Growth hormone deficiency is the most common pituitary deficiency in septo-optic dysplasia, followed by adrenocorticotropic and thyroid stimulating hormone deficiencies, while gonadotropic function is generally preserved and diabetes insipidus is found more rarely [34]. The KIGS study found septo-optic dysplasia in 2.4% of cases and no reports of partial ectopic posterior pituitary [28]. Our patient is the first report of septo-optic dysplasia (optic nerve hypoplasia, midline abnormalities) associated to partial ectopic posterior pituitary gland. No hypothalamic-pituitary endocrine deficiencies have been detected to date, despite regular screening.

The etiology of ectopic posterior pituitary is now thought to be a combination of genetic and environmental factors rather than simply ischemic/traumatic injury as was presumed previously [16, 35]. Several genetic factors involved in organogenesis have been linked to its pathogenesis in addition to other brain malformations such as optic nerve hypoplasia, holoprosencephaly and midline deformities [7, 20, 35]. With the current understanding of the etiopathology of ectopic posterior pituitary, we hypothesize that the variant we described can be explained as an initial organogenesis derangement that caused the posterior pituitary to settle at the floor of the 3rd ventricle or median eminence. Afterward, either micro- or macro-environmental factors epigenetically influenced organogenesis, causing the posterior pituitary to continue its normal migration and thereby reversing the initial process. Research focusing on the interplay between genetic and environmental factors, rather than each one alone, might help us to better understand the pathophysiology of this phenomenon.

Our study was limited by its small number of participants and by its retrospective nature. Referral bias and lack of ascertainment of milder or asymptomatic cases need to be considered given that all children were seen and diagnosed at a quaternary care center. Despite the clarity of our imaging findings and similarity in the six reported cases, we lack pathology proof of the findings of pituitary tissue in both orthotopic and ectopic position. Last, genetic testing was not available for any of our patients and might have furthered our understanding of the underlying cause of their partial ectopic posterior pituitary.

Conclusion

This case series shows that partial ectopic posterior pituitary gland is possibly an extremely rare condition that can be associated with a variable clinical phenotype. While only two of six children with this condition demonstrated anterior pituitary hormone deficits to date, longer-term follow-up is necessary to determine whether later endocrine manifestations develop. Certainly, children with imaging of possible partial ectopic posterior pituitary gland on MRI should be screened for hypopituitarism.

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Compliance with ethical standards

Conflicts of interest None

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