From the Archives of the AFIP

Lesions of the Pineal Region: Radiologic-Pathologic Correlation[1]

Alice Boyd Smith, Lt Col, USAF MC • Elisabeth J. Rushing, COL, MC, USA • James G. Smirniotopoulos, MD

CME FEATURE
See pp 2051–2058.

LEARNING OBJECTIVES FOR TEST 6

After reading this article and taking the test, the reader will be able to:

- Discuss the differential diagnosis of lesions of the pineal region.
- Describe the clinical and pathologic features of lesions of the pineal region.
- List the imaging characteristics of lesions of the pineal region.

TEACHING POINTS
See last page

Lesions of the pineal region include a diverse group of entities. The most common neoplastic lesions are the germ cell tumors. Germ cell tumors may be hormonally active, and evaluation of serum or cerebrospinal fluid levels of oncoproteins assists in making the diagnosis. Neoplasms arising from the pineal parenchyma include the low-grade pineocytoma, pineal parenchymal tumor of intermediate differentiation, and the highly malignant pineoblastoma. Germ cell tumors and pineal parenchymal neoplasms do not have pathognomonic imaging findings, but imaging in combination with laboratory evaluation helps narrow the differential diagnosis. Neoplasms may also arise from the variety of cell types residing in the proximity of the pineal gland. These include lipomas, meningiomas, and astrocytomas. Congenital lesions such as epidermoid and dermoid cysts and lipomas can also occur. Knowledge of the variety of lesions that occur in the pineal region, their imaging appearances, and their clinical features assists in narrowing the radiologic differential diagnosis and optimizing patient treatment.

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Abbreviations: CSF = cerebrospinal fluid, FLAIR = fluid-attenuated inversion-recovery, GCT = germ cell tumor, hCG = human chorionic gonadotropin, H-E = hematoxylin-eosin, PPTID = pineal parenchymal tumor of intermediate differentiation, PTPR = papillary tumor of the pineal region, WHO = World Health Organization

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[1]From the Departments of Radiologic Pathology (A.B.S.) and Neuropathology (E.J.R.), Armed Forces Institute of Pathology, Washington, DC; and Department of Radiology and Radiological Sciences, Uniformed Services University of the Health Sciences, 4301 Jones Bridge Rd, Bethesda, MD 20814 (A.B.S., J.G.S.). Received May 11, 2010; revision requested July 21; final revision received August 17; accepted August 17. For this CME activity, the authors, editors, and reviewers have no relevant relationships to disclose. **Address correspondence to** A.B.S. (e-mail: *alsmith@usuhs.mil*).

Introduction

A variety of lesions involve the pineal region, including neoplastic processes and congenital lesions. Tumors of the pineal region are classified into those arising from the pineal parenchyma, germ cell neoplasms, metastasis, and lesions arising from adjacent structures (eg, astrocytoma, meningioma). Pineal region neoplasms occur more frequently in children, accounting for 3%–8% of intracranial neoplasms in the pediatric population. They make up less than 1% of intracranial tumors in adults (1–3). The germ cell neoplasms are the most common, accounting for 40% of all pineal neoplasms, and neoplasms of pineal parenchymal origin account for 14%–27% (4). Knowledge of the clinical behavior and imaging characteristics of these lesions helps narrow the differential diagnosis.

In this article, we review the normal anatomy of the pineal region, describe the signs and symptoms of pineal region masses, and present the pathologic and imaging features of lesions of the pineal region, including tumors of pineal parenchymal origin, germ cell neoplasms, pineal cyst, and other pineal region masses.

Normal Pineal Region Anatomy

The pineal gland is a small reddish-brown structure that derives its name from its pinecone-like shape. The pineal ranges in size from 10 to 14 mm; it is located in the midline, above the tentorium and superior colliculi and below the splenium of the corpus callosum and the vein of Galen, and is attached to the superior aspect of the posterior border of the third ventricle (Fig 1). It develops as a diverticulum in the diencephalic roof of the third ventricle during the second month of gestation. The mature gland is suspended from the pineal stalk from the posterior roof of the third ventricle. The pineal secretes melatonin, which is involved in diurnal rhythms.

Histologically, lobules of pineocytes (95%) and astrocytes (5%) separated by a fibrovascular stroma make up the normal gland (Fig 2). The pineocyte is a specialized neuron related to the retinal rods and cones. Concentric calcifications, known as corpora arenacea, appear in adolescence and are seen in approximately 40% of patients 17–29 years old. The pineal does not have a blood-brain barrier and therefore enhances on contrast material–enhanced images.

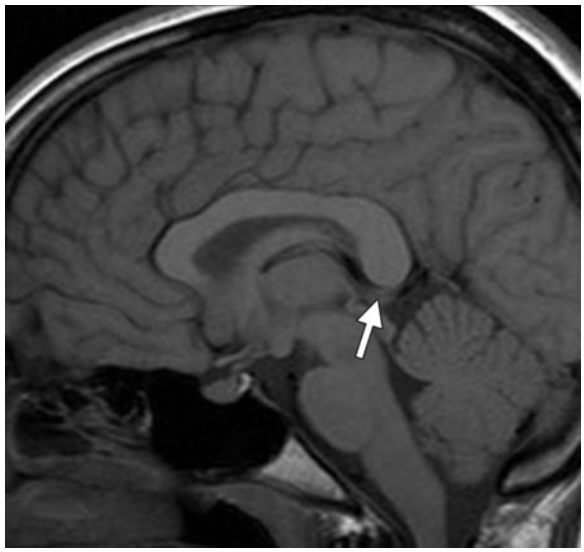


Figure 1. Normal pineal anatomy. Sagittal T1-weighted magnetic resonance (MR) image shows the normal anatomy of the pineal region. The pineal gland (arrow) lies below the splenium of the corpus callosum. The flow void from the vein of Galen crosses just above the pineal gland. The tectal plate is located immediately inferior to the gland.

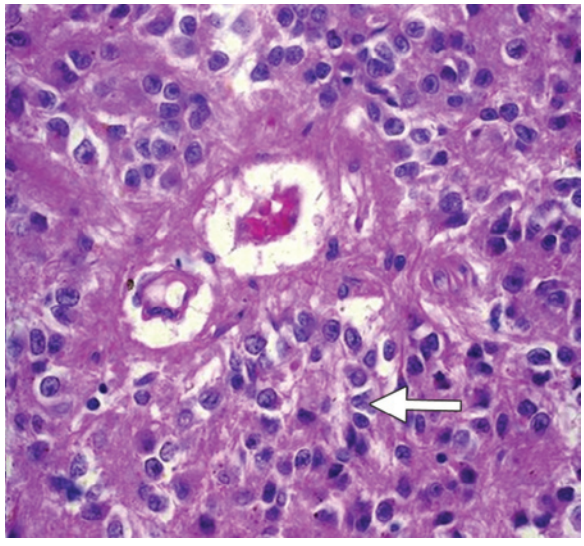


Figure 2. Normal pineal gland. Photomicrograph (original magnification, ×200; hematoxylin-eosin [H-E] stain) shows clusters and rosettes (arrow) of normal pineocytes within a fibrous stroma.

Signs and Symptoms of Pineal Region Masses

Signs and symptoms of pineal region masses are most often related to mass effect on the adjacent structures, but higher-grade structures, such as

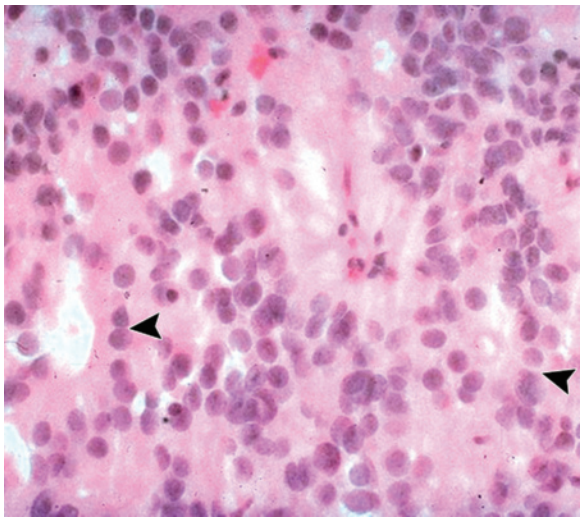


Figure 3. Pineocytoma. Photomicrograph (original magnification, ×200; H-E stain) shows small, uniform cells that resemble normal pineocytes. Many of these are arranged in rosettes (arrowheads).

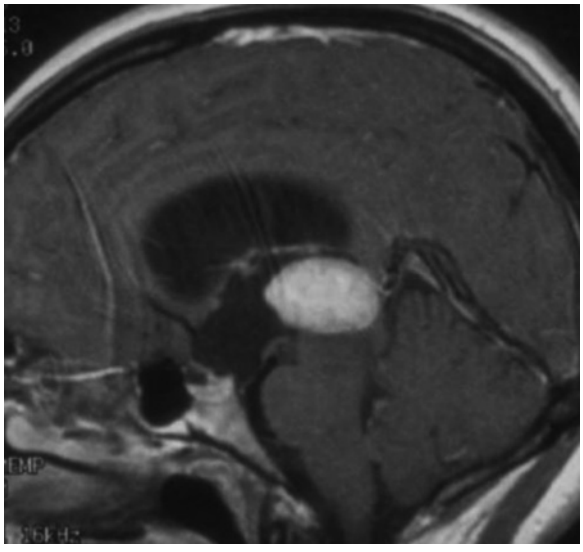


Figure 4. Pineocytoma in a 35-year-old man with a history of headaches. Sagittal postcontrast T1-weighted MR image shows an avidly enhancing mass in the pineal region with resultant hydrocephalus.

a pineoblastoma, may also invade the surrounding tissue. These signs and symptoms include Parinaud syndrome, precocious puberty, and, rarely, pineal apoplexy.

Parinaud syndrome consists of a failure of conjugate vertical eye movement, mydriasis, failed ocular convergence, and blepharospasm due to compression or invasion of the tectal plate. Hydrocephalus results from obstruction of the aqueduct of Sylvius; patients may also develop headache, nausea, and vomiting as a result of increased intracranial pressure. Precocious puberty is more commonly associated with germ cell tumors (GCTs) and may be related to increased human chorionic gonadotropin (hCG) secreted by the tumor. Hemorrhage into a pineal tumor or cyst is referred to as pineal apoplexy; the most common presenting symptom is a sudden decrease in consciousness associated with headache. Secondary parkinsonism attributed to pineal lesions has been reported, but is rare and of unclear cause (5).

Tumors of Pineal Parenchymal Origin

Pineal parenchymal tumors are rare lesions, accounting for less than 0.2% of intracranial neoplasms (6). They are neuroepithelial neoplasms arising from pineocytes or their precursors. These lesions include the low-grade pineocytoma, the intermediate-grade pineal parenchymal tumor of intermediate differentiation (PPTID), and the highly malignant pineoblastoma.

Pineocytoma

Pineocytoma is a slow-growing World Health Organization (WHO) grade I lesion that accounts for 14%–60% of pineal parenchymal neoplasms. They occur throughout life but predominantly manifest in adults (mean age, 38 years) (4). No gender predilection is reported. The 5-year survival is 86%–100%, and there are no reported relapses after gross total resection (4). Cerebrospinal fluid (CSF) dissemination rarely occurs.

Pathologic and Histologic Features.—Pineocytomas are composed of relatively small, uniform, mature cells that resemble pineocytes (Fig 3). Lobular architecture and pineocytomatous rosettes are common features.

Imaging Findings.—At computed tomography (CT), pineocytomas are well demarcated, usually less than 3 cm, and iso- to hyperattenuating. Pineal parenchymal tumors expand and obliterate pineal architecture, "exploding" the normal pineal calcification toward the periphery. At MR imaging, pineocytomas are well-circumscribed lesions that are hypo- to isointense on T1-weighted images and hyperintense on T2-weighted images. On postcontrast images, they typically demonstrate avid, homogeneous enhancement (Fig 4).

Teaching Point

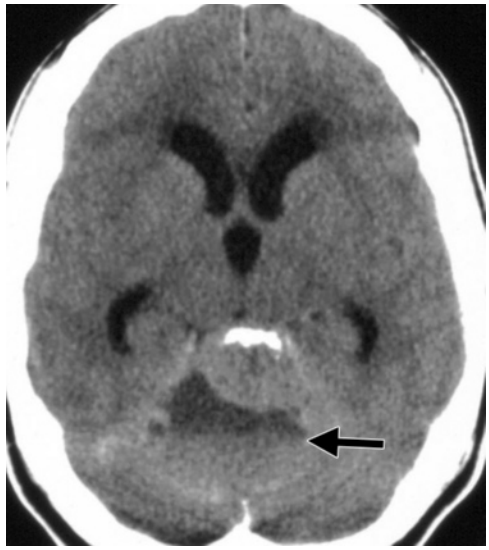


Figure 5. Pineal apoplexy secondary to a pineocytoma in a 30-year-old woman. Axial nonenhanced CT image shows a hyperattenuating lesion with a posterior cystic component in the pineal region. There is anterior displacement of the pineal calcifications. A hematocrit level is noted within the cystic component (arrow), a finding consistent with hemorrhage. Hydrocephalus is also present.

Cystic or partially cystic changes may occur, occasionally making differentiation from a pineal cyst difficult (7,8). However, at immediate postcontrast imaging, cystic-appearing pineocytomas demonstrate internal or nodular wall enhancement (9). Hemorrhage into the lesion (pineal apoplexy) rarely occurs (Fig 5).

Pineal Parenchymal Tumor of Intermediate Differentiation

PPTID was described in the 2000 WHO classification of tumors of the central nervous system and is classified as a WHO grade II or III neoplasm. They make up at least 20% of all pineal parenchymal tumors and affect patients of any age, but the peak prevalence is in early adulthood; a slight female preponderance is reported. The 5-year survival is 39%–74% (4). Rarely, central nervous system or other metastases have been reported.

Pathologic and Histologic Features.—At gross inspection, PPTID is similar in appearance to pineocytoma. It is a well-circumscribed lesion without evidence of necrosis. Histologic evaluation reveals diffuse sheets of uniform cells and the formation of small rosettes, with features intermediate between those of pineocytoma and those of pineoblastoma (Fig 6). Low to moderate levels of mitotic activity and nuclear atypia are seen.

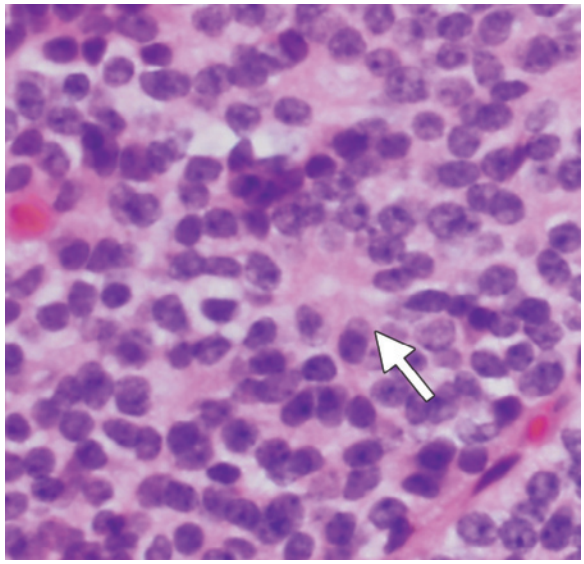
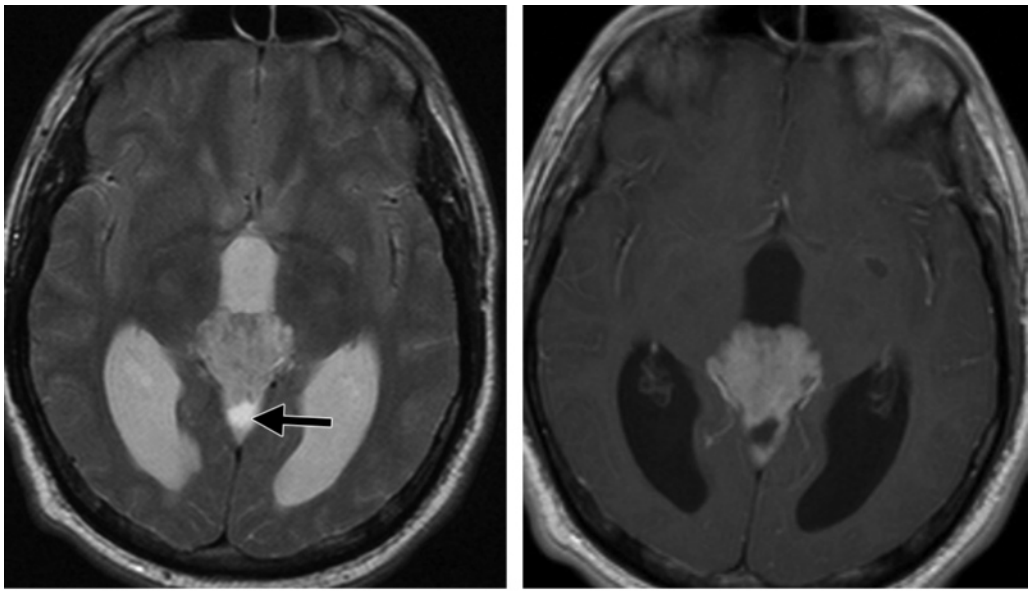


Figure 6. PPTID. Photomicrograph (original magnification, ×200; H-E stain) shows diffuse sheets of uniform cells and formation of small rosettes (arrow). Features are intermediate between those of pineocytoma and those of pineoblastoma.

Imaging Findings.—No specific imaging findings separate PPTID from pineoblastoma or pineocytoma. PPTIDs demonstrate high signal intensity on T2-weighted images and enhance on postcontrast images (Fig 7). Cystic areas may also be seen.



a. b.

Figure 7. PPTID in a 39-year-old man with blurry vision. Papilledema was noted at examination. **(a)** Axial T2-weighted MR image shows a hyperintense mass involving the pineal region with resultant hydrocephalus. A cystic region is present posteriorly (arrow). **(b)** On an axial postcontrast T1-weighted MR image, the solid portion of the mass enhances avidly.

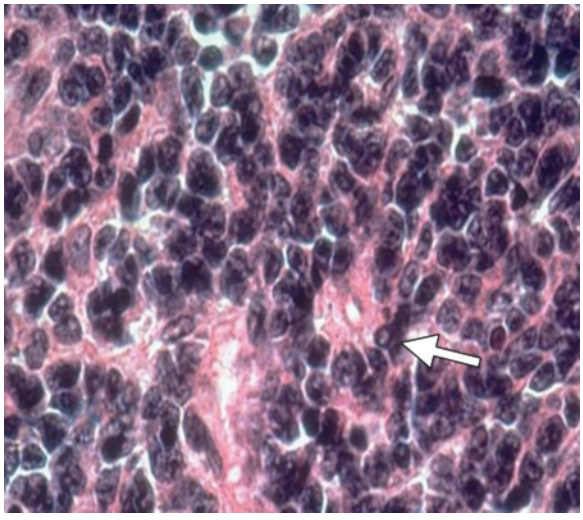
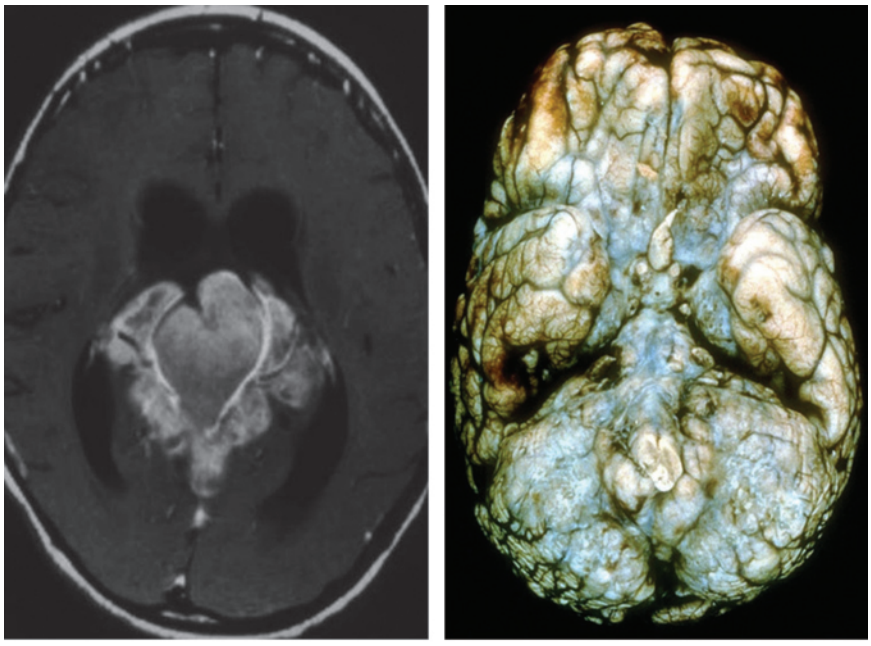


Figure 8. Pineoblastoma. Photomicrograph (original magnification, ×200; H-E stain) shows a markedly cellular neoplasm. Sheets of cells with scant cytoplasm are noted, and there is rosette formation (arrow).

Pineoblastoma

Pineoblastomas are highly malignant WHO grade IV lesions that represent the most primitive form of pineal parenchymal tumors and account for 40% of pineal parenchymal tumors (4). They are embryonal tumors described as a primitive neuroectodermal tumor of the pineal gland (10). They most commonly occur in the first 2 decades but can occur at any age, and there is no gender predilection. CSF dissemination commonly occurs and is the most common cause of death. The 5-year survival is 58% (4).

Pathologic and Histologic Features.—Pineoblastomas are highly cellular embryonal neoplasms that resemble other primitive neuroectodermal neoplasms of the central nervous system. Cells have scant cytoplasm and are arranged in diffuse sheets (Fig 8). Homer-Wright rosettes (neuroblastic differentiation) or Flexner-Wintersteiner rosettes (retinoblastic differentiation) may be



a. b.

Figure 9. Pineoblastoma in a 4-year-old girl with headaches, vomiting, and double vision. **(a)** Axial postcontrast T1-weighted MR image shows an ill-defined enhancing pineal mass with resultant hydrocephalus. The region of enhancement extends into the subarachnoid space, and there is a suggestion of parenchymal involvement. **(b)** Photograph of the gross specimen shows nodularity and discoloration along the leptomeningeal surface, findings consistent with CSF spread.

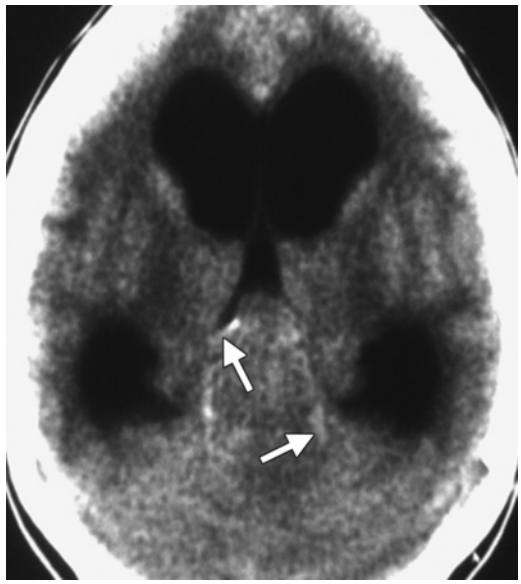
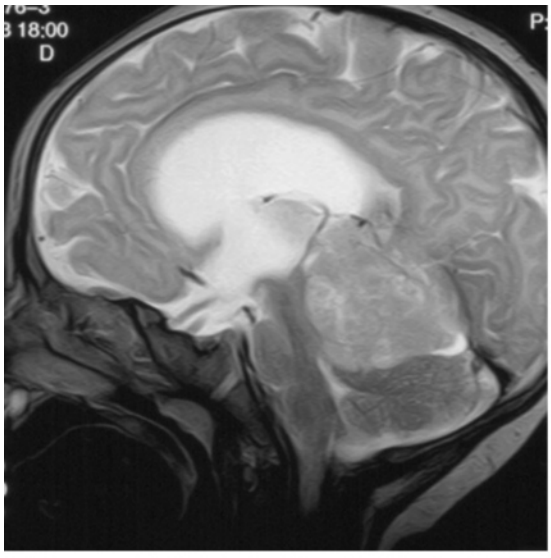


Figure 10. Pineoblastoma in a 10-year-old girl with lethargy, emesis, and downward gaze. Axial nonenhanced CT image shows a large pineal region mass with resultant hydrocephalus. The pineal calcifications are exploded toward the periphery (arrows).

seen, and hemorrhage or necrosis may be present. Infiltration into adjacent structures and craniospinal dissemination commonly occur (Fig 9).

Imaging Findings.—CT reveals a large (typically ≥3 cm), lobulated, typically hyperattenuating mass, an appearance that reflects its highly cellular histologic features. The pineal calcifications, if seen, may appear exploded at the periphery of the lesion (Fig 10). Nearly 100% of patients have obstructive hydrocephalus. At MR imaging, pineoblastomas are heterogeneous in appearance, with the solid portion appearing hypo- to isointense on T1-weighted images and iso- to mildly hyperintense to the cortex on T2-weighted images. Pineoblastomas demonstrate heterogeneous enhancement on postcontrast images.



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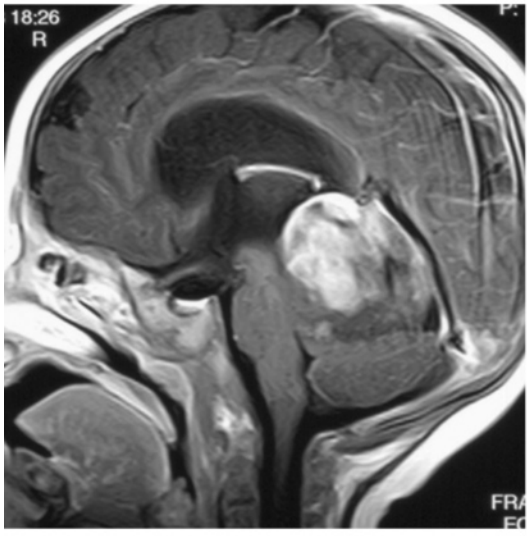

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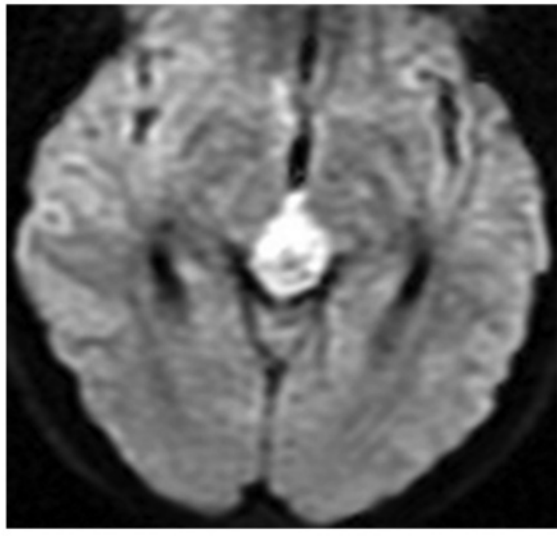


c.

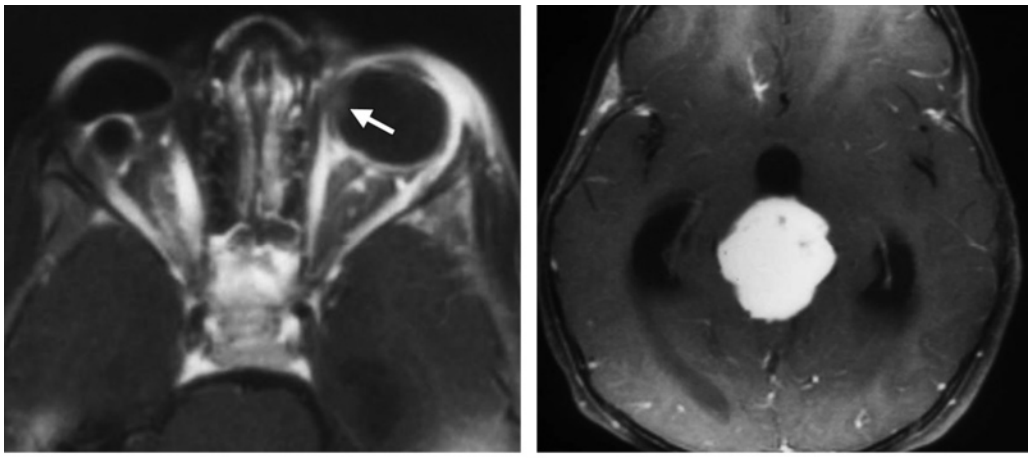
Figure 11. Pineoblastoma in a 4-year-old boy with nausea and vomiting. **(a)** Sagittal T2-weighted MR image shows a large mass in the pineal region with resultant hydrocephalus. The mass is hyperintense relative to gray matter. **(b)** Postcontrast T1-weighted MR image shows heterogeneous enhancement within the mass. **(c)** Diffusion-weighted image shows hyperintensity within the lesion. The mass had low signal intensity on the apparent diffusion coefficient map, a finding indicative of reduced diffusion and reflective of the highly cellular nature of the neoplasm.

Necrotic regions and hemorrhage may be present. There is considerable overlap with the imaging appearances of the more benign pineal parenchymal neoplasms. Extensive cystic change rarely occurs in pineoblastomas. Owing to the increased cellularity, reduced diffusion may be seen (Fig 11). CSF dissemination is a common finding and necessitates imaging of the entire craniospinal axis.

Teaching Point

Trilateral Retinoblastoma

Trilateral retinoblastoma refers to the presence of bilateral ocular retinoblastoma and an intracranial, typically midline, small cell tumor. Intracranial tumors associated with retinoblastoma occur most frequently in the region of the pineal gland (pineoblastoma) (Fig 12). The second most common location is the suprasellar region. Patients with trilateral retinoblastoma most frequently have a family history and present with ocular disease earlier than those with sporadic or unilateral retinoblastoma. The mean survival of patients with trilateral retinoblastoma has been reported to be up to 19 months (11).



a. b.

Figure 12. Trilateral retinoblastoma in a 2-year-old girl with a history of enucleation for retinoblastoma. **(a)** Axial postcontrast fat-saturated T1-weighted MR image shows a focus of enhancement along the medial wall of the left globe (arrow), a finding consistent with retinoblastoma. The right globe was removed due to retinoblastoma, and a prosthesis is in place. **(b)** Axial postcontrast T1-weighted MR image shows an associated enhancing pineoblastoma with resultant hydrocephalus.

Papillary Tumor of the Pineal Region

Papillary tumor of the pineal region (PTPR) is a recently recognized neoplasm in the WHO 2007 classification. It is a rare neuroepithelial neoplasm that occurs in both children and adults, with a reported age range of 5–66 years (mean age, 31.5 years) (12). PTPRs are thought to arise from specialized ependymocytes in the subcommissural organ, which is located in the pineal region (12).

Owing to their rarity, the histologic grading criterion has yet to be defined but most likely corresponds to WHO grade II or III. In a multicenter retrospective study of 31 patients, progression occurred in 72%; CSF dissemination has been reported in 7% (12). The 5-year survival and progression-free survival were 73% and 27%, respectively, and local recurrence frequently occurs even after compete resection and radiation therapy (12).

Pathologic and Histologic Features.—PTPRs are well-circumscribed lesions that can measure up to 5 cm and may have a cystic component. At histologic evaluation, they demonstrate an epithelial-like growth pattern, papillary features, rosettes, and perivascular pseudorosettes (Fig 13).

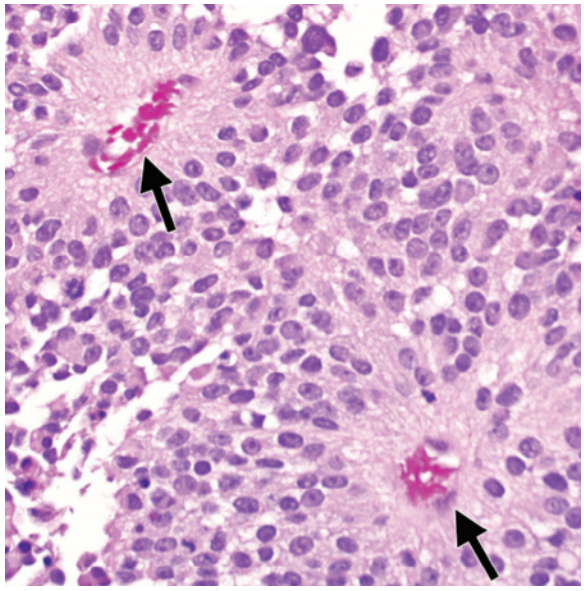
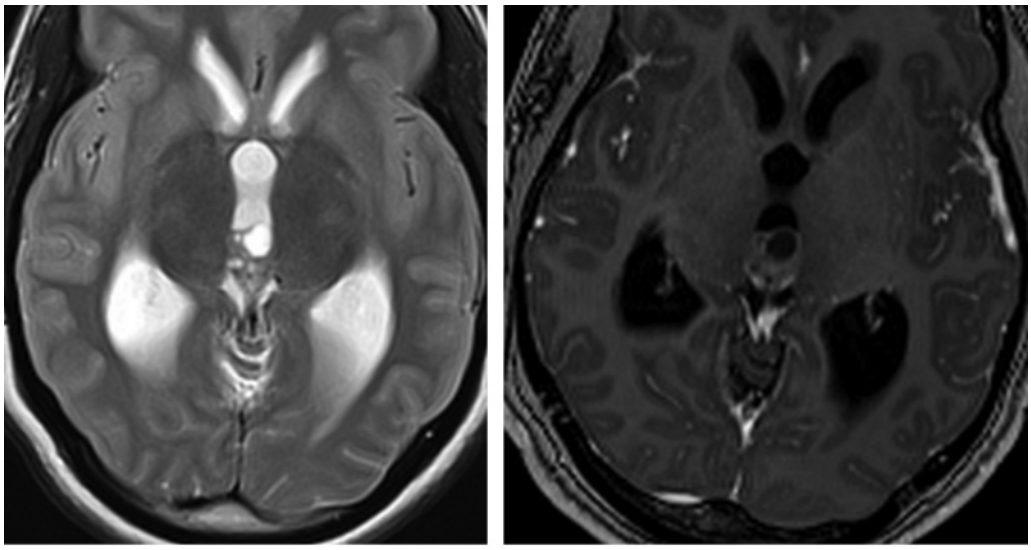


Figure 13. PTPR. Photomicrograph (original magnification, ×200; H-E stain) shows pseudorosette formation around the vessels (arrows).

The differential diagnosis for PTPR includes other pineal parenchymal tumors, papillary ependymomas, choroid plexus neoplasms, and metastasis. The immunohistochemical findings help differentiate PTPR from other lesions in the pineal region, especially ependymoma and choroid plexus papilloma.



a. b.

Figure 14. PTPR in a 17-year-old girl with headaches, vomiting, and double vision. **(a)** Axial T2-weighted MR image shows a small, heterogeneous, cystic and solid lesion in the pineal region. Hydrocephalus is present. **(b)** Postcontrast T1-weighted MR image shows enhancement of the solid portion of the lesion.

Imaging Findings.—PTPRs are well-circumscribed lesions with variable signal intensity on T1-weighted images, high signal intensity on T2-weighted images, and enhancement on postcontrast images (13). Cystic areas are commonly present (12) (Fig 14). Hyperintensity on T1-weighted images has been described, which is hypothesized to be related to secretory inclusions containing protein or glycoprotein (14).

Germ Cell Tumors

GCTs arise from residual primordial ectoderm, mesoderm, or endoderm, and each tumor subtype represents the neoplastic correlate of a distinct stage of embryonic development. These lesions account for greater than half of the pineal region neoplasms (15). The WHO classifies them into germinomas and nongerminomatous GCTs. The nongerminomatous GCTs include teratomas, embryonal carcinoma, yolk sac tumor, choriocarcinoma, and the mixed GCTs.

Several theories exist regarding the origin of intracranial GCTs. One theory is that of aberrant migration. According to this theory, instead of germ cells migrating from the yolk sac to their normal location in the ovaries or testes, they migrate to other locations, coming to rest predominantly in midline sites that include the third ventricle, mediastinum, and sacrococcygeal region (16). Another theory is the embryonic cell theory, in which a mismigrational pluripotent embryonic cell gives rise to the germ cell neoplasms (17).

Others propose that only the germinomas arise from germ cells and the remainder of the GCTs result from misplacement of embryonic cells into the lateral mesoderm. The result is entrapment of these cells in different regions of the brain (18). Central nervous system GCTs are most commonly located in the pineal and suprasellar regions. These lesions result in increased serum and CSF levels of tumor-produced oncoproteins (α-fetoprotein, β-hCG, placental alkaline phosphatase) (Table 1).

The prevalence of intracranial GCTs varies with geography. In Japan and other Asian countries, they account for up to 11% of pediatric brain tumors, whereas in Western countries they account for 0.4%–3.4% (1). Germinomas represent the majority of these neoplasms, and teratomas are the second most common (3). Most patients with intracranial GCTs are between 10 and 30 years old (19). In the pineal region, GCTs occur approximately three times more frequently in males (20).

Table 1
GCTs and Associated Oncoproteins

	Oncoprotein*		
Type of GCT	AFP	β-hCG	PLAP
Pure germinoma	–	–	+ or –
Syncytiotrophoblastic germinoma	–	+	+ or –
Mature teratoma	–	–	–
Immature teratoma	+ or –	+ or –	–
Choriocarcinoma	–	+	+ or –
Yolk sac tumor	+	–	+ or –
Embryonal carcinoma	–	–	+
Mixed GCT	+ or –	+ or –	+ or –

Source.—Reference 4 (p 203).
*AFP = α-fetoprotein, PLAP = placental alkaline phosphatase, + = present, – = absent.

Germinoma

Germinomas account for 1%–2% of all cranial neoplasms, and 90% of patients are less than 20 years old. Central nervous system germinomas are similar histologically and genetically to dysgerminoma in the ovary and seminoma in the testis (17). Fifty percent to 65% of intracranial germinomas occur in the pineal region, and 25%–35% are located in the suprasellar region. Those that occur in the pineal region are 10 times more common in males, whereas suprasellar germinomas do not have a sex predilection. Dissemination by CSF and invasion of the adjacent brain commonly occur, but the prognosis is good (5-year survival at least 90%) and the lesions are highly responsive to radiation therapy (21).

Teaching Point

Pathologic and Histologic Features.—Germinomas are well-circumscribed lesions that demonstrate a two-cell pattern of lymphocytes and large polygonal primitive germ cells (Fig 15a). The abundance of lymphocytes contributes to the hyperattenuation seen at CT and the reduced diffusion at diffusion-weighted MR imaging. Germinomas can be divided into two subtypes: pure germinoma and germinoma with syncytiotrophoblastic cells. Those containing syncytiotrophoblastic giant cells have a higher recurrence rate and decreased long-term survival and demonstrate elevated CSF levels of hCG (17).

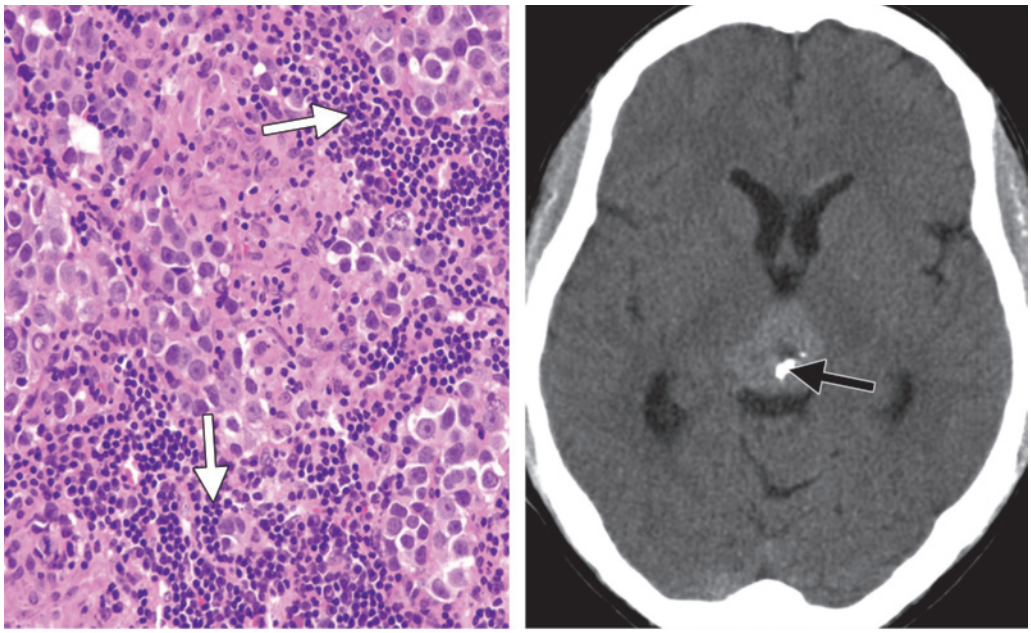
Imaging Findings.—CT demonstrates a sharply circumscribed, hyperattenuating mass that engulfs the pineal calcifications (Fig 15b) (22). The increased attenuation is related to the highly cellular lymphocyte component within the tumor. Hydrocephalus may be present. MR imaging typically reveals a solid mass that may have cystic components (23). Germinomas are iso- to hyperintense to gray matter on T1- and T2-weighted images and demonstrate avid, homogeneous enhancement on postcontrast images (Fig 16a). Reduced diffusion may be seen, a finding indicative of the highly cellular nature (Fig 16b).

The possibility of CSF seeding necessitates imaging evaluation of the entire neuroaxis (Fig 16c). The differential diagnosis for these lesions includes the primary pineal neoplasms. However, if oncoproteins are present or engulfment of the pineal calcifications is noted at CT, these findings help narrow the differential diagnosis.

Teaching Point

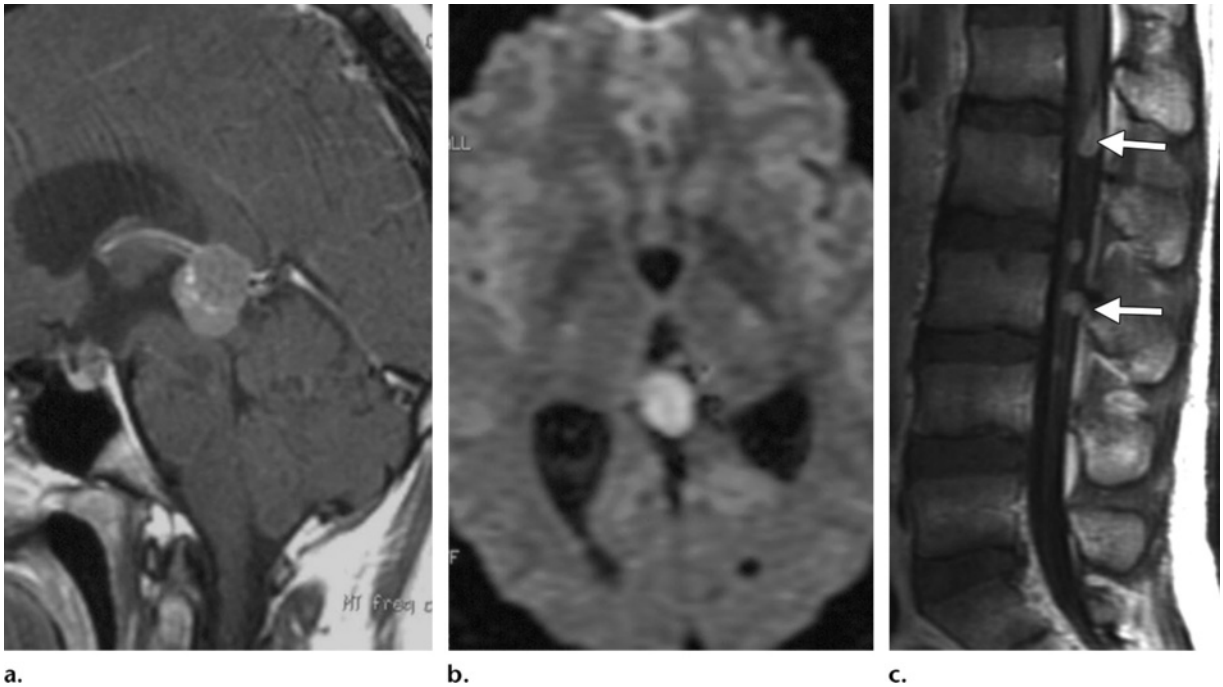
Teratoma

Teratomas differentiate along ectodermal, endodermal, and mesodermal lines. There are three types of teratoma: mature teratoma (fully differentiated tissue), immature teratoma (complex mixture of fetal-type tissues from all three germ layers and mature tissue elements), and teratoma with malignant transformation. Teratoma with malignant transformation is the least common form and demonstrates malignant degeneration of the mature tissues.



a. b.

Figure 15. Germinoma in a 15-year-old boy with headaches. **(a)** Photomicrograph (original magnification, ×200; H-E stain) shows clusters of small round blue cells consistent with lymphocytes (arrows) intermixed with the large polygonal primitive germ cells. The highly cellular lymphocytic component accounts for the increased attenuation seen at CT and the high signal intensity at diffusion-weighted MR imaging. **(b)** Axial nonenhanced CT image shows a hyperattenuating lesion in the pineal region that has engulfed the pineal calcification (arrow).



a. b. c.

Figure 16. Germinoma in a 19-year-old man with headaches. **(a)** Sagittal postcontrast T1-weighted MR image shows a lesion in the pineal region that homogeneously enhances. Note the associated mild hydrocephalus. **(b)** Diffusion-weighted MR image shows high signal intensity in the lesion, a finding indicative of high cellularity. **(c)** Sagittal gadolinium-enhanced T1-weighted MR image shows nodular enhancing masses (arrows) along the cauda equina, findings consistent with drop metastases.

Pathologic and Histologic Features.—Evaluation of a mature teratoma reveals a lobulated neoplasm with a complex mixture of adult-type tissues from all three embryonic germ layers (Fig 17). Skin and skin appendages may be seen due to the ectodermal component. The mesoderm contributes to the presence of cartilage, bone, fat, and smooth and skeletal muscle. Respiratory or enteric epithelium arises from the endodermal component. Immature teratomas contain incompletely differentiated tissue elements that resemble fetal tissue. Even if a lesion has only a minor component of this undifferentiated tissue, it is still classified as an immature teratoma.

Imaging Findings.—CT reveals a multiloculated, lobulated lesion with foci of fat attenuation, calcification, and cystic regions. T1-weighted MR images may show foci of T1 shortening due to fat and variable signal intensity related to calcification. On T2-weighted images, the soft-tissue component is iso- to hypointense. The soft-tissue component demonstrates enhancement on postcontrast images (Fig 18). The malignant form may have a more homogeneous imaging appearance (fewer cysts and calcifications), thus making it difficult to distinguish from other neoplasms.

Other GCTs

Choriocarcinoma, yolk sac tumors, and embryonal carcinoma are rare neoplasms. These neoplasms may have imaging findings similar to those of other germ cell neoplasms or primary pineal neoplasms. Evaluation of serum oncoproteins assists in making the appropriate diagnosis. These lesions may also hemorrhage, resulting in T1 shortening.

Pineal Cyst

Pineal cysts are reported in 25%–40% of cases in autopsy series and in 23% of patients in imaging studies of normal volunteers (24). Pineal cysts occur in all age ranges but are most predominant in adults 40–49 years of age; studies demonstrate a female predominance (25,26). Their origin is debated, with some suggesting they result from degenerative changes in the gland (27). These lesions are typically asymptomatic and are usually 2–15 mm in size. Follow-up studies have indicated that these lesions remain stable in size over time (28). When they exceed 15 mm, patients may become symptomatic, typically with headache or visual changes (26,29). Intracystic hemorrhage ("pineal apoplexy") and acute hydrocephalus rarely occur; resultant death has been reported (30).

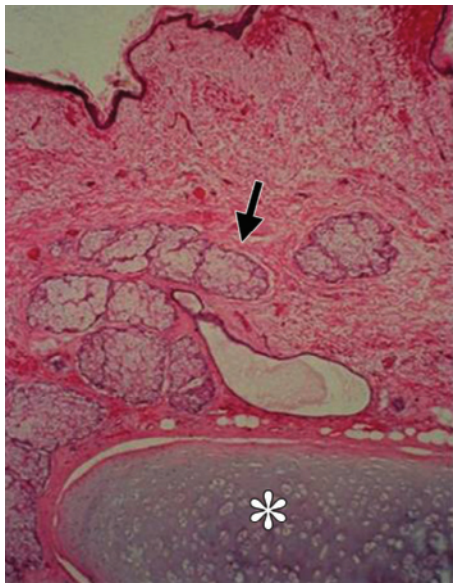


Figure 17. Mature teratoma. Photomicrograph (original magnification, ×200; H-E stain) shows multiple tissue types including sebaceous glands (arrow) and hyaline cartilage (*).

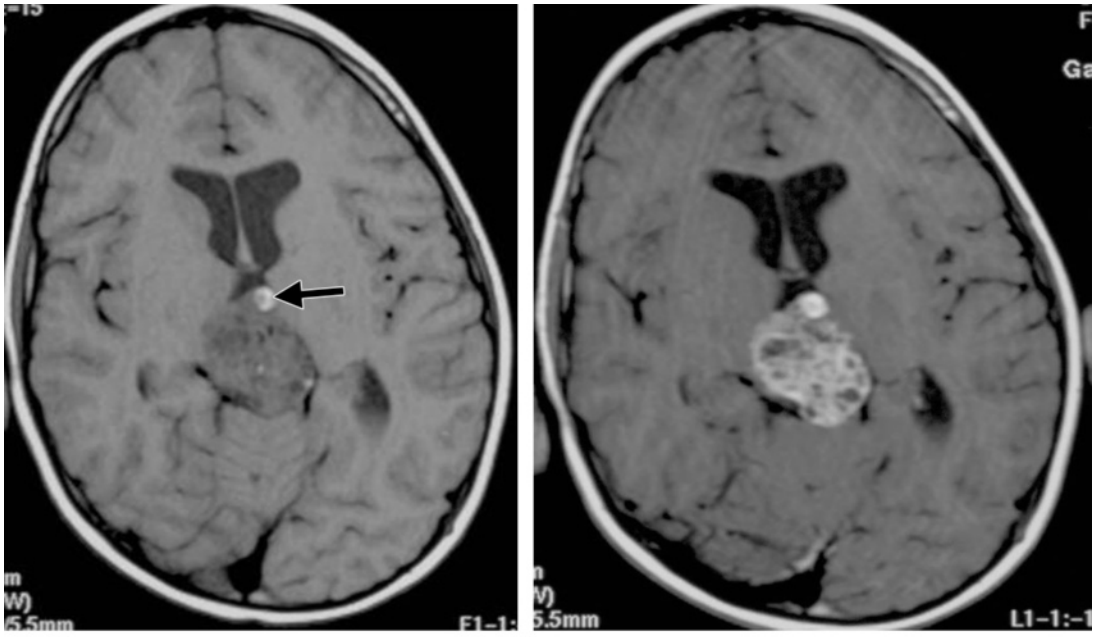
Pathologic and Histologic Features

The cyst may be uni- or multilocular, and the wall comprises three layers. The inner layer consists of gliotic tissue, the middle layer is composed of pineal parenchymal tissue, and the outer layer is formed by connective tissue (10) (Fig 19). The fluid in the cyst is proteinaceous and may contain hemorrhagic components.

Imaging Findings

At MR imaging, pineal cysts are round or oval, thin-walled, and well-circumscribed. They typically demonstrate signal intensity similar to that of CSF on T1- and T2-weighted images. On fluid-attenuated inversion-recovery (FLAIR) images, the signal may not be completely suppressed due to the proteinaceous contents. On gadolinium-enhanced images, enhancement of the cyst wall occurs in most pineal cysts but is typically incomplete; this finding has been attributed to fragmentation of the pineal parenchyma as the cyst enlarges (32) (Fig 20).

At delayed imaging, uniform enhancement of the cyst has been reported, resulting in the appearance of a solid mass (33). The mechanism behind this finding is not understood, but it may be related to passive diffusion of the contrast agent through the cyst wall or to active secretion of contrast agent by the cyst wall (24). Fine internal septa and internal cysts may be seen at high-resolution imaging. The differential diagnosis includes cystic tumors such as astrocytoma, pineocytoma, and pineoblastoma.



a. b.

Figure 18. Teratoma in an 8-year-old boy with a 2-week history of Parinaud syndrome. **(a)** Axial T1-weighted MR image shows a lobulated, heterogeneous lesion that contains an area of hyperintensity (arrow), a finding consistent with fat. **(b)** Postcontrast MR image shows enhancement of the soft-tissue portions of the lesion.

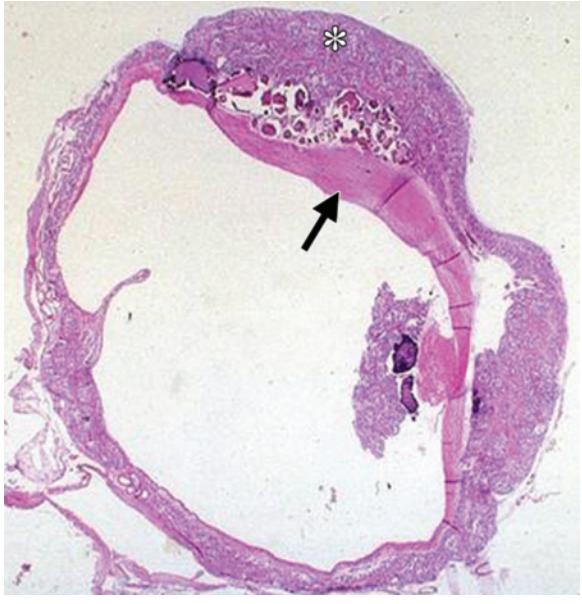


Figure 19. Photomicrograph (H-E stain) of a pineal cyst shows the inner layer of gliotic tissue (arrow) and an outer layer of compressed pineal parenchyma (*). (Reprinted, with permission, from reference 31.)

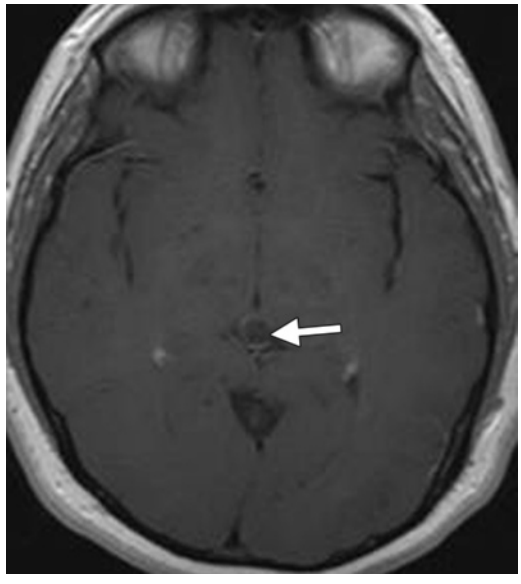


Figure 20. Pineal cyst (incidentally found in an evaluation for multiple sclerosis) in a 32-year-old woman. Axial postcontrast T1-weighted MR image shows a round, low-signal-intensity, 8-mm lesion in the pineal region, a finding consistent with a cyst. The lesion has a thin incomplete enhancing rim (arrow). No nodularity of the wall and no associated hydrocephalus are seen.

Management of Pineal Cysts

Management of pineal cysts is controversial. The natural history is not completely understood since no studies have been performed, to our knowledge, to follow the cyst to complete resolution. There have been several studies that demonstrated stability at follow-up. In a study of 32 patients, Barboriak et al (34) demonstrated that 75% of pineal cysts remained stable during a period of 0.5–9.1 years; those that changed in size were not associated with clinical findings (35).

Some authors advocate only clinical follow-up for asymptomatic pineal cysts, but this approach has not been widely accepted due to reports of pineal neoplasms mimicking pineal cysts. However, it is very rare for a tumor to mimic a pineal cyst (9,25). Typically, larger pineal cysts (≥10 mm) are followed up with imaging studies to document stability. Occasionally, surgical intervention is performed to obtain a definitive diagnosis (7,9).

Other Pineal Region Masses

Many other lesions occur in the pineal region and derive from the cell types that reside in the proximity. These include meningioma, ependymoma, choroid plexus tumors, central neurocytoma, ganglioglioma, epidermoid and dermoid cysts, and lipomas. Metastases also occur in the pineal region. Rarer lesions of the pineal region include solitary fibrous tumor, sarcoid lesions, and melanoma (36,37).

Epidermoid and Dermoid Cysts

Epidermoid and dermoid cysts are congenital inclusion cysts containing epithelial elements. Epidermoid cysts make up approximately 1% of intracranial tumors, and 3%–4% of intracranial epidermoid cysts occur in the pineal region (38). A variety of theories exist as to the origin of intracranial epidermoid and dermoid cysts, including a defect in cleavage of the neural tissue from the cutaneous ectoderm and occurrence of embryonic ectodermal inclusions (38). Dermoid cysts occur three to 10 times less commonly than epidermoid cysts (39,40).

Epidermoid cysts grow slowly as a result of desquamation of epithelial cells and can achieve a relatively large size. In patients with epidermoid cysts of the pineal region, the peak age at presentation is the 3rd decade of life (38). Patients with dermoid cysts present at a younger age, typically in childhood or adolescence. Dermoid cysts increase in size by means of both desquamation and glandular secretion. Neoplastic transformation rarely occurs, but squamous cell carcinoma can develop in both lesions.

Pathologic and Histologic Features.—The wall of epidermoid cysts is composed of simple stratified squamous epithelium, and the cyst contents consist of layers of keratinaceous debris (Fig 21), which impart a "pearly" appearance to the gross specimen. Dermoid cysts contain dermal appendages (hair follicles, sweat glands) (41). Both lesions slowly expand over time and rupture can result in chemical meningitis, which may be fatal.

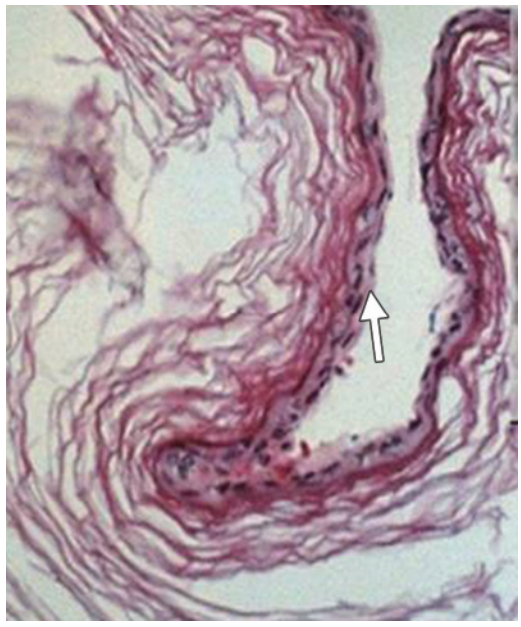
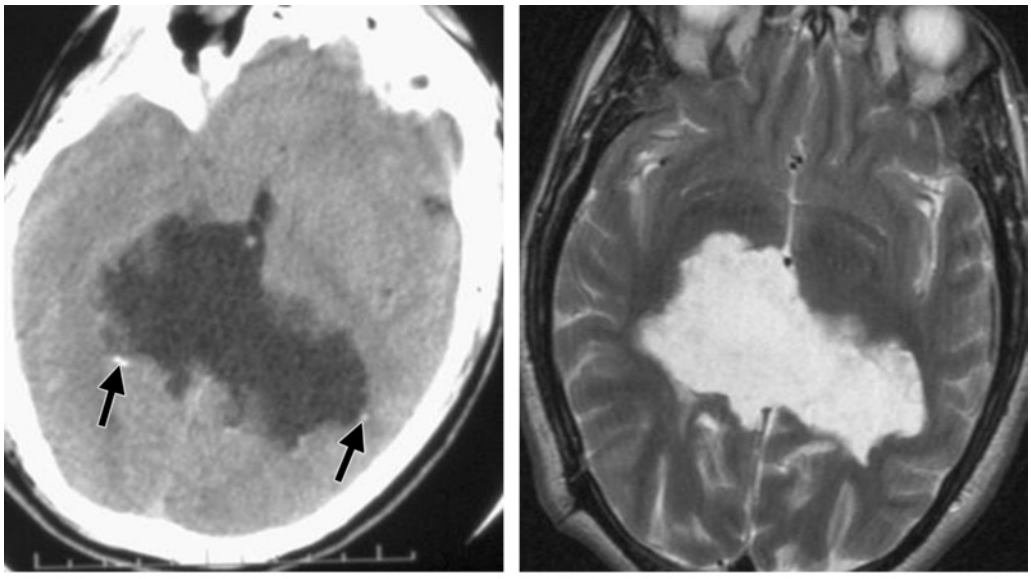


Figure 21. Epidermoid cyst. Photomicrograph (original magnification, ×200; H-E stain) shows the outer stratified squamous epithelial layer (arrow). The wavy material is the keratinaceous debris contained in the cyst.

Imaging Findings.—At CT, epidermoid cysts have low attenuation, similar to that of CSF. Dermoid cysts have a more variable appearance, and areas of low attenuation may be seen due to a lipid component—not due to fat, which is of mesodermal origin. Peripheral calcifications may be seen in both lesions.

At MR imaging, epidermoid cysts are hypointense on T1-weighted images and hyperintense on T2-weighted images, with signal intensity similar to that of CSF. They insinuate into adjacent structures and encase nerves and blood vessels, making resection difficult. On FLAIR images, epidermoid cysts do not show complete saturation, thus allowing them to be differentiated from arachnoid cysts. On diffusion-weighted images, they demonstrate increased signal intensity, a finding that also assists in making the diagnosis (Fig 22). Epidermoid cysts do not enhance internally, but rim enhancement may rarely be



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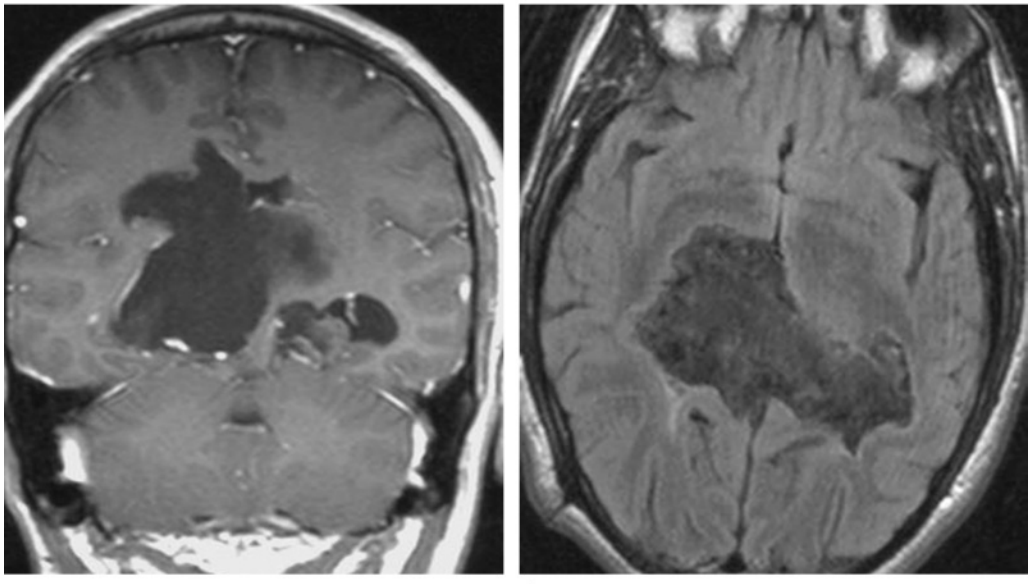

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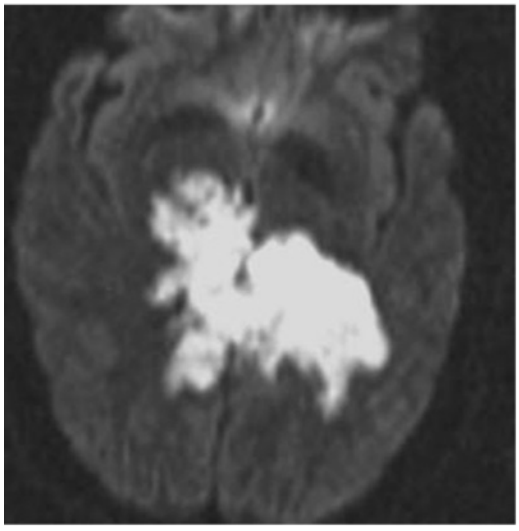
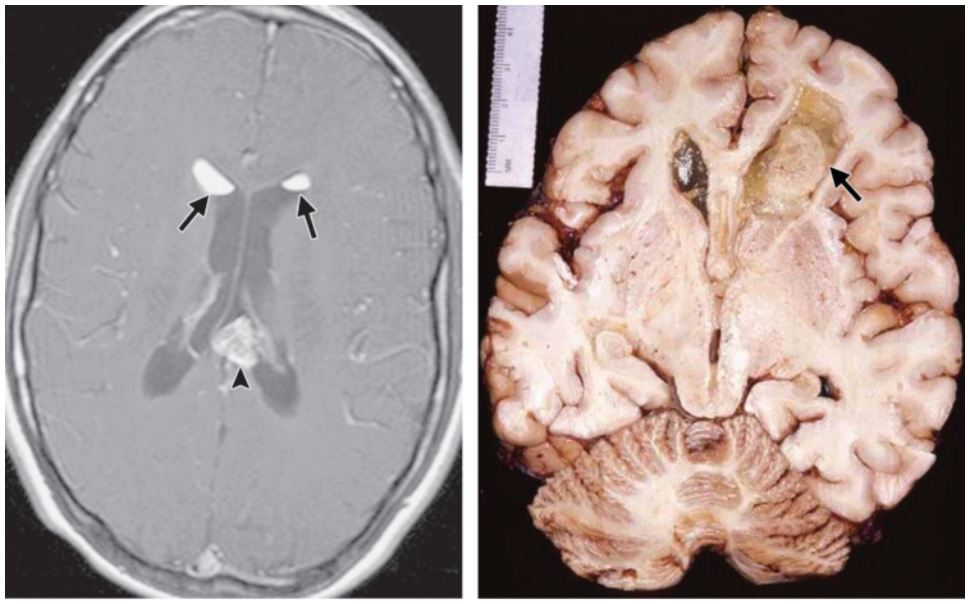


e.

Figure 22. Epidermoid cyst in a 27-year-old patient with headaches and nausea. **(a)** Axial nonenhanced CT image shows a large, low-attenuation lesion arising from the pineal region. The lesion insinuates into the adjacent brain parenchyma. Peripheral calcifications are present (arrows). **(b)** On an axial T2-weighted MR image, the lesion is hyperintense, with signal intensity similar to that of CSF. **(c)** Coronal postcontrast T1-weighted MR image shows the lesion insinuating into the adjacent parenchyma. No enhancement is associated with the lesion. The areas of peripheral enhancement are vascular structures. **(d)** On an axial T2-weighted FLAIR image, the signal in the lesion is not completely suppressed. **(e)** Diffusion-weighted MR image shows that the lesion is very hyperintense.



a. b.

Figure 23. Ruptured dermoid cyst in a 16-year-old girl with altered mental status. **(a)** Axial postcontrast T1-weighted MR image shows a hyperintense lesion (arrowhead) projecting anterior to the splenium of the corpus callosum. The signal intensity of the lesion did not change after administration of contrast material. Linear low-signal-intensity structures can be seen within the lesion, a finding consistent with hair. Lipid-fluid levels are seen in the frontal horns of the lateral ventricles (arrows). **(b)** Photograph of the gross specimen shows yellow material consistent with lipid (arrow) in the frontal horn of the left lateral ventricle.

seen and indicates an inflammatory or infectious process. In the rare case of malignant transformation (in both epidermoid and dermoid cysts), enhancement may be seen within the cyst (42).

Dermoid cysts have a variable appearance on MR images owing to lipid content (which results in T1 shortening) and hair, which may appear as curvilinear regions of low signal intensity on T1- and T2-weighted images. The lipid signal will be suppressed on fat-suppression images. Rim enhancement may rarely be seen and reflects inflammation or infection, but there is no internal enhancement, unlike in teratomas (41). Dermoid cysts are unilocular, also unlike teratomas (Table 2). In the event of rupture of a dermoid cyst, lipid signal intensity may be seen in the sulci and ventricles (Fig 23).

Teaching Point

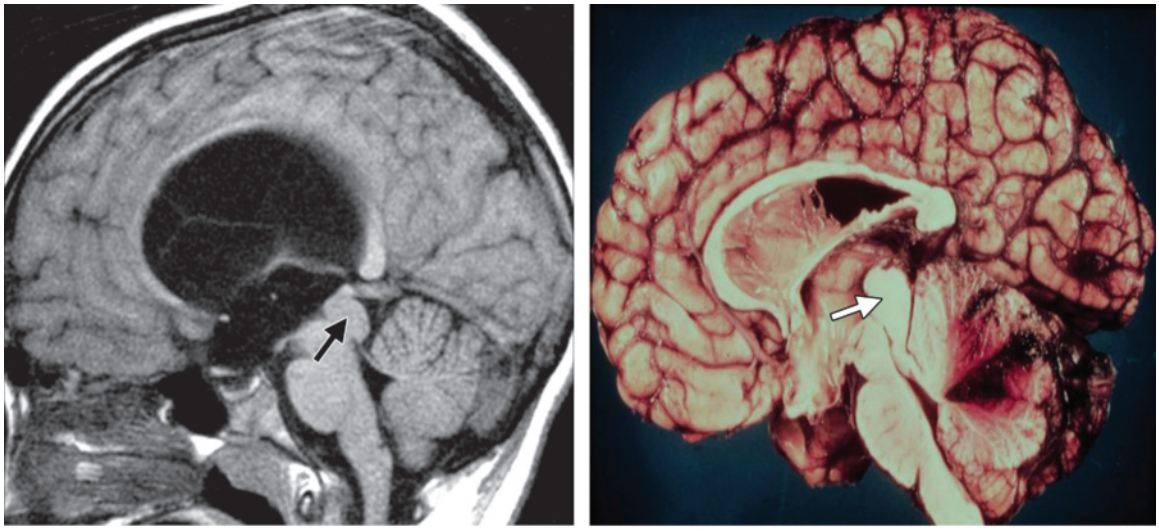
Table 2
Comparison of Dermoid Cyst versus Teratoma

Dermoid Cyst	Teratoma
Inclusion cyst	Germ cell neoplasm
Unilocular	Multilocular
Rim enhancement	Internal enhancement
Rim calcification	Internal calcification

Astrocytoma

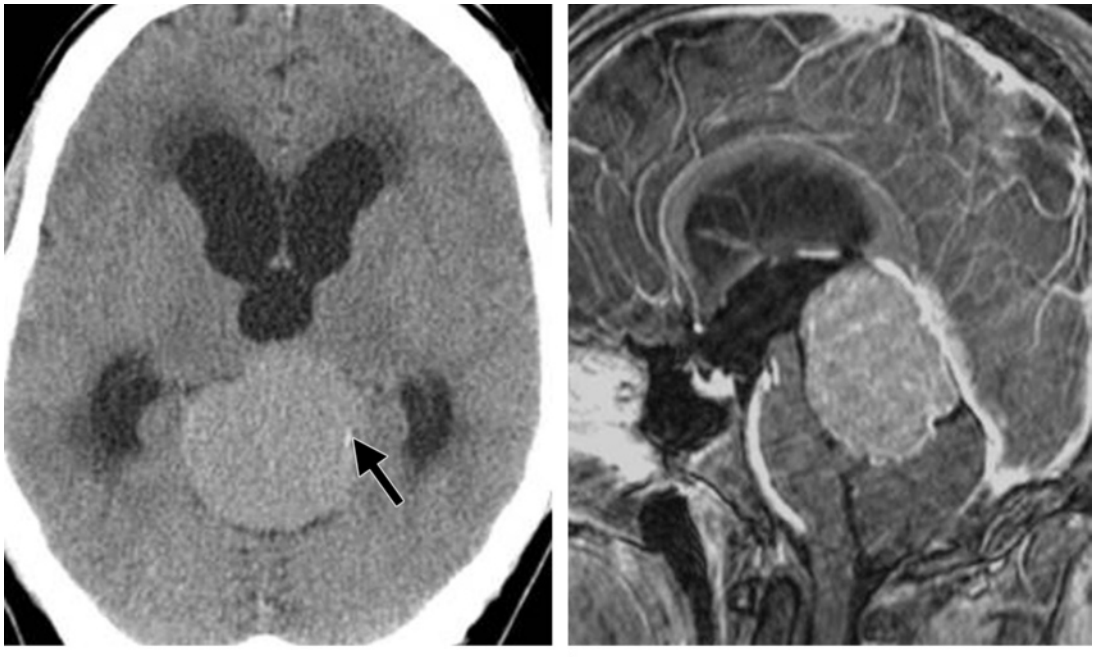
Astrocytomas arising in the pineal region are uncommon. They derive from stromal astrocytes, and in the pineal region they arise from the splenium of the corpus callosum, the thalamus, or the tectum of the midbrain. Rarely, they may arise from the neuronal elements within the pineal gland. They may be circumscribed (pilocytic, WHO grade I) or diffusely infiltrating (WHO grades II–IV).

Those that occur in the region of the tectum are usually low grade (WHO grade I or II) and result in enlargement of the tectum with secondary obstruction of the aqueduct (Fig 24). Tectal gliomas occur more frequently in childhood and are slow growing; shunting is usually the only treatment required for long-term survival (43). At MR imaging, bulbous enlargement of the tectal plate is noted. The lesion is typically isointense on T1-weighted images and hyperintense on T2-weighted images with no to minimal enhancement on postcontrast images. Close imaging follow-up is performed to ensure stability.



a. b.

Figure 24. Tectal glioma in a 5-year-old girl with headaches and drowsiness. **(a)** Sagittal nonenhanced T1-weighted MR image shows enlargement of the tectal plate (arrow) with resultant compression of the aqueduct. There is marked hydrocephalus involving the lateral and third ventricles. **(b)** Photograph of the gross specimen shows enlargement of the tectal plate (arrow).

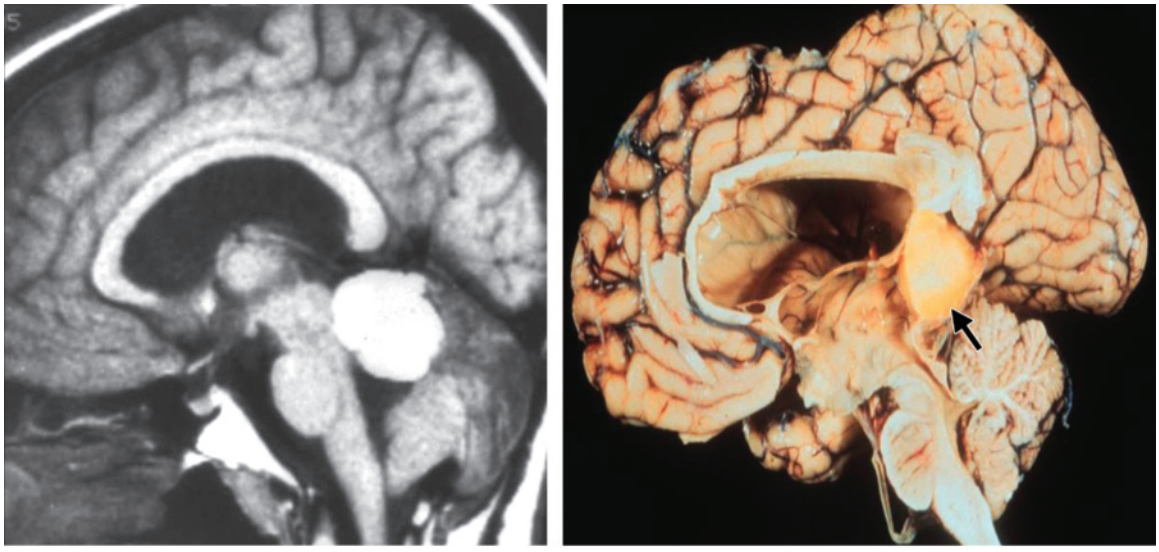


a. b.

Figure 25. Meningioma in a 42-year-old woman with headaches and visual changes. **(a)** Nonenhanced CT image shows a large hyperattenuating lesion with an associated calcification (arrow) in the pineal region. There is resultant hydrocephalus and transependymal flow of CSF. **(b)** Sagittal postcontrast T1-weighted MR image shows a homogeneously enhancing broad-based lesion attached to the tentorium.

Meningioma

At CT, meningiomas are typically hyperattenuating, reflecting the highly cellular nature of these lesions. Calcifications are seen in 15%–20%. They are vascular, so avid enhancement is seen on postcontrast images. Meningiomas are dural-based lesions, and on postcontrast images a dural tail may be seen. At MR imaging, they are hypo- to isointense on T1-weighted images and iso- to hyperintense on T2-weighted images (Fig 25).



a. b.

Figure 26. Lipoma in a 27-year-old woman with headaches, nausea, and vomiting. **(a)** Sagittal nonenhanced T1-weighted MR image shows a well-circumscribed, hyperintense lesion in the quadrigeminal plate cistern. **(b)** Photograph of a gross specimen from another patient shows a yellow, fatty mass (arrow) in the quadrigeminal plate cistern.

Lipoma

Lipomas arise from abnormal differentiation of the meninx primitiva, which is the undifferentiated mesenchyme that surrounds the developing brain and normally develops into the leptomeninges and subarachnoid space. Lipomas represent malformations and not neoplasms. Blood vessels and nerves course through them, making resection difficult if required.

At CT, lipomas have low attenuation, consistent with fat. At MR imaging, they have the same signal characteristics as fat (hyperintense on T1-weighted images with saturation on fat-saturated images) (43) (Fig 26). No enhancement is seen on postcontrast images.

Metastasis

Metastases to the pineal gland are rare, with autopsy reports indicating a prevalence of 0.4%–3.8% in patients with solid tumors. The most common tumors to spread to the pineal region are those of the lung (most frequent), breast, kidney, esophagus, stomach, and colon (19). Pineal metastases may be present without metastases to the brain parenchyma.

Conclusions

The differential diagnosis for pineal region lesions includes germ cell neoplasms, pineal cell neoplasms, gliomas, and congenital and non-neuroglial lesions. Germinoma, pineoblastoma, and meningioma have high attenuation at CT due to their high cellularity, but if pineal calcification is seen the germinoma will tend to engulf it, whereas in pineoblastomas it will be exploded to the periphery. Meningiomas have a broad attachment to the dura.

Reduced diffusion is present in epidermoid cysts and may be present in germinomas and pineoblastomas. However, epidermoid cysts do not have internal enhancement (unless there is rare development of squamous cell carcinoma) and appear similar to CSF on CT, T1-weighted, and T2-weighted images.

The presence of lipid or fat attenuation at CT leads to the differential diagnosis of a teratoma, dermoid cyst, or lipoma. Intrinsic increased T1 signal intensity may be seen in pineal parenchymal neoplasms or GCTs with hemorrhage, in hemorrhagic metastases, and in lipomas, teratomas, or dermoid cysts. Use of fat saturation and gradient-echo sequences can help differentiate these lesions.

Evaluation of serum or CSF oncoproteins assists with diagnosis of germ cell neoplasms. Knowledge of the various imaging findings and use of CSF and serum laboratory studies will help narrow the differential diagnosis for pineal region neoplasms.

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RadioGraphics

From the Archives of the AFIP
Lesions of the Pineal Region: Radiologic-Pathologic Correlation

Alice Boyd Smith, Lt Col, USAF MC • Elisabeth J. Rushing, COL, MC, USA • James G. Smirniotopoulos, MD

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Page 2003
Pineal parenchymal tumors expand and obliterate pineal architecture, "exploding" the normal pineal calcification toward the periphery.

Page 2007
CSF dissemination is a common findiang and necessitates imaging of the entire craniospinal axis.

Page 2010
Dissemination by CSF and invasion of the adjacent brain commonly occur, but the prognosis is good (5-year survival at least 90%) and the lesions are highly responsive to radiation therapy (21).

Page 2010
The differential diagnosis for these lesions includes the primary pineal neoplasms. However, if oncoproteins are present or engulfment of the pineal calcifications is noted at CT, these findings help narrow the differential diagnosis.

Page 2016
Rim enhancement may rarely be seen and reflects inflammation or infection, but there is no internal enhancement, unlike in teratomas (41).