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Imaging of Meningiomas

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Outline

- **Our patient**
 - **Clinical presentation**
 - **Radiologic presentation**
- Cerebellopontine angle anatomy
- Differential diagnosis of cerebellopontine angle masses
- Meningioma epidemiology
- Radiologic characteristics of meningiomas



Our Patient: Clinical Presentation

- 71 year old male presents with **progressive right-sided sensorineural hearing loss** over the last several years
- Past Medical History
 - Coronary artery disease
 - Diabetes mellitus type 2
 - Hypertension
 - Peripheral vascular disease
 - Dyslipidemia

ACR Appropriateness Criteria for Sensorineural Hearing Loss

Radiologic Procedure	Rating
MRI head and internal auditory canal without and with contrast	9
MRI head and internal auditory canal without contrast	7
CT temporal bone without contrast	6
CT temporal bone with contrast	4
CT head without contrast	3
CT head with contrast	3
CT head without and with contrast	3
CT temporal bone without and with contrast	1
CTA head with contrast	1
MR venography head without contrast	1
MRA head without and with contrast	1
MRA head without contrast	1

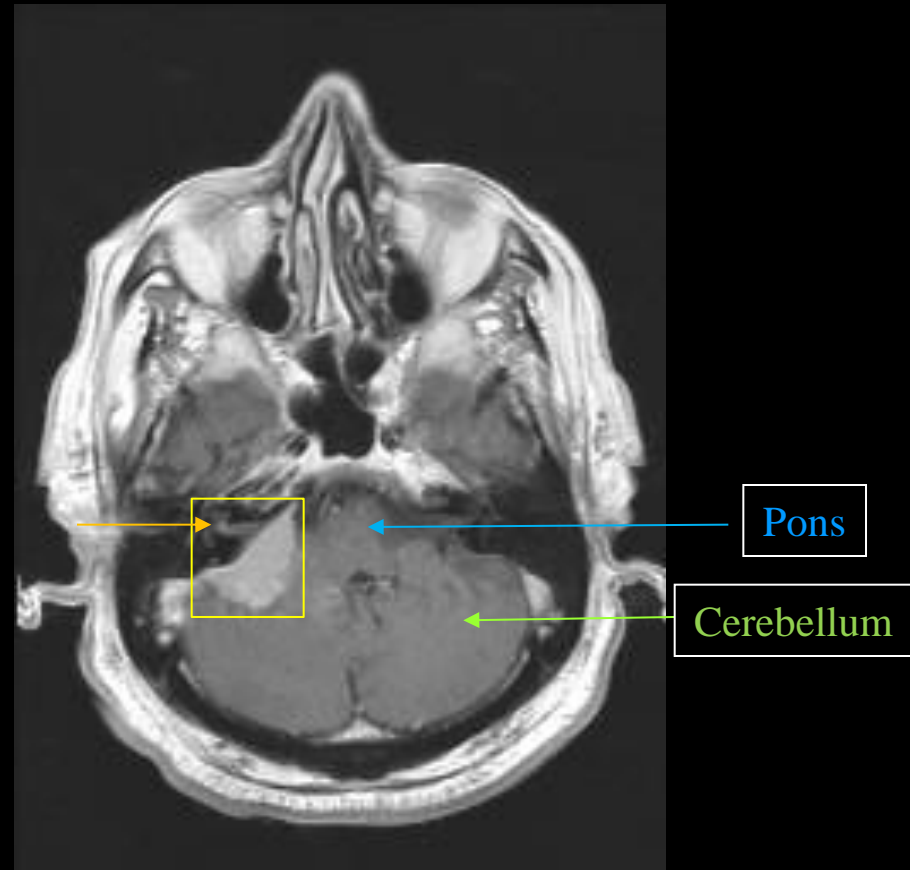
From American College of Radiology. (2013)
Hearing Loss and/or Vertigo ACR
Appropriateness Criteria. Retrieved from
<https://acsearch.acr.org/docs/69488/Narrative/>

Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate



Our Patient: Mass on MRI

- Extra-axial homogeneously enhancing **mass in the right cerebellopontine angle**
- Extension into the **right porus acousticus**



Post-contrast T1-
weighted MR head.

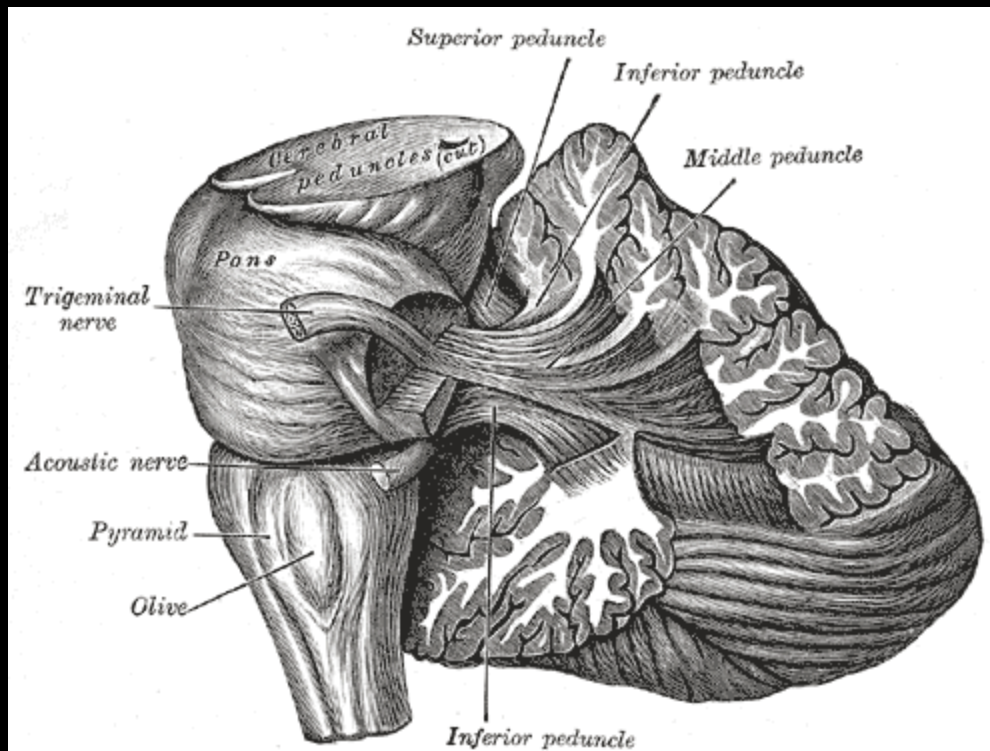


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Anatomy of the cerebellopontine angle (CPA)



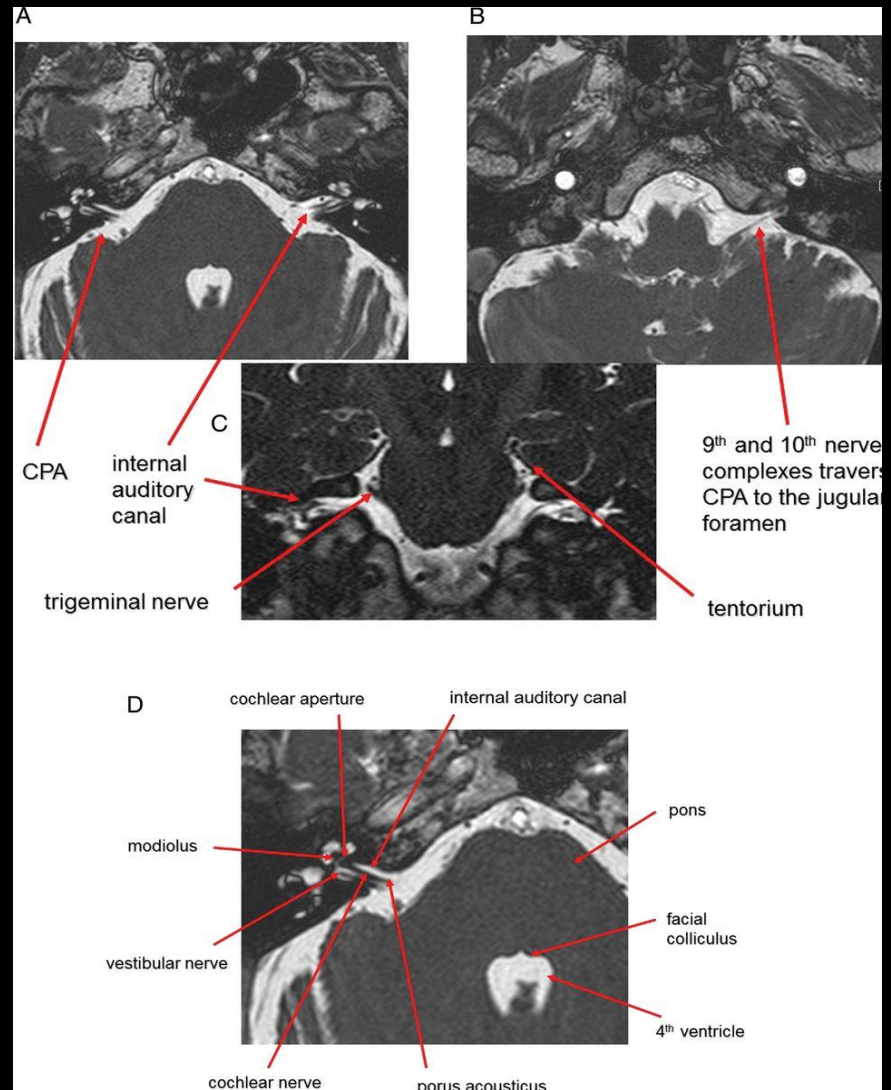
From Gray's Anatomy

- Triangular cisternal space bathed in CSF, located in lateral posterior fossa
 - Base: Tentorium
 - Lateral: Posterior temporal bone
 - Medial: Pons
 - Posterior: Cerebellum



Anatomy of the cerebellopontine angle (CPA)

- CN V traverses superior aspect of cerebellopontine angle
- CN VII and VIII arise from lateral aspect of inferior medulla and ascend to the porus acusticus
 - Cistern extends into the petrous temporal bone as the internal auditory canal. Medial aperture is the porus acusticus.
- CN IX-XI traverse inferior lateral aspect of CPA to exit at jugular foramen





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Differential diagnosis of cerebellar pontine angle mass

- **Vestibular schwannoma**
 - 70-80%
- **Meningiomas**
 - 10-15%
- **Epidermoid tumors**
 - 5%
- **Less common diagnoses (<1% each)**
 - **Arachnoid cyst**
 - **Lipoma**
 - **Metastases**



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Diagnosis: Meningioma

- Tumor arising from the arachnoid cap cells
- Most common extra-axial intracranial neoplasm
- Two times more common in females
- Most common in middle age group (40-60 years)

- World Health Organization (WHO) classification
 - Grade I: Benign (90%)
 - Grade II: Atypical (5-7%)
 - Grade III: Malignant (1-3%)



Meningiomas: Symptoms

Clinical presentation depends on lesion location

- Often asymptomatic and discovered incidentally on imaging done for other reasons
- Seizures
- Headaches
- Motor/sensory deficits
- Cranial nerve signs



Meningiomas: Location

- May arise in varied locations
 1. Convexity-lateral hemisphere (20-34%)
 2. Parasagittal (18-22%)
 3. Sphenoid wing and middle cranial fossa (17-25%)
 4. Spine (12%)
 5. Cerebellopontine angle (2-4%)
 6. Intraventricular (2-5%)
 7. Orbital (1%)
 8. Outside the dura (~1%)



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- **Radiologic characteristics of meningiomas**



Radiologic tests for meningioma

- **Magnetic Resonance Imaging**
- Computed Tomography
- Angiography



Return to our patient



Patient 1. T1-weighted
precontrast MR head.



Patient 1. T2-weighted
MR head

- Extra axial lesion at the right cerebellopontine angle is **slightly hypointense on T1-weighted sequence**
- Lesion is **iso to hyperintense on T2-weighted sequence** relative to surrounding grey matter.
- This patient is currently being monitored clinically with plans for possible future surgical resection of the meningioma.



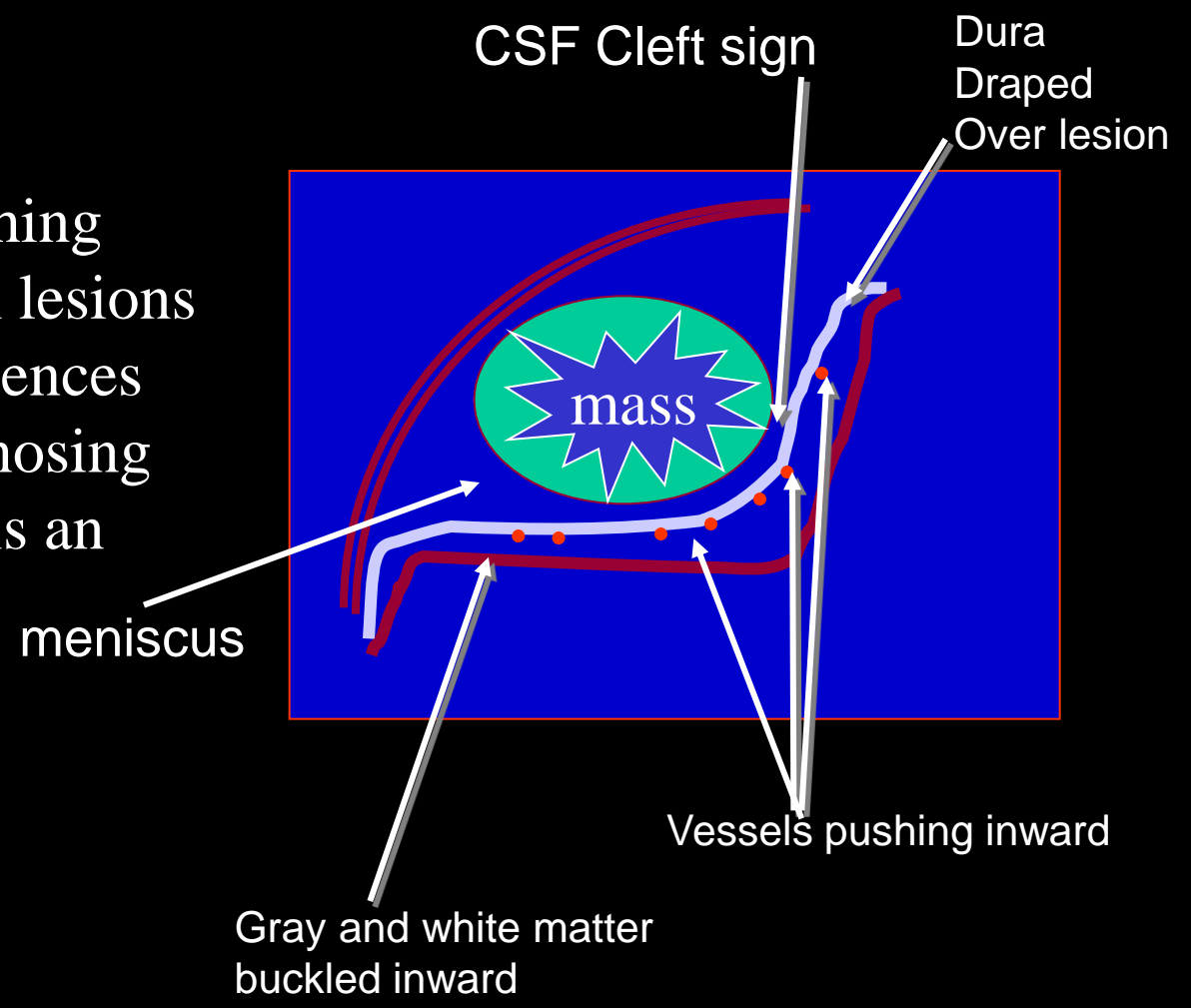
Magnetic Resonance Imaging

- Imaging modality of choice for diagnosing meningioma
 - **T1-weighted sequence**: Isotense to slightly hypointense relative to grey matter
 - **T2-weighted sequence**: Isointense to slightly hyperintense relative to grey matter. Low signal intensity on T2 suggests calcification
 - **T1 C+**: Typically show avid, homogeneous enhancement, though may occasionally have necrotic or calcified areas that do not enhance
- Dural tail: Enhancement of dura infiltrating away from the lesion. Estimated 59% sensitivity and 94% specificity for meningioma

Location: Intra or Extra Axial?

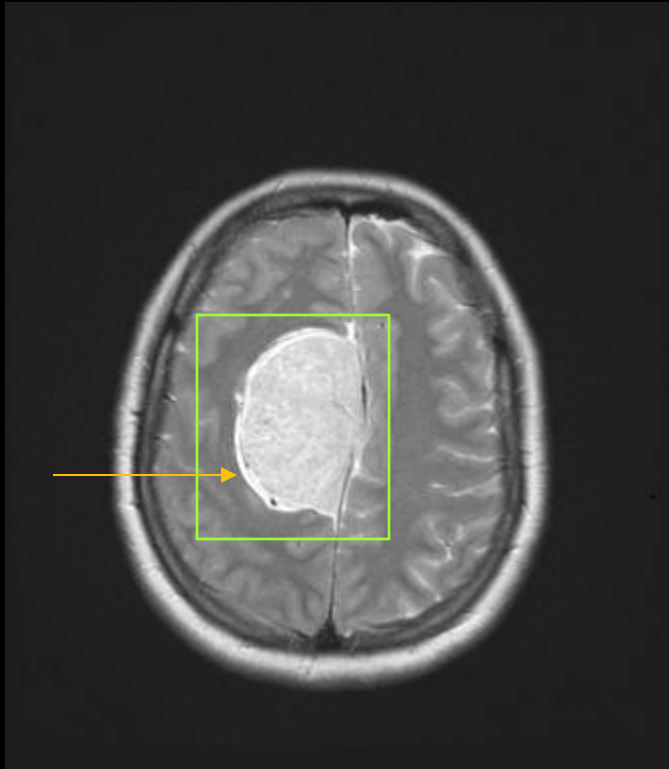
CSF Cleft sign

- Useful for distinguishing intra from extra axial lesions on T2-weighted sequences
- May be used in diagnosing meningioma, which is an extra axial lesion





CSF Cleft Sign



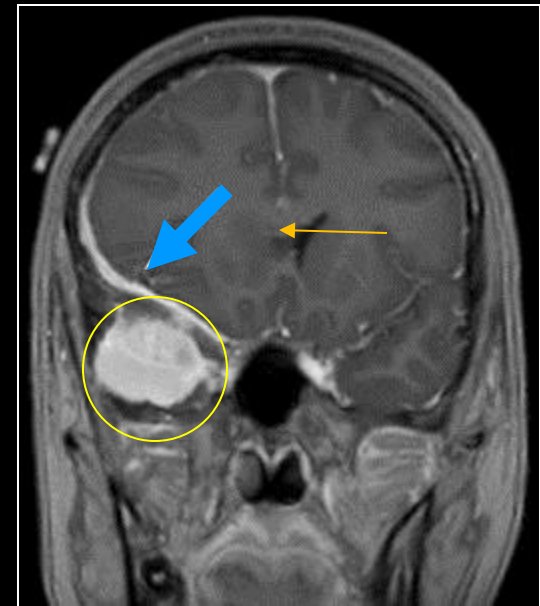
- 6.1x4.3x6.1cm extra axial **right parafalcine meningioma** with intermediate to high signal on T2 weighted imaging.
- CSF cleft sign: **Thin rim of fluid** manifests as high signal surrounding this meningioma

Companion patient 2. T2
weighted MR Head



Meningioma Dural Tail

- **Homogenously enhancing extra axial mass**
- **Broad dural tail** extending along the sphenoid wing and lateral aspect of the right frontal lobe
- Subfalcine herniation to the left by 7 mm and **effacement of the right lateral ventricle.**

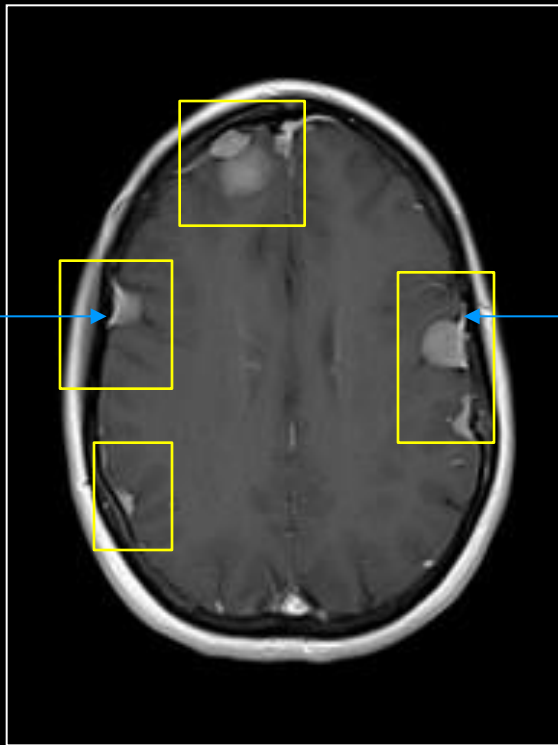


Post-contrast coronal
T1-weighted MR
head.



Multiple Meningiomas

- Multiple meningiomas may occur in a single patient and may be sporadic, radiation-induced, or associated with neurofibromatosis type II or other familial inheritance.



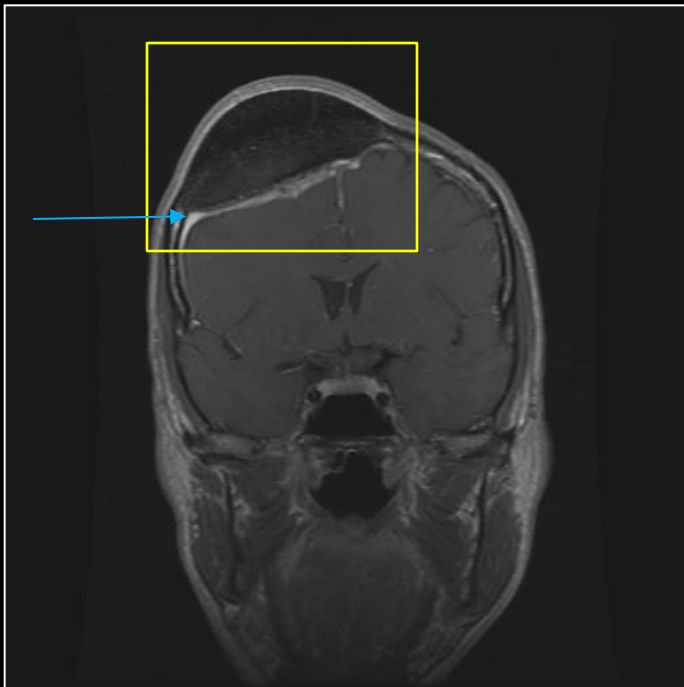
- **Multiple extra-axial dural-based enhancing masses.**
- Underlying **dural enhancement** is present.
- These lesions proved to be meningiomas in a patient with NFII.

Companion patient 3. Post-contrast T1-weighted MR Head.



Extradural Meningioma

Approximately 1% of meningiomas may arise outside of the dura. Meningiomas have been described in locations such as the mandible, mediastinum, and temporal bone. These meningiomas have been hypothesized to result from arachnoid cap cells trapped in the cranial sutures at birth or from meningotheelial differentiation from mesenchymal precursors.



- Markedly **hypointense mass** involving the right frontoparietal region and crossing the midline slightly to the left.
- **Thickening and enhancement of the underlying dura.**
- This was proven on pathology to be an intraosseous meningioma.

Companion patient 4. Coronal precontrast T1-weighted sequence MR head.



Radiologic tests for meningioma

- Magnetic Resonance Imaging
- **Computed Tomography**
- Magnetic Resonance Spectroscopy

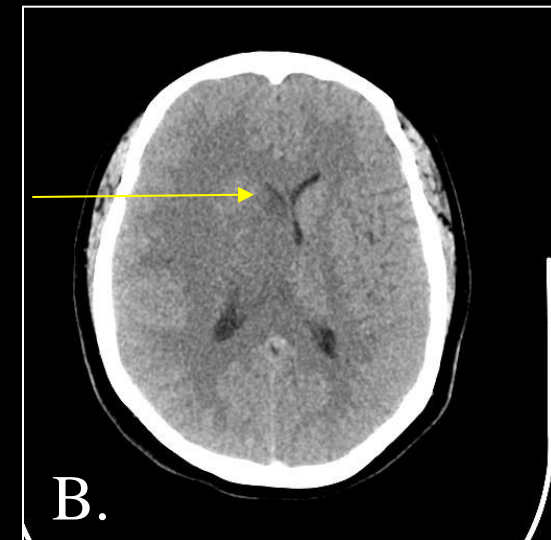
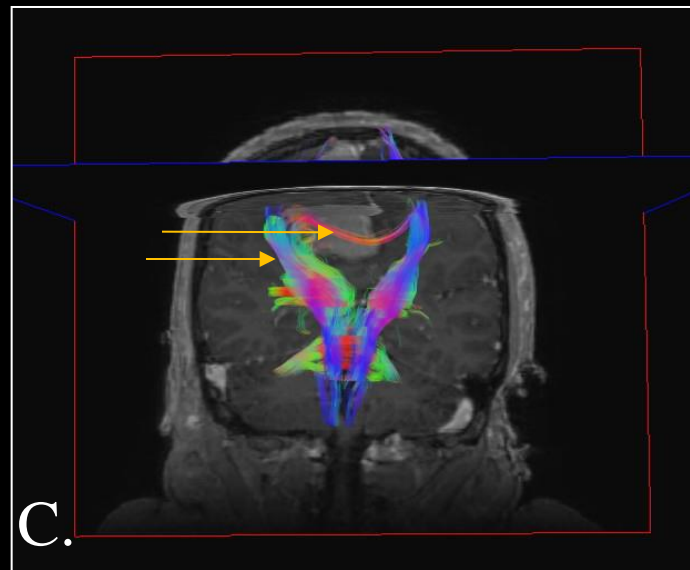
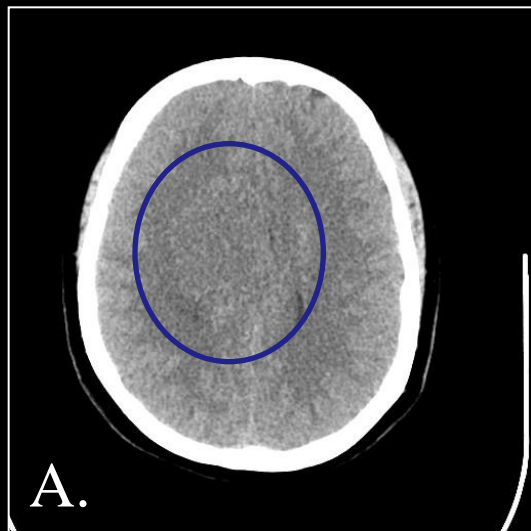


Computed Tomography

- Meningiomas appear **hyperdense** (75%) or **isodense** (25%) on noncontrast CT, usually with **homogeneous attenuation**, though may be heterogeneous if associated with necrosis or calcification.
- CT may assist with detection of:
 - Intracranial compressive effects
 - Hyperostosis associated with benign meningioma (common)
 - Osteolysis associated with malignant meningioma (rare)
 - Superior to MRI in detecting psammomatous calcifications (seen in 25% of meningiomas)
- While not imaging modality of choice for evaluating meningiomas, many are first detected incidentally on CT scans done for other reasons



Meningioma Compressive Effects on CT

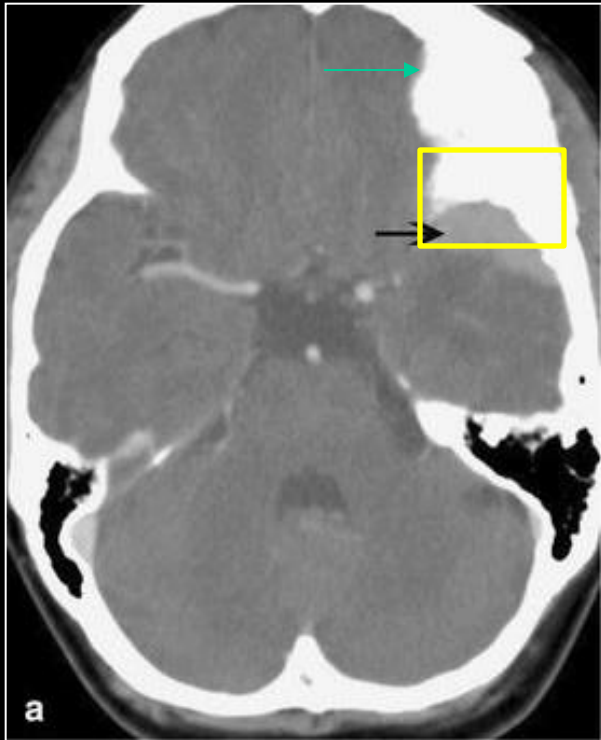


Companion patient 2. Non-contrast CT Head (A and B) and DTI Tractography (C) .

- A. There is a slightly hyperdense 6.0x4.5x6.1cm parafalcine mass.
- B. This results in a 10mm leftward shift of midline structures with **effacement of the frontal horn of the right lateral ventricle**.
- C. Diffusion tensor imaging tractography confirms **mild displacement of the major corticospinal, association, and commissural tracts** by the meningeoma.



Bone changes in meningioma on CT



- **Extra axial dural-based mass** is present in the left middle cranial fossa
- **Hyperostosis of temporal and sphenoid bone and orbital roof.**

CT angiogram head

From Saloner D, Uzelac A, Hetts S, Martin A, Dillon W. Modern meningioma imaging techniques. *J Neurooncol.* 2010 Sep;99(3):333-40.



Radiologic tests for meningioma

- Magnetic Resonance Imaging
- Computed Tomography
- **Angiography**

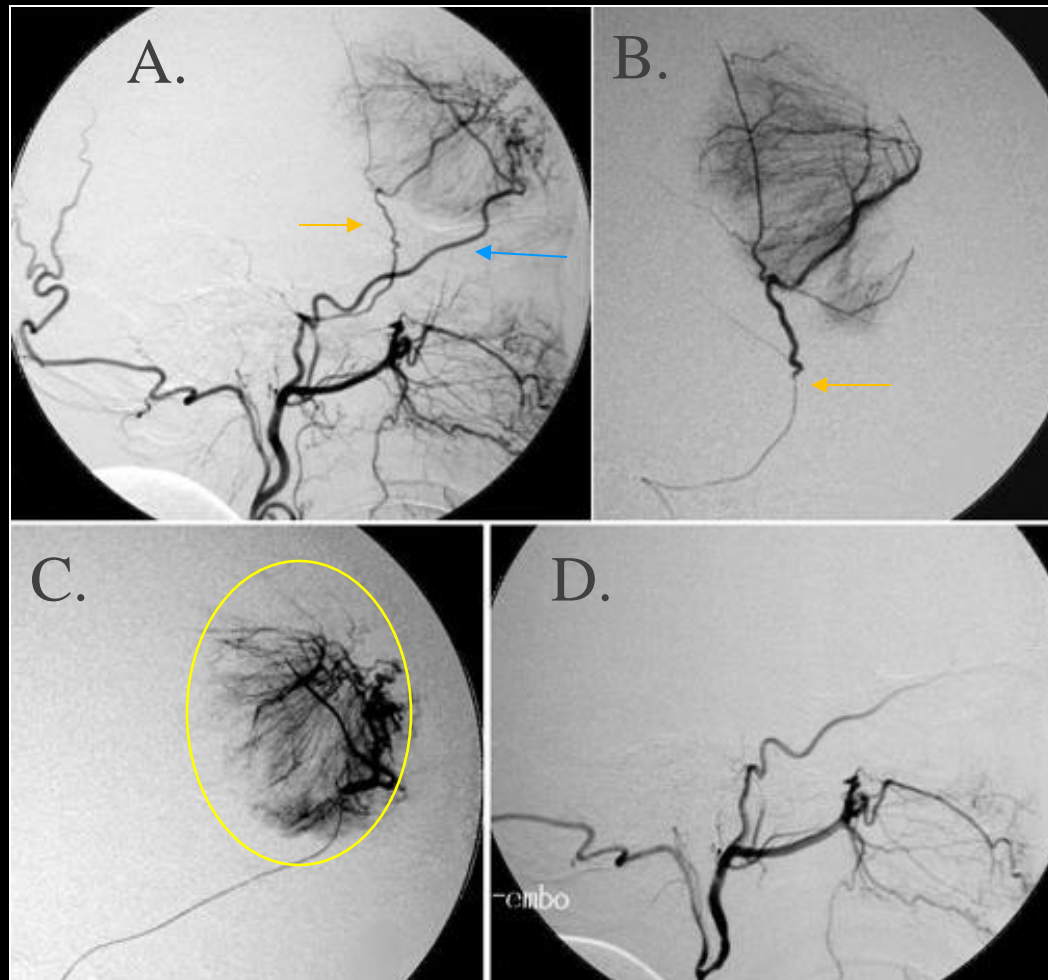


Angiography

- Angiography is typically done for preoperative embolization, which helps to reduce tumor vascularity and intraoperative blood loss.
- Meningiomas are predominantly supplied by meningeal vessels and have a characteristic “spokewheel” appearance of the vessels on angiography.
- “Mother in law sign”: Tumor contrast blush on angiography “comes early and stays late.” There is a hypervascular blush throughout the arterial phase with late venous phase persistence and a slow washout.



Angiography



- A. Pre-embolization left external carotid artery lateral angiogram with meningioma tumor blush supplied by **middle meningeal** and **superficial temporal arteries**
- B. **Middle meningeal artery** branch arteriogram
- C. Superficial temporal branch arteriogram. Characteristic **“spoke wheel” appearance** is present
- D. Post particulate embolization of tumor bed and coil embolization of feeding middle meningeal artery



Summary Learning Points

- Meningiomas arise from the arachnoid cap cells and are the most common extra axial intracranial neoplasm.
- They are usually benign, though ~10% may show more aggressive features on histology. Symptoms are varied and depend on location of tumor.
- Menu of radiologic tests
 - MRI: Imaging modality of choice for evaluating meningioma. Isointense to hypointense on T1, isointense to hyperintense on T2, typically with homogenous contrast enhancement. CSF cleft sign helps in proving tumor is extra axial and dural tail is further characteristic of meningioma.
 - CT: May appear hyperdense to isodense. Not first choice imaging modality though may assist with detection of compressive effects and bony changes associated with meningiomas.
 - Angiography: Performed pre-operatively to reduce tumor vascularity and intraoperative blood loss. Meningiomas show characteristic “spoke wheel” pattern of vascularity and early tumor blush with slow washout.



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