Diverse Imaging Appearances and Locations of Meningioma.

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Learning objectives

To describe typical and atypical findings of meningiomas in CT and MRI.

To assess frequent and infrequent localizations in 41 cases of our archive.

To establish possible differential diagnosis when atypical characteristics or unusual localizations are found.

Background

Meningiomas are the most common primary nonglial extraaxial tumor and account for 15% of all intracranial neoplasms. They can be found in any place where meninges exist and are benign in most of the cases.

There are 15 different histological types of meningiomas, classified in the WHO (World Health Organization) grading system in three grades. In the WHO Grade I (classically defined as benign and accounting for 80% of all meningiomas), the most common subtypes are the transitional, fibroblastic, and meningothelial ones. The WHO Grade II meningiomas are atypical and the WHO Grade III meningiomas are malignant.

Meningiomas are usually recognised on imaging studies by their typical localizations and characteristic features; however, some of them have atypical appearances and occur in atypical locations that can mimic other intracranial pathologies, leading to misdiagnosis.

Imaging findings OR Procedure details

Meningiomas are typically well-circumscribed, broad-based extra-axial lesions closely abutting the duramadre.

On unenhanced CT they are usually hyperdense, with frequent calcifications, that can be nodular, punctate or dense and confluent (Figure 1).
Adjacent bone may show hyperostosis and bone erosion (Figure 2).

Meningiomas generally show homogeneous enhancement on contrast enhanced CT (Figure 3).

The homogeneous enhancement, the presence of calcifications and the adjacent bone sclerosis on CT are signs suggestive of benignity.

On MRI meningiomas are classically iso- or slightly hypointense on T1W images, with variable signal intensity on T2W images (iso-hyperintense), and intense homogeneous gadolinium enhancement (Figure 4).

They can also present a heterogeneous appearance, mainly on T2W images, due to the existence of vascularization and the presence of calcifications and cystic foci (Figure 5). MRI is less sensitive and specific than the CT for calcifications' characterization; its signal intensity may vary (generally low both on T1W and T2W images) (Figure 6).

According to some recent studies, the histological type of meningiomas might be suggested depending on its aspect on T2W MRI; fibroblastic and transitional meningiomas would be hypointense, and the angioblastic ones would be hyperintense.

The typical radiological signs of extra-axial lesion are better identified on MRI; although not specific, they can be observed more frequently in meningiomas than in other extra-axial lesions. These signs are the following: "cortical buckling" of the underlying brain, "dural-tail" sign, "cerebrospinal fluid cleft" sign and "pial vascular structures" interposed between the tumor and the brain surface (Figure 7).

These are some less frequent or atypical radiological appearances of the meningiomas (among others):

- Large amount of edema. In patients with meningiomas, the amount of edema is better quantified on FLAIR sequences and it is not related to the tumor size (Figure 8). It has been suggested that the degree of perilesional edema may be due to the meningiomas’ location (in our experience, associated mainly with the six olfactory groove or frontobasal meningioma cases included in our series), histological type and tumor blood supply. The true nature of this phenomenon is still unclear, but tumors with a disproportionate degree of edema could orientate to more aggressive histological types, with a greater malignant potential.
• Heterogeneous internal structure and heterogeneous enhancement (Figure 9).

• Multilobular or irregular borders (Figure 10).

• Peripheral rim enhancement, low-grade astrocytoma alike.

• En plaque meningiomas, which tend to infiltrate the duramadre and frequently invade the adjacent bones. This type of meningioma is much more commonly associated with subjacent bone hyperostosis, which is disproportionately greater in size compared with the (intracranial) tumor (Figure 11).

• Cystic meningiomas. They are uncommon and its most frequent location is overlying the cerebral convexity (particularly in the frontoparietal regions) or parasagittal. Cysts associated with meningiomas may be intra- or peritumoral (Figure 12).

• Necrosis, fat transformation and bleeding (Figure 13).

• Target appearance (central enhancement), that may mimic an aneurysm (Figure 14).

**Typical localizations of meningioma** include the convexity, parasagittal, the sphenoid wing, the olfactory groove and the parasellar region. Meningiomas' most frequent locations are variable, depending on different series.

The cases we present do not estimate the real prevalence of meningiomas' localizations in our environment, because they have been collected from our Radiology Department teaching image files, and therefore do not represent all the patients diagnosed with meningiomas in our hospital.

We present the most illustrative images of different locations of meningiomas according to our experience (41 cases) during the last 8 years (2004-2012).

**27 cases of supratentorial meningiomas**

• 13 cases of convexity / parasagittal meningiomas (Figure 15).

• 6 cases of sphenoid meningiomas (Figure 16).

• 6 cases of olfactory groove meningiomas (Figure 17).

• 2 cases of parasellar meningiomas (Figure 18).

The **sphenoid wing meningiomas** are the most common of the skull base and its location is very typical, but its extension varies widely. Some of them are very invasive and its extension should be specified facing the neurosurgical approach (Figure 19).
3 cases of tentorial meningiomas (Figure 20).

6 cases of subtentorial meningiomas

- 3 cases of cerebellopontine angle meningiomas (Figure 21).
- 3 cases of clival and clivo-sphenoidal meningiomas (Figure 22).

It is sometimes difficult to make the differential diagnosis between cerebellopontine angle meningioma (the second most common tumor in the posterior cranial fossa) and acoustic neurinoma (the most common in this location); diagnosis is suspected based on the frequency of the following radiological features.

Dural-tail sign and adjacent bone reaction are uncommon in acoustic neurinomas. Cysts and calcifications may be seen in 10% of the cases. Inhomogeneous enhancement may be present in up to 32% of the cases. Internal auditory canal (IAC) extension is frequent (80% of the cases) (Figure 23).

Dural-tail sign and adjacent bone reaction are more frequent in meningiomas. There are usually no cysts and calcifications may be seen only in 20% of cases. The contrast enhancement is homogeneous, and the extension to IAC is possible but uncommon.

3 cases of multiple meningiomas (meningiomatosis) (Figure 24).

- One operated patient, with recurrence in the convexity and other locations such as the optic nerves' sheets and the cerebellopontine angle.
- One patient with parasellar and temporal locations.
- One patient with multiple lesions: falx-convexity, intraventricular (operated) and cerebellar tentorium.

Meningiomatosis is more frequently seen in women. In young patients, type 2 neurofibromatosis is the most common cause.

The differential diagnosis for meningiomatosis includes multiple metastases (Figure 25).

2 cases of spinal meningiomas (one in cervical and another in dorsal spine) (Figure 26).

Spinal meningiomas are the second most common intradural extramedullary malignancies after metastases. They are more commonly located in the dorsal spine and its differential diagnosis must be basically made with schwannoma, neurofibroma and paraganglioma (Figure 27).
**Fig. 1:** Different patients with calcified meningiomas on Axial brain CT.
Fig. 2: Calcified sphenoid wing meningioma (A, B) with reactive subjacent bone sclerosis (arrows) at plain brain CT with bone window settings (C, D).
Fig. 3: Typical parasagittal meningioma on plain (A) and contrast-enhanced (B) brain CT. Homogeneous enhancement.
Fig. 4: Typical parasagittal meningioma on Axial SE T1 (A), Axial (B) and Coronal (D) FSE T2 and Sagittal SE T1W + Gd (C) brain MRI.
Fig. 5: Calcified olfactory groove meningioma with heterogeneous signal intensity and vasogenic perilesional edema at Axial (A, B) and Coronal (C, D) FSE T2W brain MRI.
**Fig. 6:** Calcified meningioma with perilesional edema. Hypointense central calcification on Sagittal plain (A) and Gadolinium-enhanced (B) SE T1W and Axial FSE T2W (C) brain MRI.

**Fig. 7:** Typical radiological signs of extra-axial lesion in different patients with meningiomas. A - Pial vascular structures (short arrows) and cerebrospinal fluid cleft sign (large arrow) on Sagittal SE T1W brain MRI. B - Cerebrospinal fluid cleft sign (arrow) and perilesional edema (asterisk) on Axial FSE T2W brain MRI. C - Dural-tail sign (arrows) on Sagittal SE T1W brain MRI.
Fig. 8: Great perilesional edema (asterisks) in two different patients with meningiomas.
1 - Axial FLAIR brain MRI (A). 2 - Calcified meningioma of the olfactory groove on axial non-enhanced brain CT (B).
**Fig. 9:** Parietal meningioma of the convexity with heterogeneous structure on plain (A) and contrast-enhanced (B) brain CT.

**Fig. 10:** Meningiomas with lobulated borders in two different patients. 1 - Axial contrast-enhanced brain CT (A and B). 2 - Sagittal SE T1W Gadolinium-enhanced brain MRI (C).

**Fig. 11:** Right sphen-orbital en plaque meningioma in plain brain CT with soft-tissue window (A) and MIP bone window (B).
Fig. 12: Intratumoral cyst (asterisks) in left parasagittal meningioma. Axial (A) and contrast-enhanced (B) brain CT.
Fig. 13: Patient with multiple meningiomas on axial plain brain CT. Intraventricular meningioma of the right trigone with small laminar hemorrhage (short arrows) and perilesional edema (asterisks). Tentorial meningioma with central calcification (large arrow).
**Fig. 14:** "Inverse target appearance" due to central and lineal peripheric calcification en tentorial meningioma with supratentorial extension. Axial plain (A, B) and contrast-enhanced (C, D) brain CT. Coronal T2W (D) and Sagittal plain (E) and Gadolinium-enhanced (F)T1W brain MRI.
Fig. 15: Parasagittal meningiomas. Different patients. 1 -Coronal (A) Gadolinium-enhanced T1W brain MRI. 2 - Sagittal (B) and Axial (C) Gadolinium-enhanced T1W brain MRI. 3 - Contrast-enhanced axial brain CT (D). Axial Plain (E) and Gadolinium-enhanced (F) T1W brain MRI.
**Fig. 16:** Sphenoid meningiomas (different patients). Axial plain brain CT (A, B), Sagittal Plain (C) and Gadolinium-enhanced (D), Axial Plain (E) and Gadolinium-enhanced (F) T1W brain MRI.

**Fig. 17:** Olfactory groove meningioma in two different patients. 1 - Contrast-enhanced brain CT (A). 2 - Plain (B) and Gadolinium-enhanced (C) Axial T1W MRI and plain (D) and Gadolinium-enhanced (E) Sagittal T1W brain MRI.
**Fig. 18:** Left parasellar meningioma with suprasellar extension. Coronal FSE T2W (A), Axial (B) Gadolinium-enhanced and plain (C) and Gadolinium-enhanced (D) Sagittal T1W brain MRI.
**Fig. 19:** Invasive sphenoid wing meningioma with homogeneous contrast-enhancement on Axial (A, B, C, D), Sagittal (E) and Coronal (F) Gadolinium-enhanced T1W brain MRI.
Fig. 20: Small tentorial meningioma, almost unnoticed (despite presenting the "cerebrospinal fluid cleft sign") on brain MRI (isointense on T2W (A) and plain Axial (B) and Sagittal (D) T1W images), but for the intense Gadolinium-enhancement (Axial (C) and Sagittal (E) T1W+ Gd images.)
Fig. 21: Cerebellopontine angle meningiomas in two different patients. 1 - Plain (A) and Gadolinium-enhanced (B) Axial T1W brain MRI. 2 - Axial (C) and Coronal (D) Gadolinium-enhanced T1W brain MRI.
**Fig. 22:** Clival meningioma with right growth that occupies the prepontine cistern. Axial plain (A) and contrast-enhanced (B) brain CT. Sagittal plain (C) and Gadolinium-enhanced (D) T1W brain MRI.
**Fig. 23:** Left acoustic neurinoma on Coronal T2W (A), Coronal Gadolinium-enhanced T1W (B) and Axial 3D FIESTA (C) brain MRI. Enlargement and erosion of internal auditory canal (arrow) on brain CT with bone window setting (D).
Fig. 24: Multiple meningiomas (meningiomatosis) in two different patients. 1 - Right optic nerve (large arrows) and right cerebellopontine angle (short arrows) meningiomas on plain (A) and contrast-enhanced (B) brain CT. 2 - Patient with operated right intraventricular meningioma. Tentorial meningioma (with central hipointensity on Gadolinium-enhanced images) that hang down towards the supravermian cistern, and multiple falcines meningiomas. Axial (C) and Sagittal (D) T1W brain MRI.
Fig. 25: Dural metastases from prostate carcinoma. Meningeal involvement characterized by a diffuse smooth thickening, nodular appearance (short arrows), with peritumoral cyst (large arrow). Axial plain (A, B) and contrast-enhanced (C, D) brain CT.
**Fig. 26:** Spinal meningiomas in two different patients. 1 - C7-D1 meningioma on Plain (A) and Gadolinium-enhanced Sagittal (B) and Axial (C) T1W cervical spine MRI. 2 - Dorsal meningioma on Plain (D) and Gadolinium-enhanced Sagittal (E) and Axial (F) T1W dorsal spine MRI.

**Fig. 27:** Spinal Paraganglioma. Intradural extramedullary lesion (medullary cone, L1-L2 level), with small internal cystic element (high-signal in T2W image) and homogeneous enhancement, meningioma-alike. Plain Sagittal T1W (A), Gadolinium-enhanced Sagittal (B) and Axial (C) T1W, Sagittal (D) and Axial (E) T2W lumbar spine MRI.
Conclusion

Meningiomas are common central nervous system tumors.

Radiologists must be aware of their less frequent locations and uncharacteristic imaging features in order to suggest the correct diagnosis in atypical cases.

References


**Personal Information**