Imaging Characteristics of Central Nervous System Tumors

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Disclosures

I have no relevant financial relationships to disclose

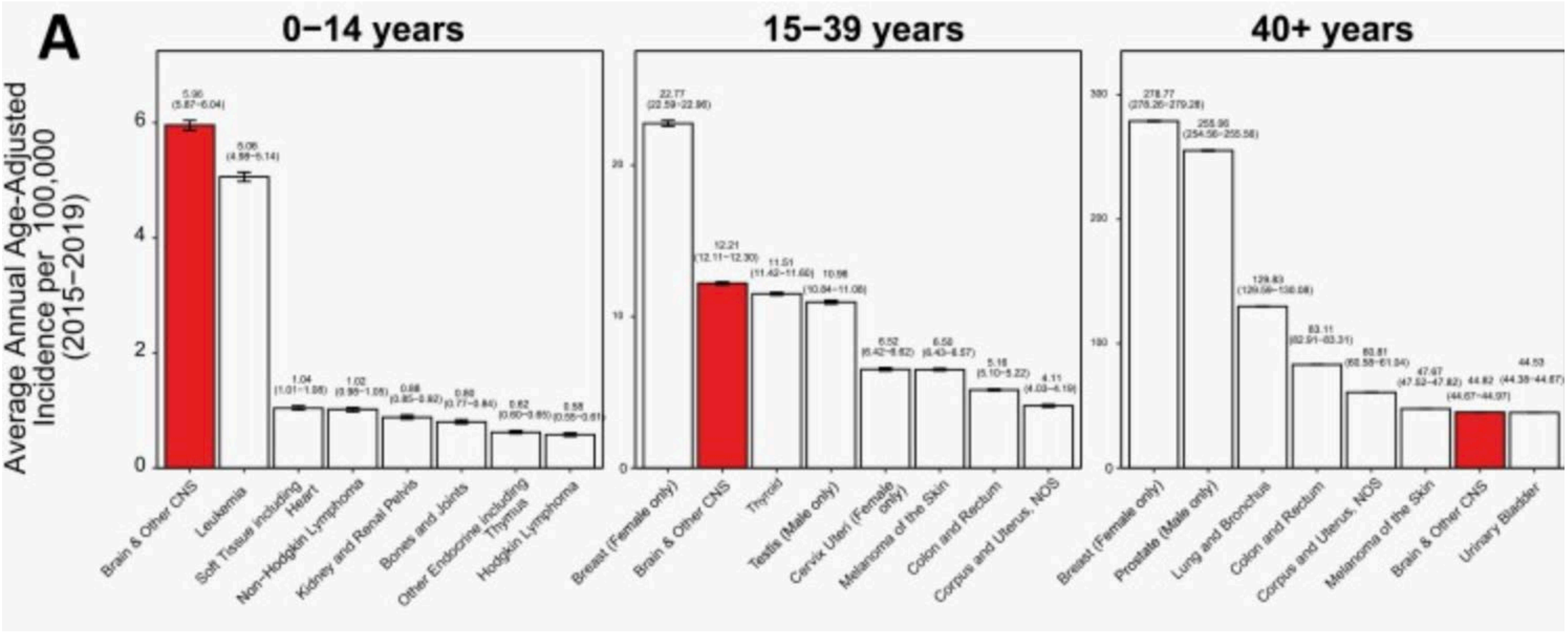
Objectives

- Recognize imaging characteristics of common adult brain tumors
- Differentiate adult brain tumors from non-malignant mimics

Limitations

- Will not discuss every type of brain tumor
- Will not discuss every imaging sequence

CNS tumor facts



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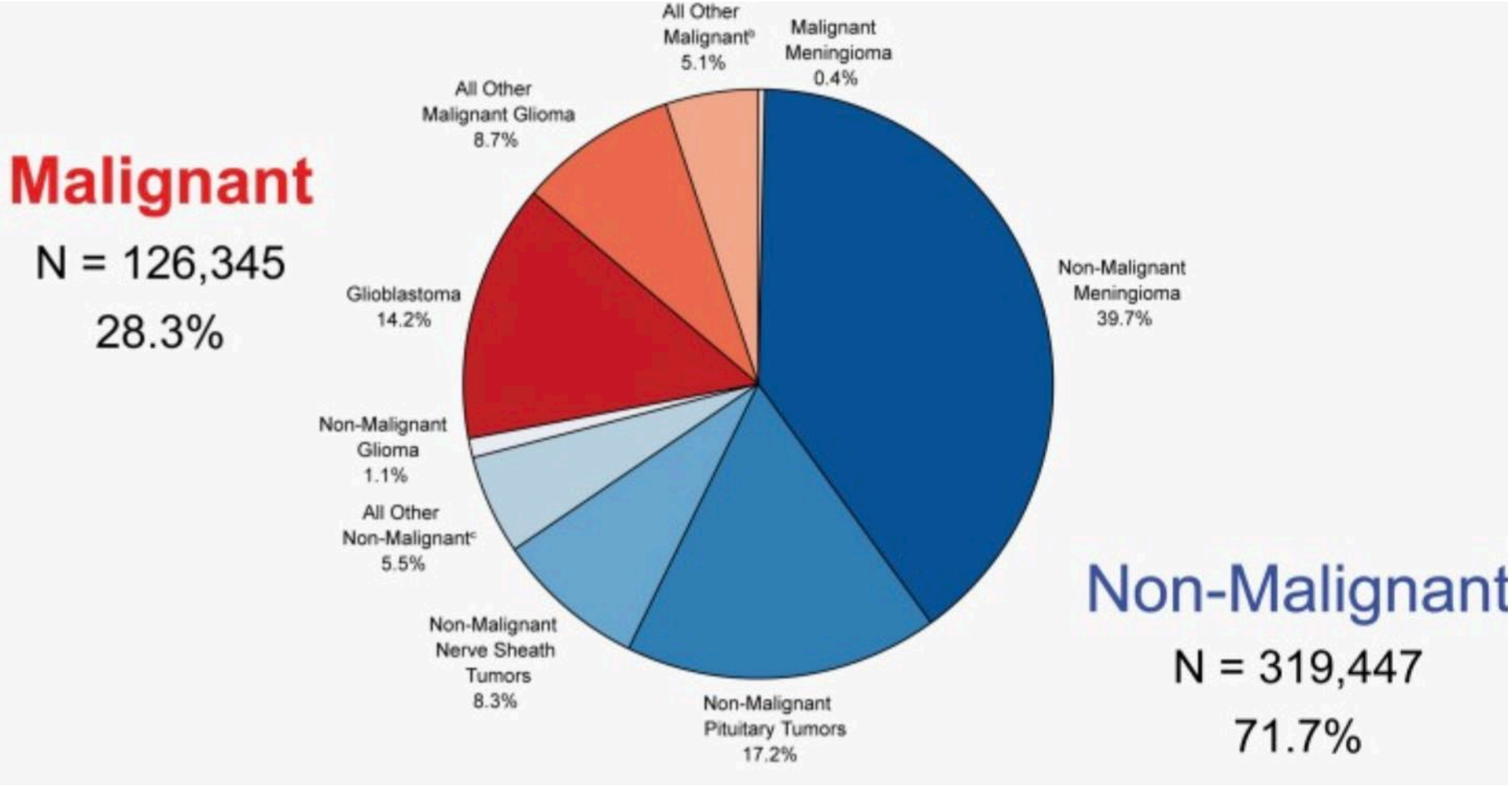
CNS tumor facts



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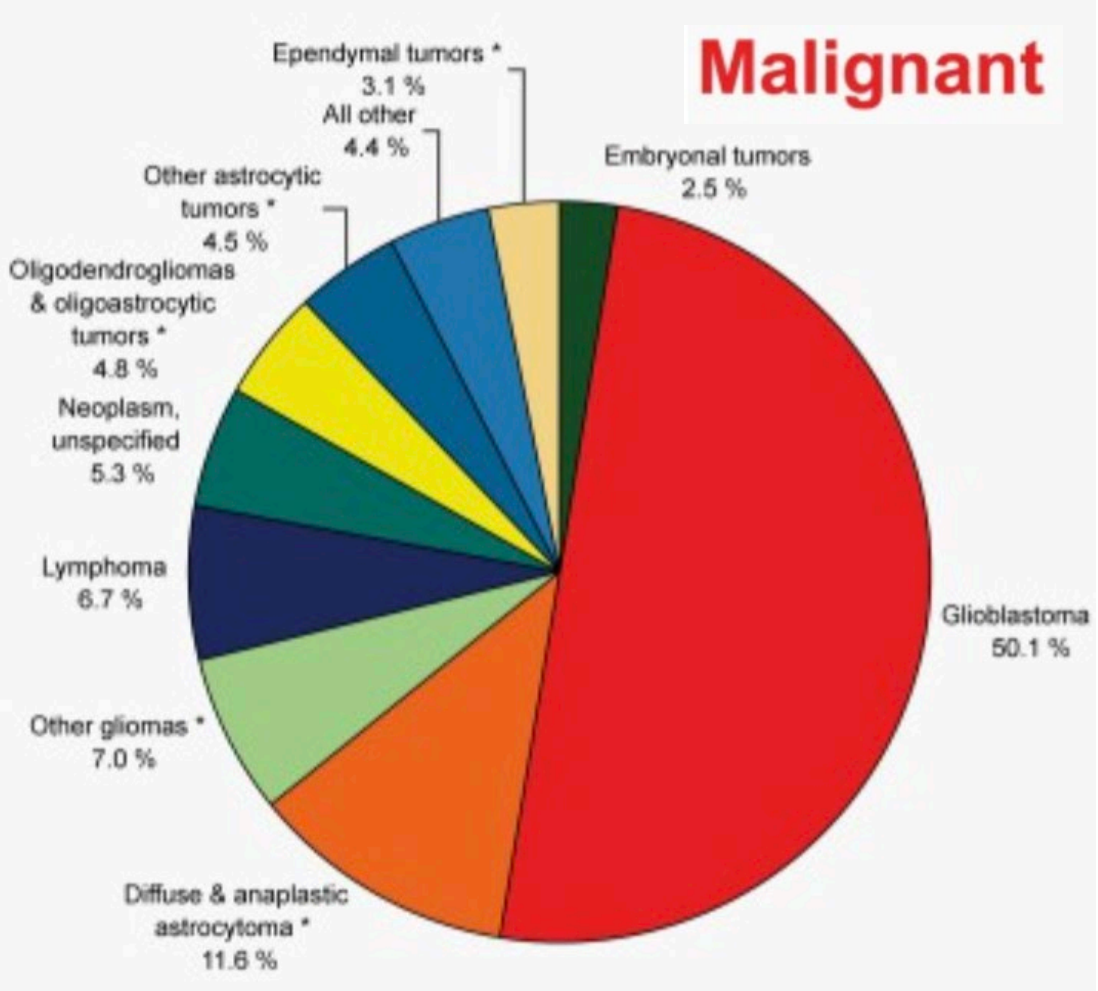
CNS tumor facts



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Why not just wait for pathologic confirmation?

- Imaging identification is important for initial treatment planning and managing patient expectations
- Examples:
  - Primary CNS lymphoma requires biopsy only; no evidence that resection of the enhancing masses is beneficial
  - Glioblastomas, which may look benign if caught early, have better survival with earlier treatment
  - Small, asymptomatic meningiomas can be observed; dural metastases, which look similar, should be treated

Overview

Glial tumors

- Astrocytoma, IDH-mutant
- Oligodendroglioma, IDH-mutant, 1p/19q co-deleted
- Glioblastoma, IDH-wildtype
  - Early glioblastoma

Meningiomas

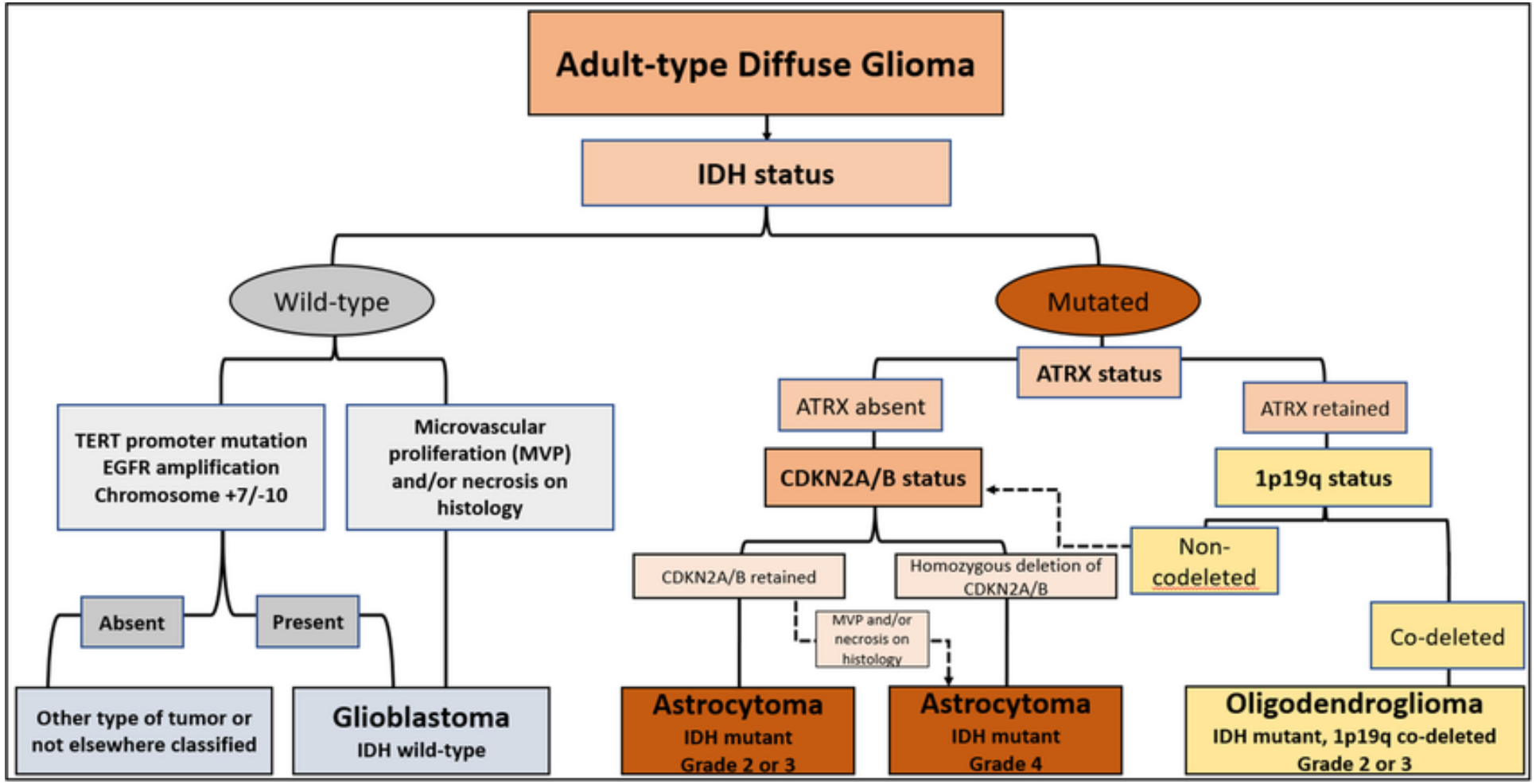
Spinal cord tumors

- Ependymoma
- Astrocytoma
- Hemangioblastoma

Primary CNS lymphoma

Non-neoplastic mimics

Glial tumor classification (WHO 2021)



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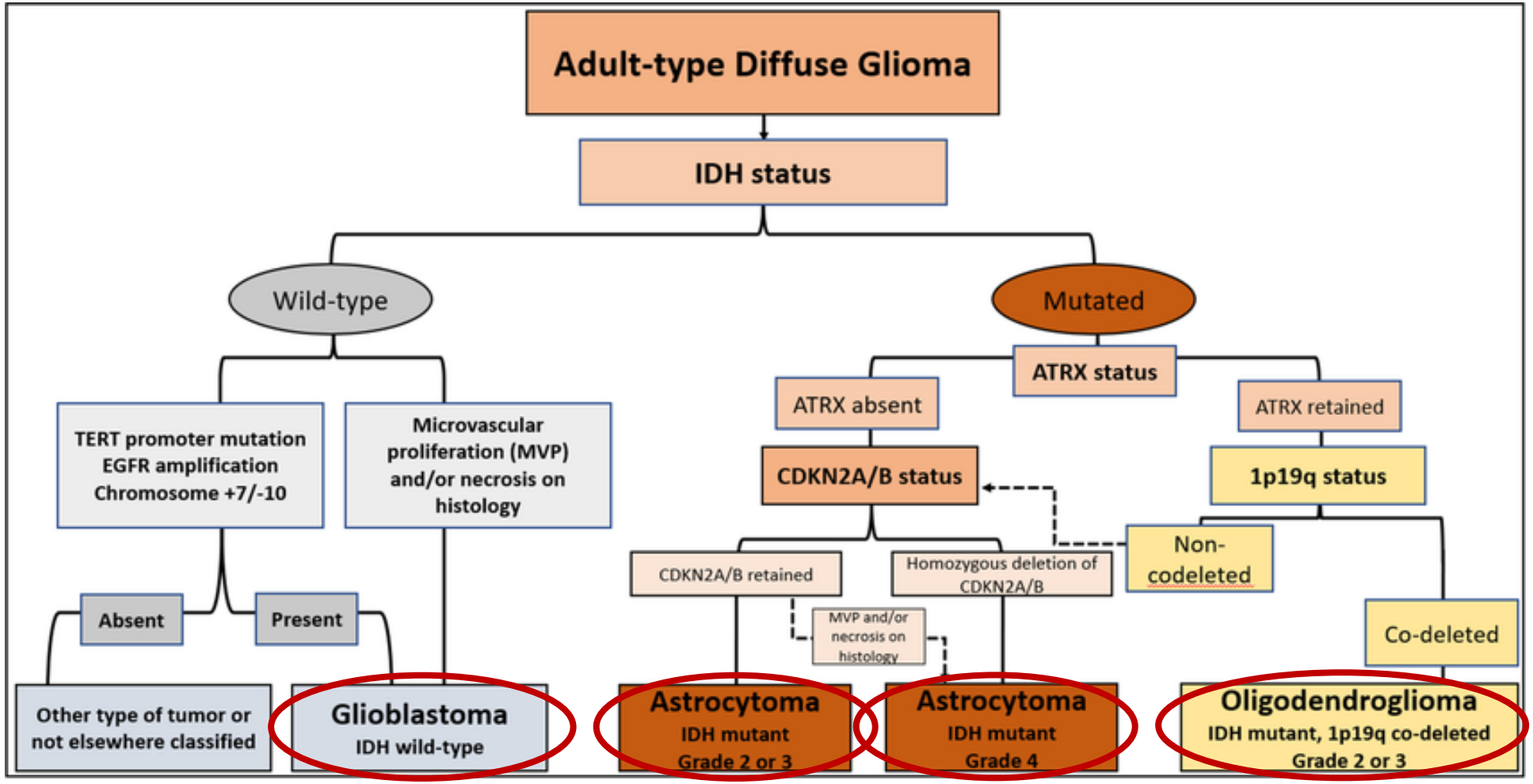

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Astrocytoma, IDH-mutant

T2 FLAIR mismatch sign

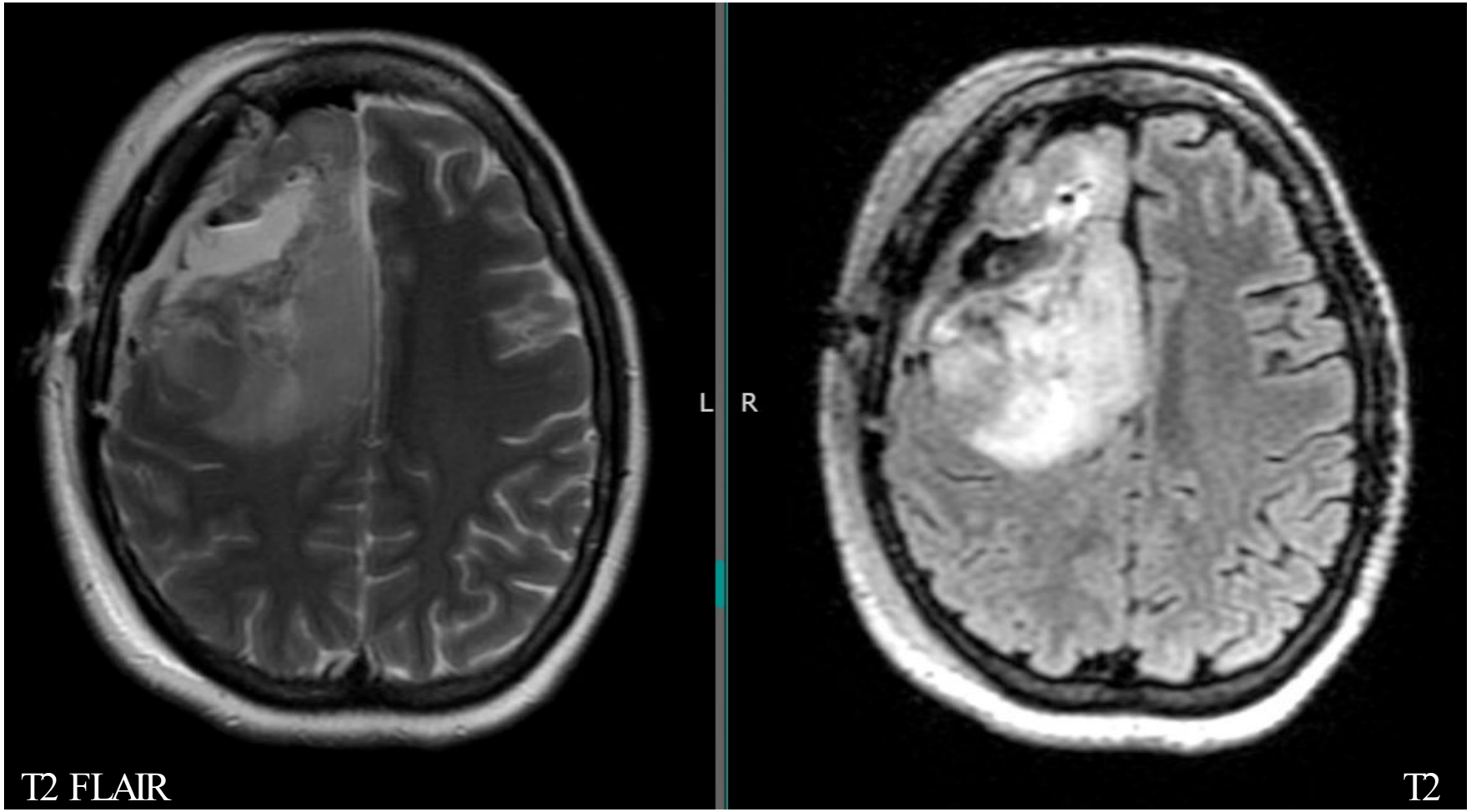
- Brighter on T2 than on T2 FLAIR due to incomplete suppression

Enhancement

- More common in grades 3-4

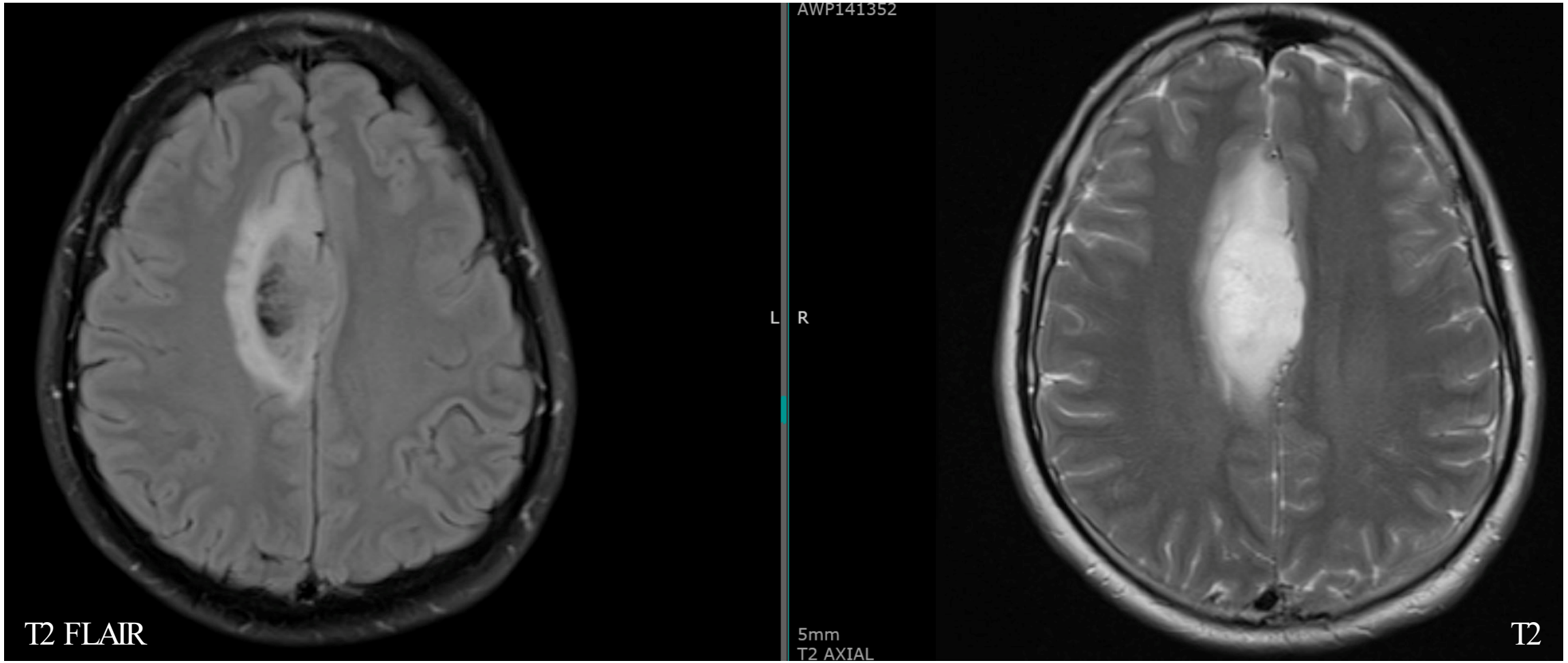
Typical location: lobar

T2/FLAIR mismatch sign



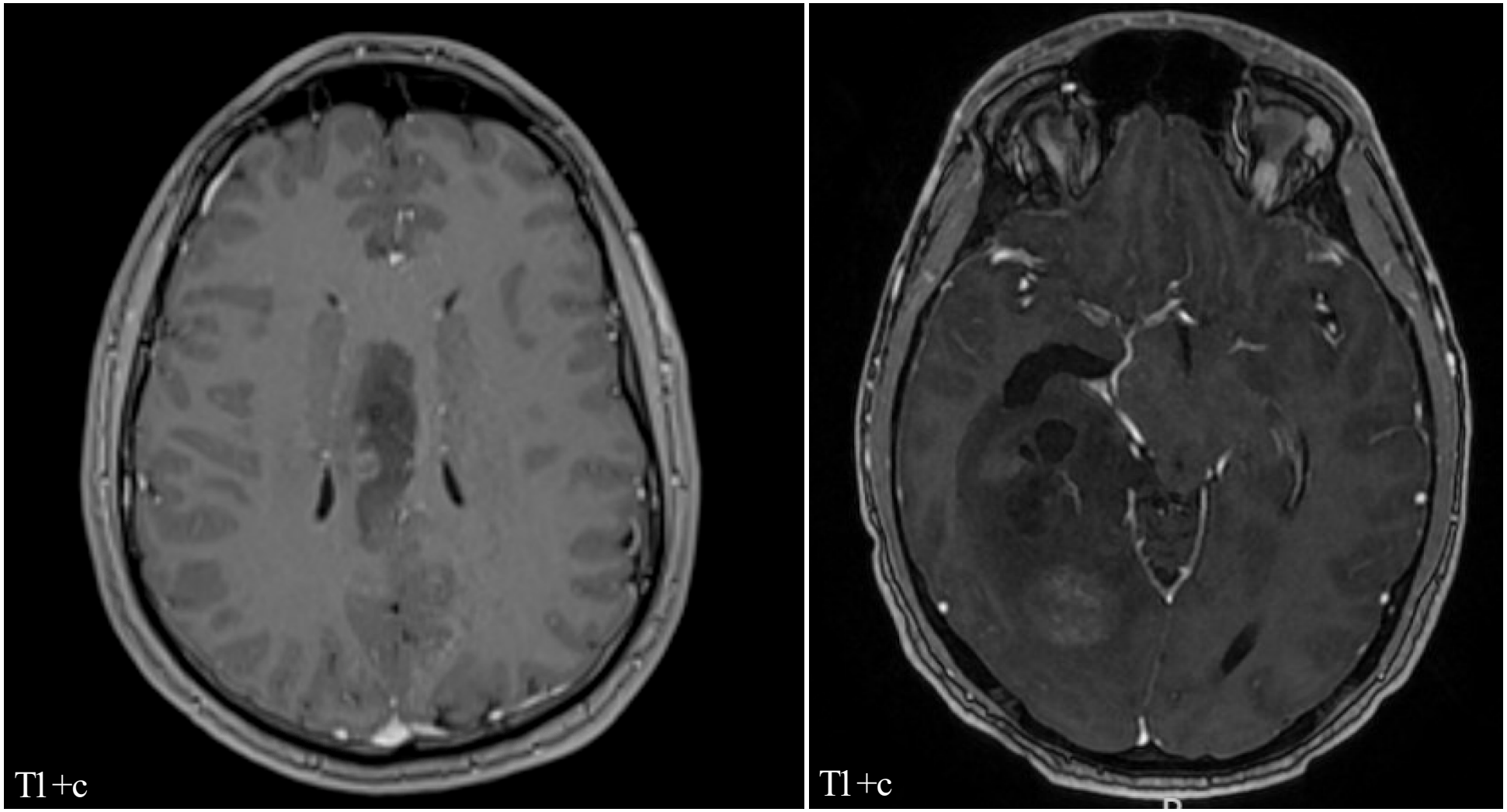
Astrocytoma, IDH-mutant, WHO grade 2

T2/FLAIR mismatch sign



Astrocytoma, IDH-mutant, WHO grade 4

Enhancement – present in higher grades (WHO 3-4)



Astrocytoma, IDH-mutant, WHO grade 4

Oligodendroglioma, IDH-mutant and 1p/19q co-deleted

Can have calcifications and cysts

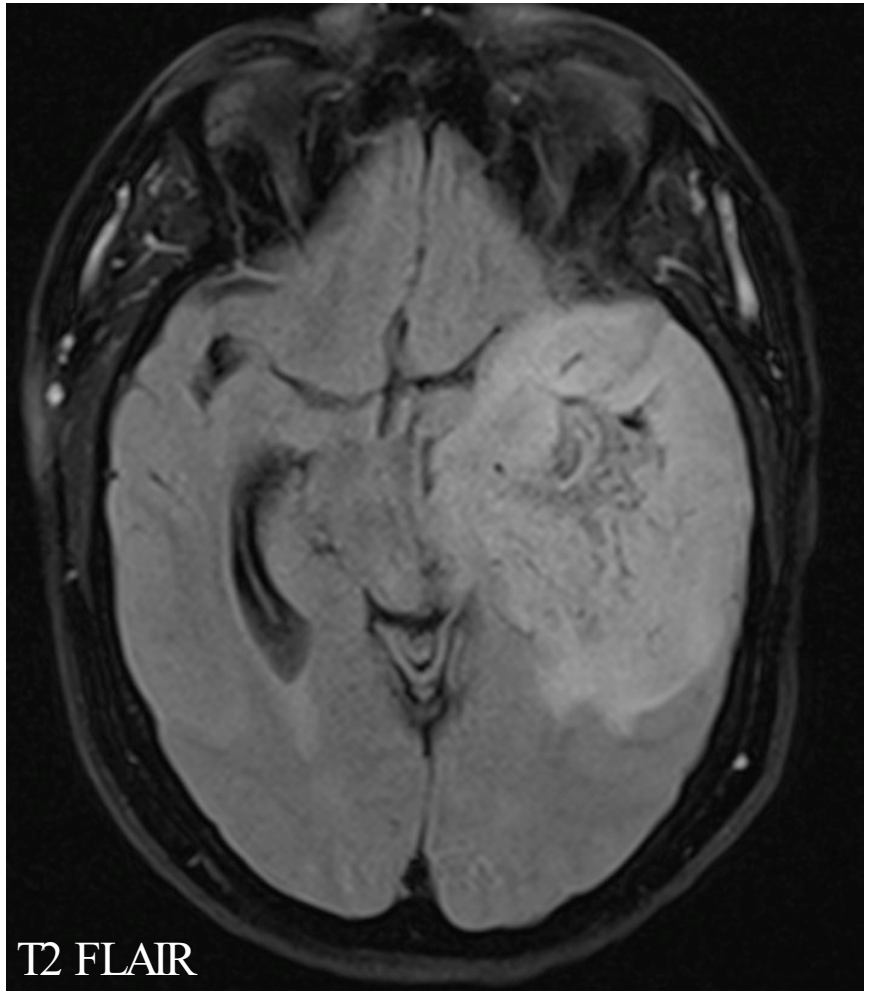
- Calcifications seen best on CT

Enhancement

- Only present in ~50%
- More common in higher grade

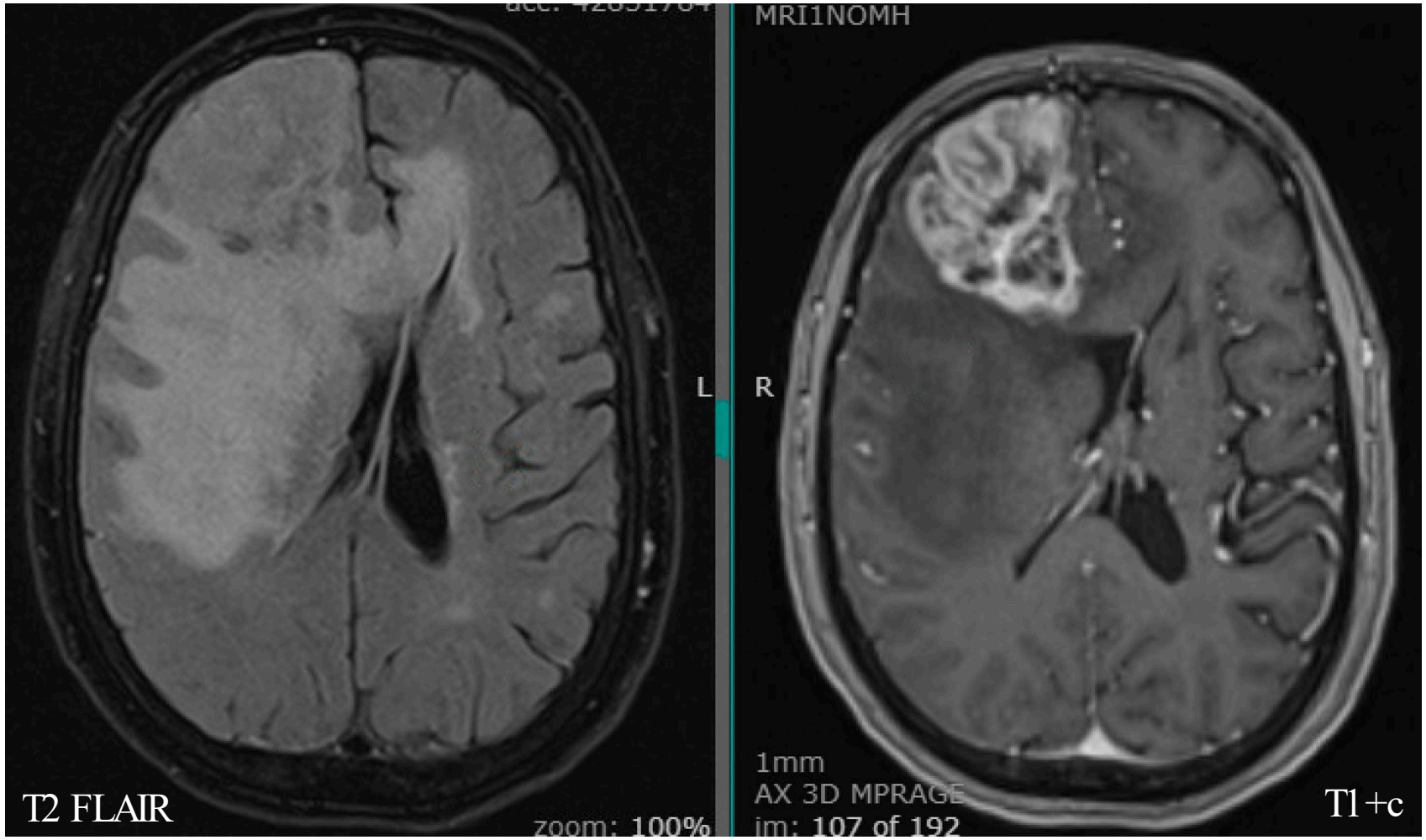
Typical location: cortical

Calcification



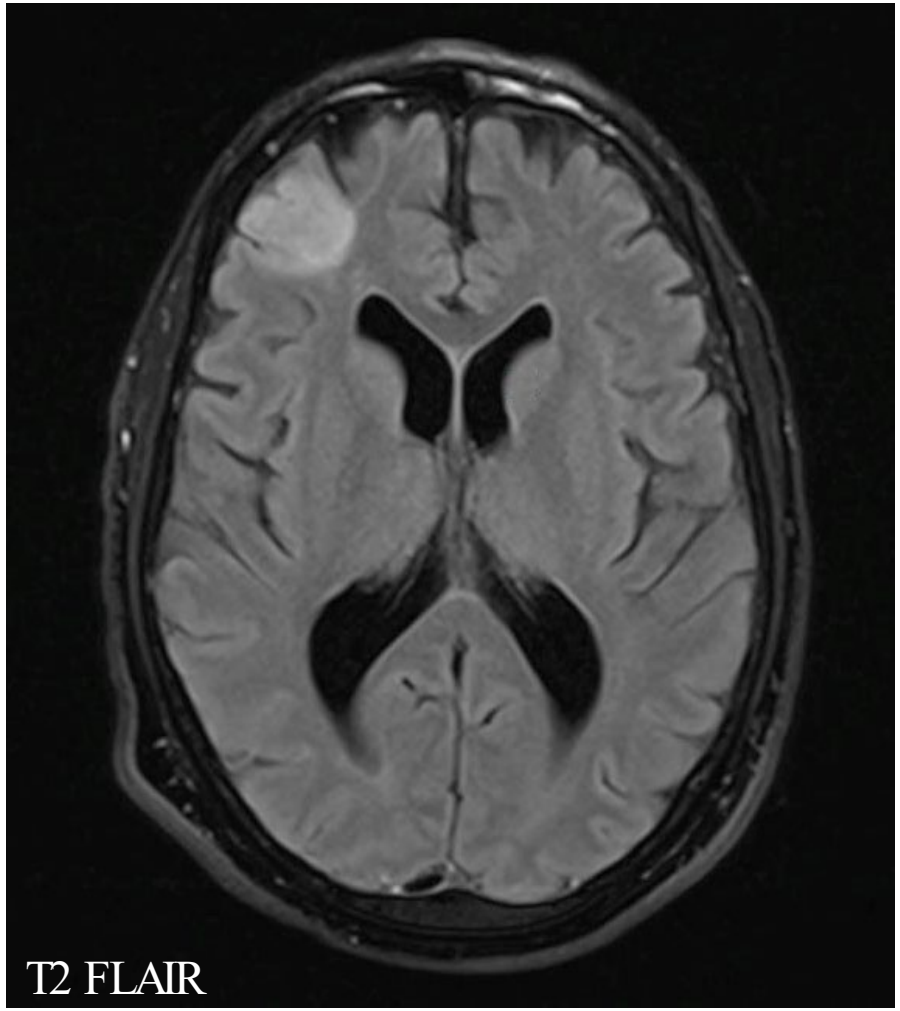
Oligodendroglioma, IDH-mutant, 1p/19q co-deleted, WHO grade 2

Enhancement – grade 3



Oligodendroglioma, IDH-mutant, 1p/19q co-deleted, WHO grade 2

Cortical location



Oligodendroglioma, IDH-mutant, 1p/19q co-deleted, WHO grade 2

Glioblastoma, IDH-wildtype, WHO grade 4

T2 signal

- Surrounding diffuse hyperintensities represent tumor and edema

Enhancement

- "Shaggy" ring enhancement

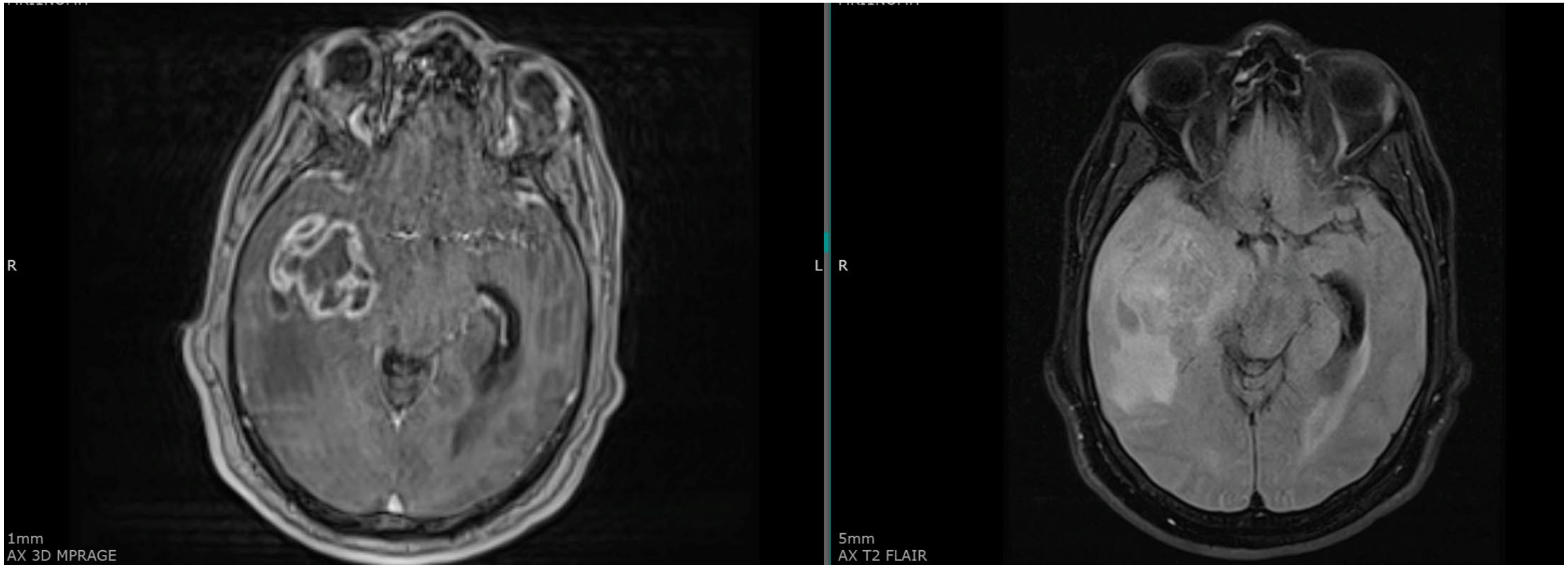
Typical location:
cerebral hemispheres

- Textbook appearance: bi-hemispheric butterfly

Early glioblastoma

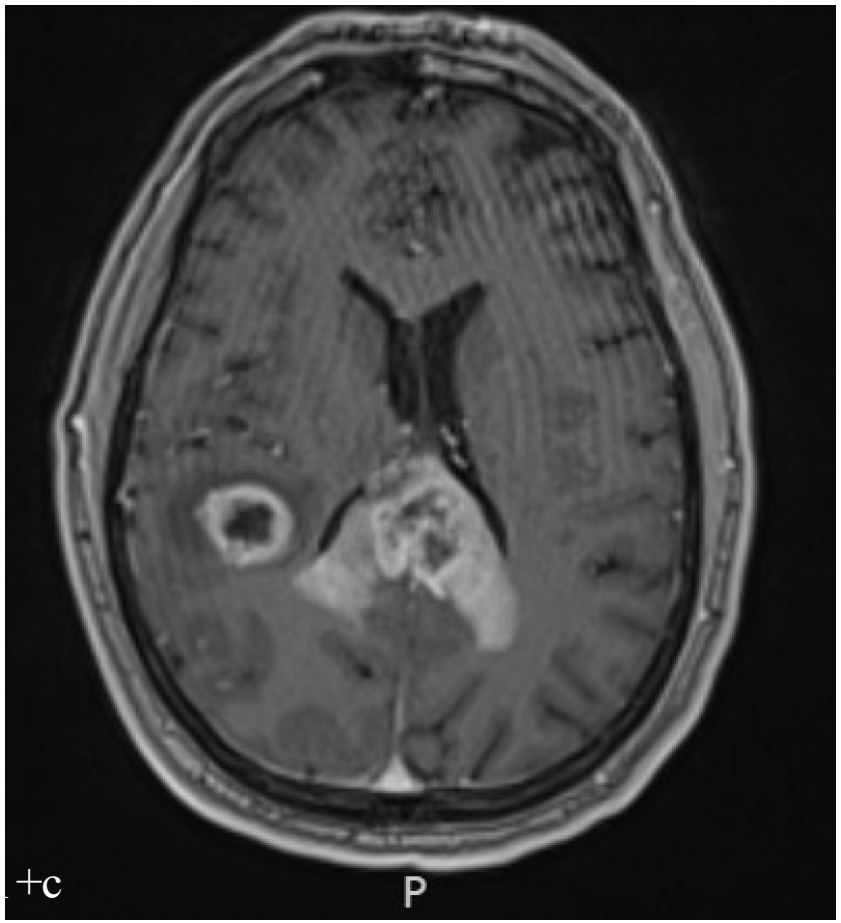
- Breaks the rules

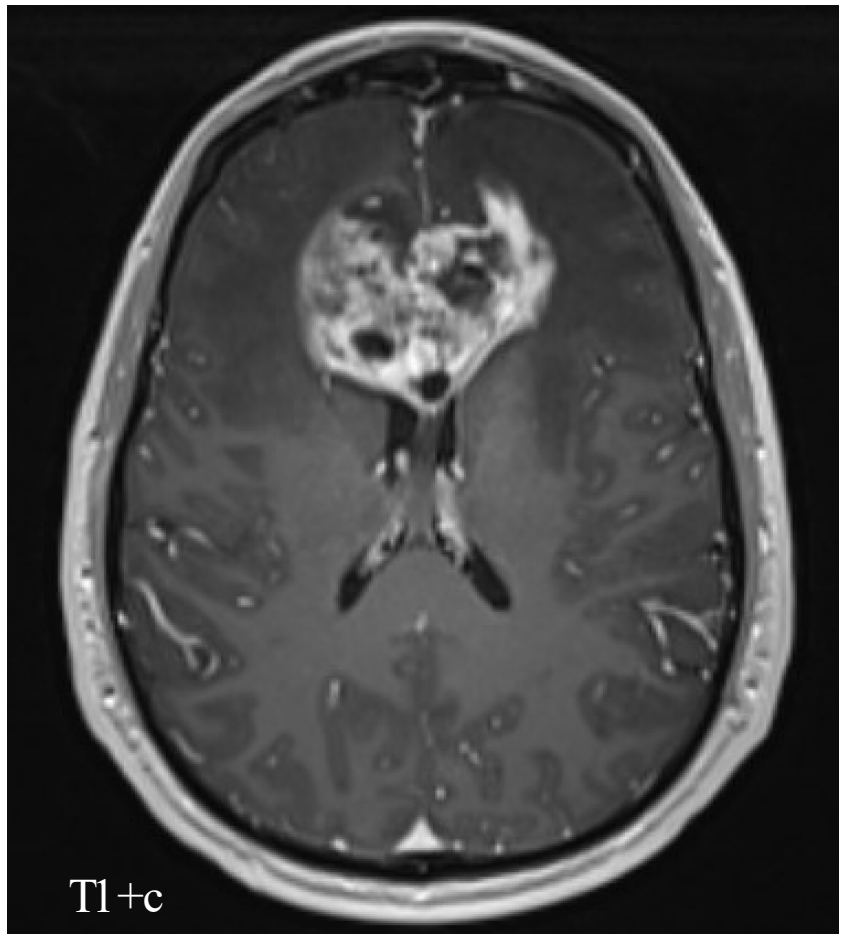
Ring enhancement and surrounding tumor/edema



Glioblastoma, IDH-wildtype, WHO grade 4

Extension across the corpus callosum





Glioblastoma, IDH-wildtype, WHO grade 4

Early glioblastoma

Enhancement

- Often without contrast enhancement or only focal nodular enhancement

Ill-defined FLAIR hyperintensity

Location

- Cortical +/- subcortical white matter

Absent:

- Necrosis
- Hemorrhage
- Edema
- Heterogenous contrast enhancement

Early glioblastoma

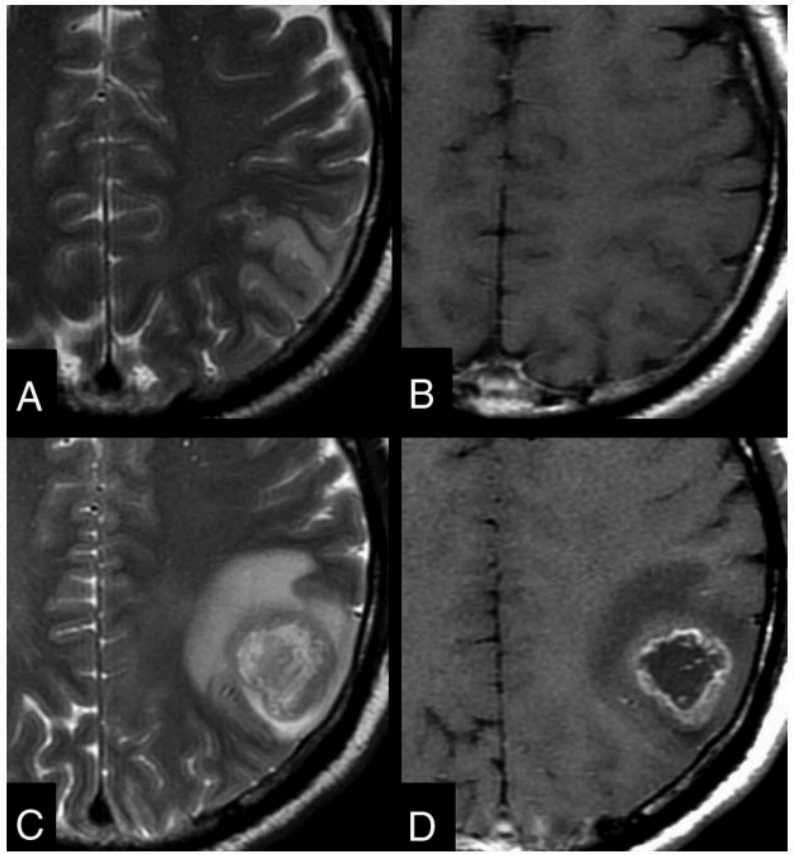


FIG 1. A 57-year-old man with a type I lesion. Axial images show a left parietal cortical lesion, which is hyperintense on the T2-weighted image (*A*) and without enhancement on the contrast-enhanced T1-weighted image (*B*). T2-weighted (*C*) and contrast-enhanced T1-weighted (*D*) images obtained 7 months later show a left parietal glioblastoma.

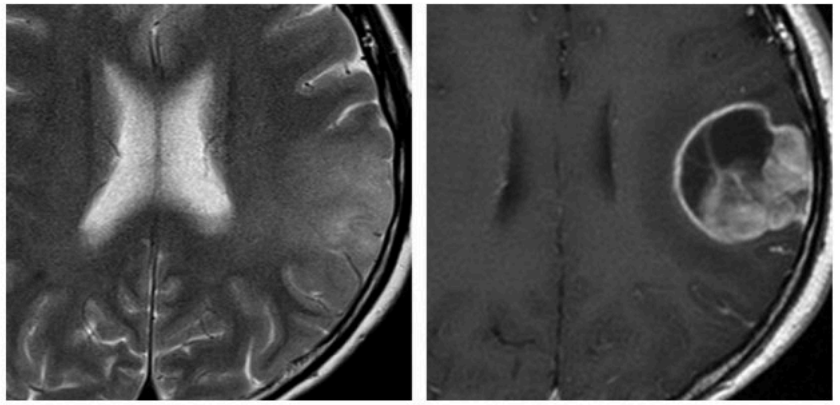


FIG 2. Axial images in a 32-year-old woman with a type II lesion. Left, T2-weighted image shows hyperintensity involving the left parietal cortex and subcortical WM. Right, contrast-enhanced T1-weighted image obtained 4 months later shows a left parietal glioblastoma.

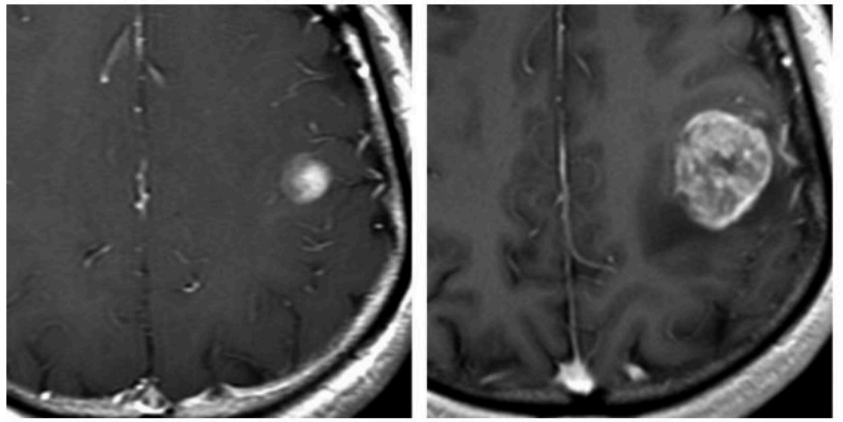
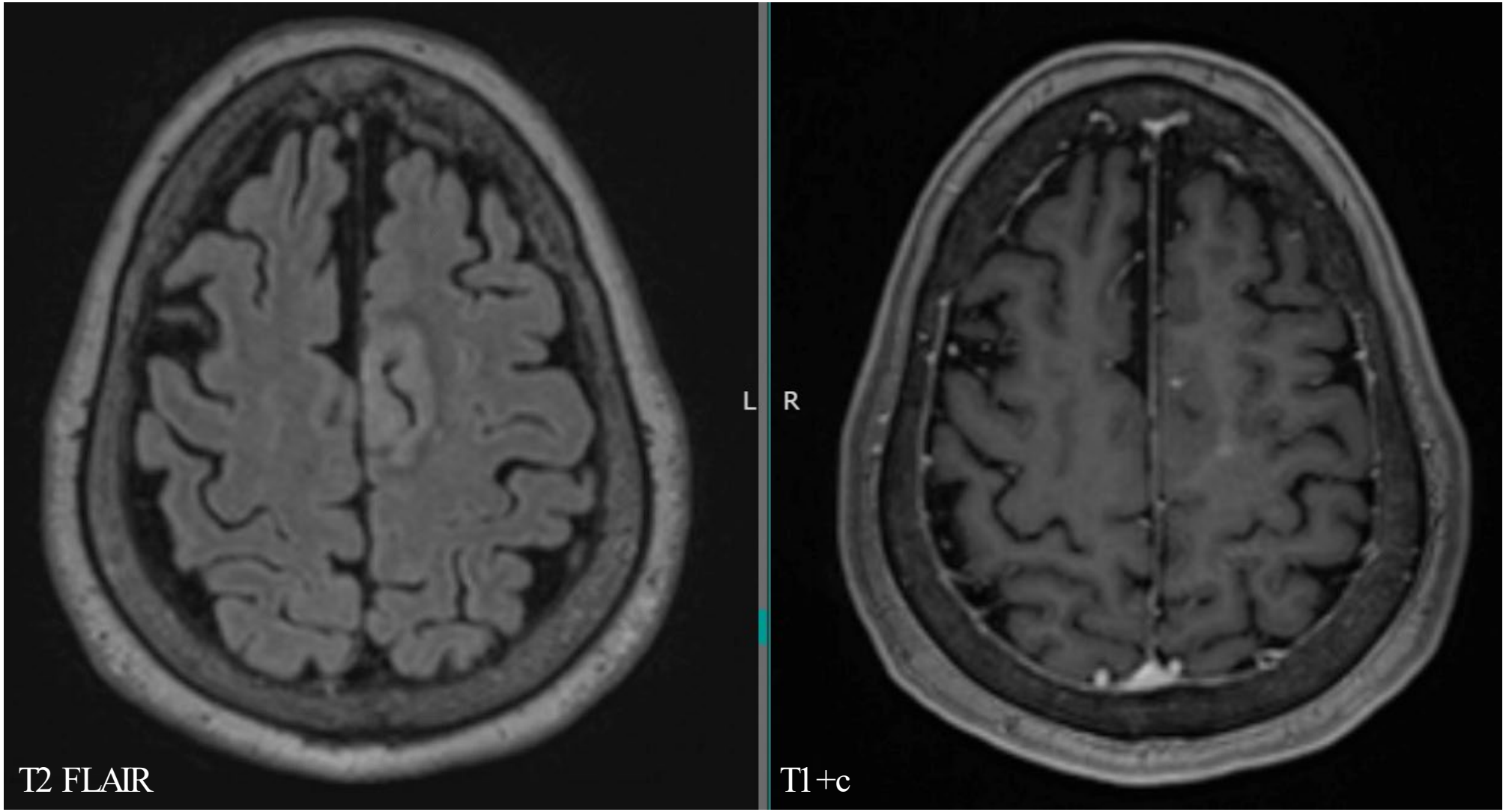


FIG 3. Contrast-enhanced T1-weigthed axial images in a 35-year-old woman with a type III lesion. Left, a cortical/subcortical contrast-enhancing lesion is present in the left frontal region. Right, the lesion transformed to a left frontal glioblastoma after 1 month.

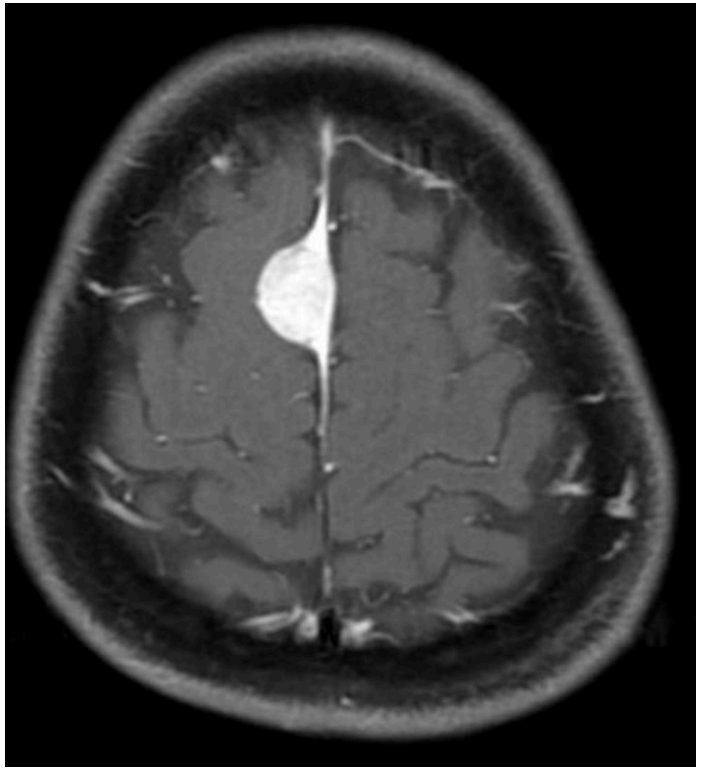
Toh CH and M Castillo. Early-Stage Glioblastomas: MR Imaging-Based Classification and Imaging Evidence of Progressive Growth. AJNR Am J Neuroradiol 2017;38:288-93

Early glioblastoma

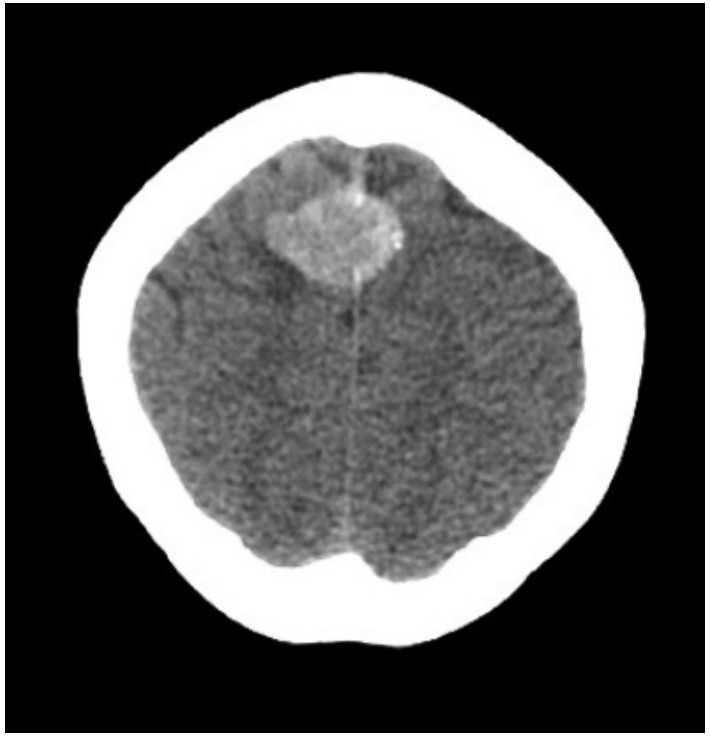


Meningiomas

- Intense homogenous enhancement with dural tail
- Can have calcifications on CT



T1+c



CT brain

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Spinal cord tumors

- Ependymoma
- Astrocytoma
- Hemangioblastoma

Spinal cord tumors

Ependymoma: circumscribed on T1 contrast and T2

- Spinal ependymoma: intramedullary
- Myxopapillary ependymoma: lumbosacral, extramedullary
- MYCN-amplified: cervicothoracic, extramedullary

Astrocytoma

Hemangioblastoma

Spinal Ependymoma

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Myxopapillary Ependymoma

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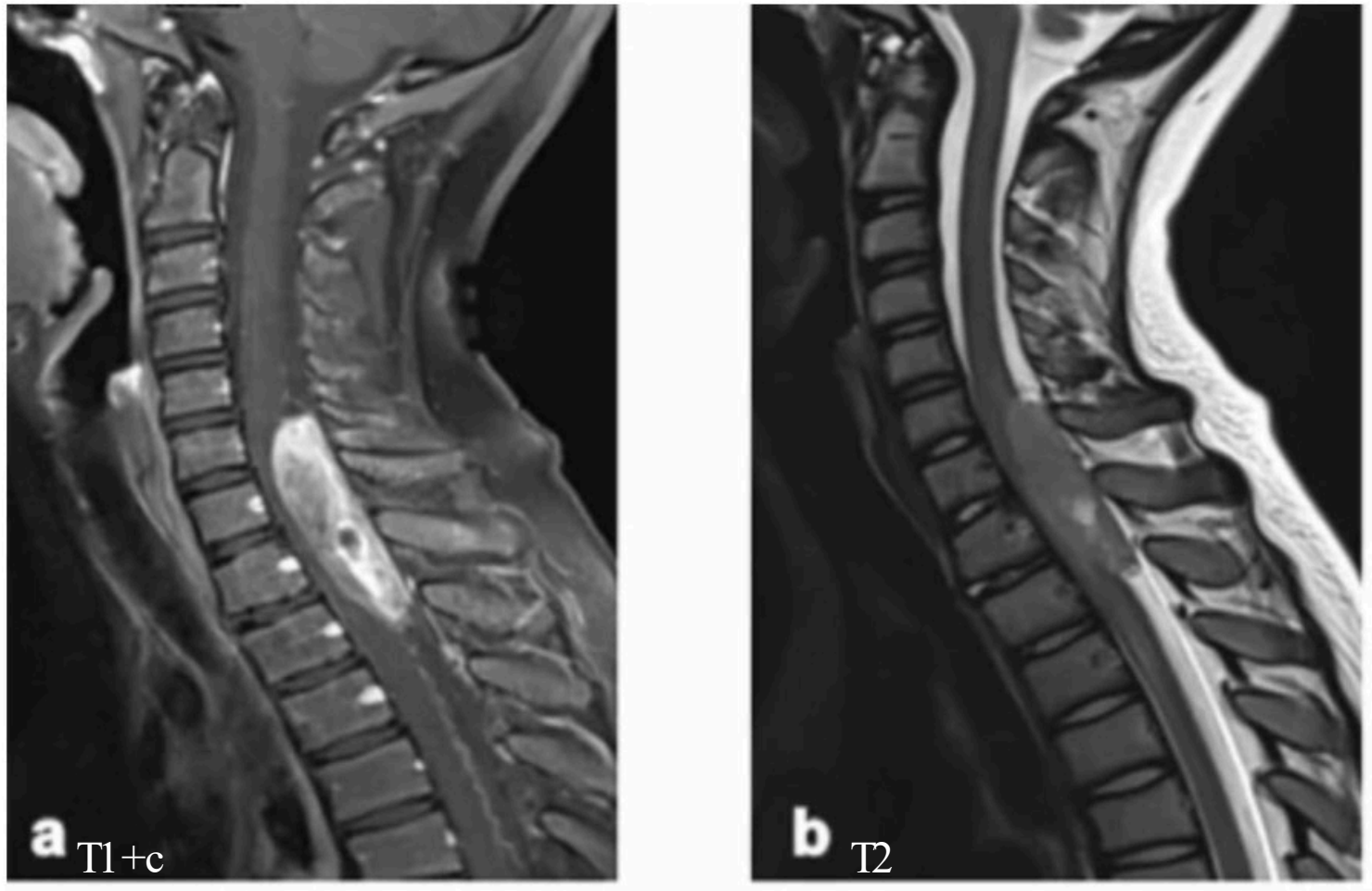
MYCN-amplified Ependymoma



*Shatara, M., Schieffer, K.M., Klawinski, D. et al. Clinically aggressive pediatric spinal ependymoma with novel MYC amplification demonstrates molecular and histopathologic similarity to newly described MYCN-amplified spinal ependymomas. acta neuropathol commun **9**, 192 (2021).*

Spinal cord tumors

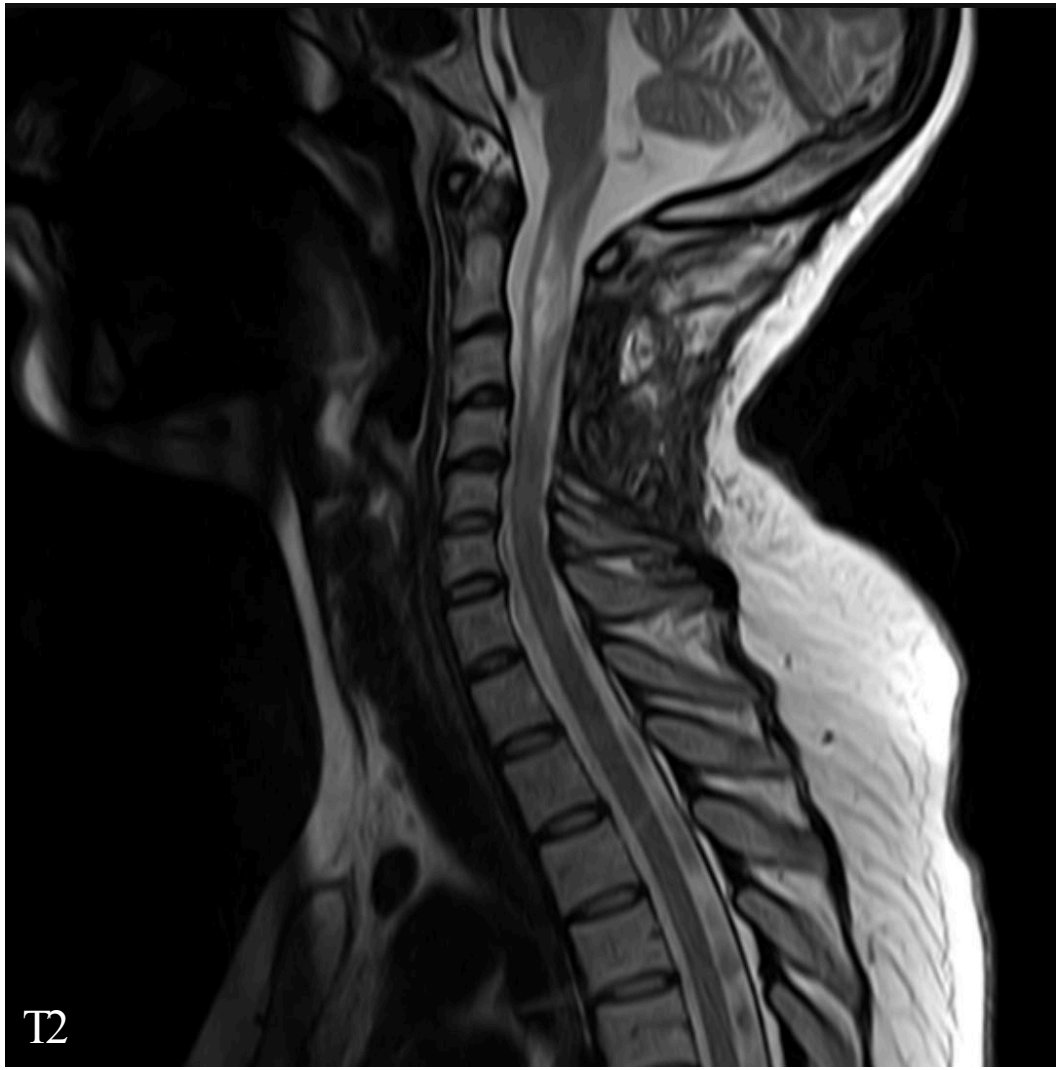
Ependymoma

Astrocytoma: infiltrative on T1 contrast and T2

- +/- enhancement, depending on grade
- Mild-moderate surrounding edema

Hemangioblastoma

Spinal astrocytoma



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Spinal cord tumors

Ependymoma

Astrocytoma

Hemangioblastoma: circumscribed on T1 contrast and infiltrative on T2

- Enhancing nodule
- Significant surrounding edema
- Syrinx

Hemangioblastoma

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Spinal cord tumors: how to tell them apart with only 2 MRI sequences

Ependymoma

- Circumscribed on T1 contrast
- Circumscribed on T2

Astrocytoma

- Infiltrative on T1 contrast
- Infiltrative on T2

Hemangioblastoma

- Circumscribed on T1 contrast
- Infiltrative on T2

Primary CNS Lymphoma

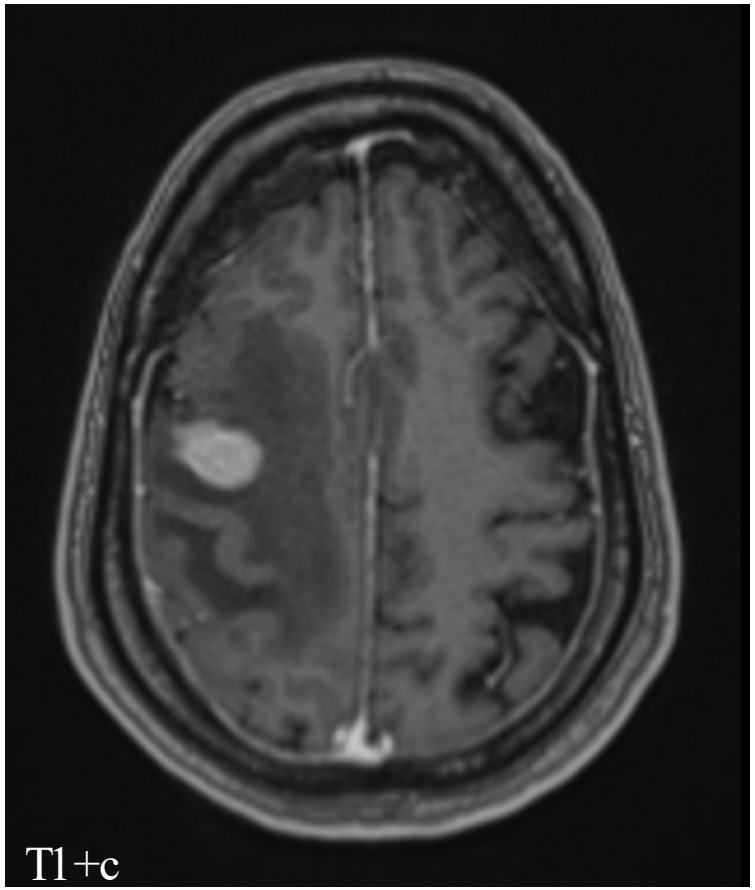
Immunocompetent

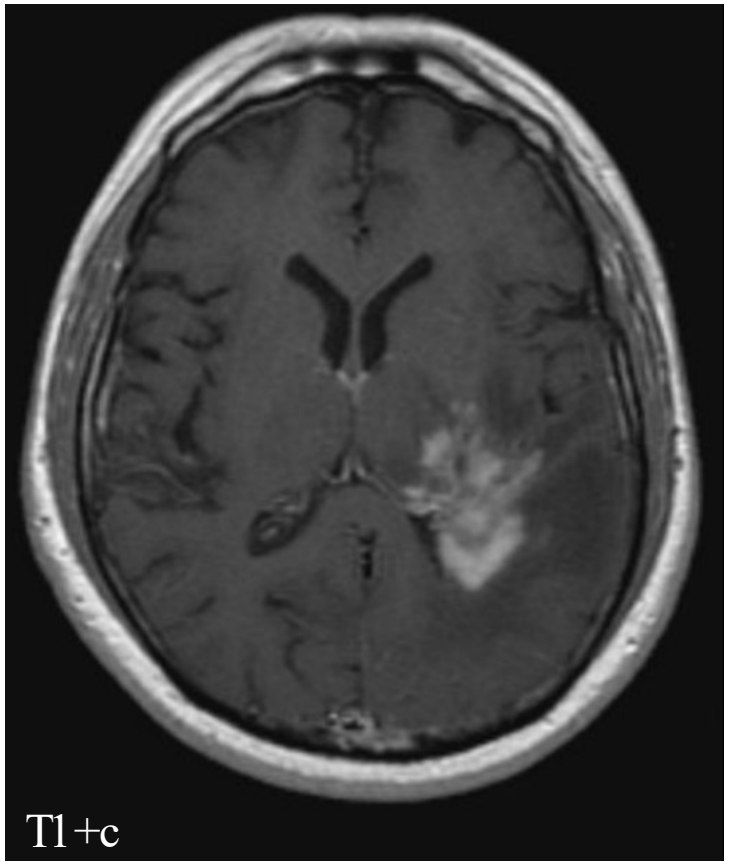
- Homogenous enhancement
- Restricted diffusion
- More commonly single lesion

Immunocompromised

- Ring enhancement
- More commonly multifocal

Primary CNS lymphoma - immunocompetent





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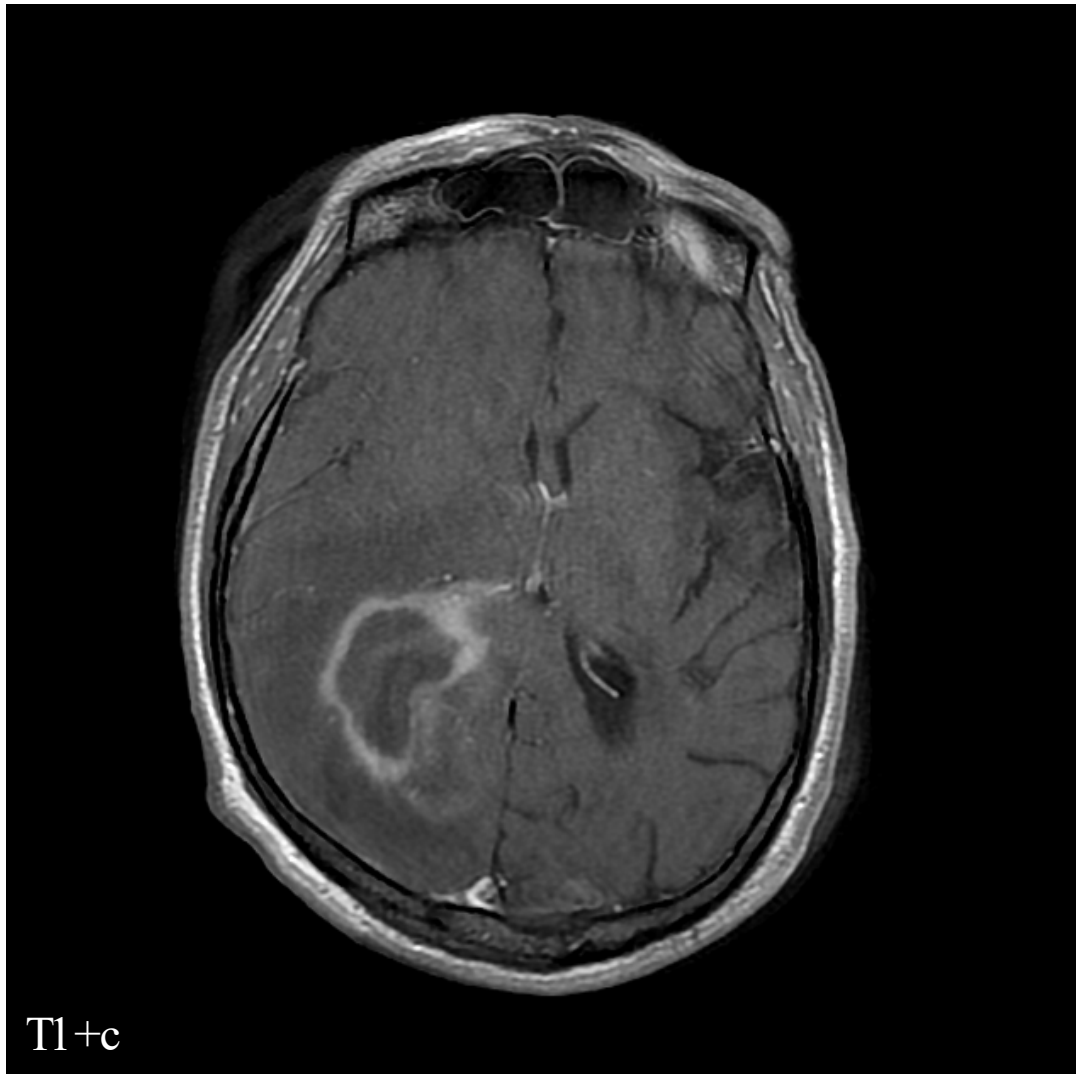
Primary CNS lymphoma - immunocompromised



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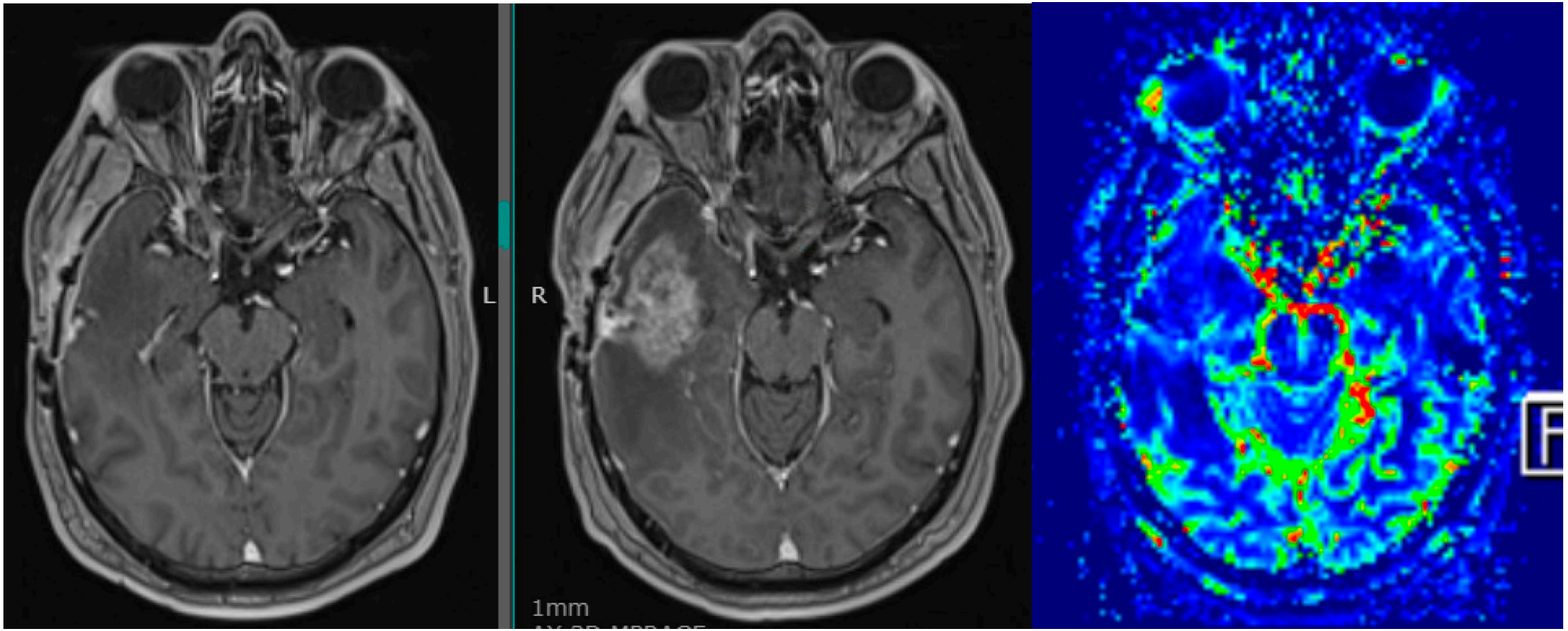
Non-neoplastic Mimics

Case 1

A51 y/o man with a glioblastoma, IDH-wildtype, MGMT-unmethylated presents to the ED with somnolence and left sided weakness. He completed chemoradiation 4 months ago and is undergoing adjuvant chemotherapy with temozolomide.

Imaging shows the following:

Imaging



3 months post-chemoradiation

4 months post-chemoradiation

Case 1

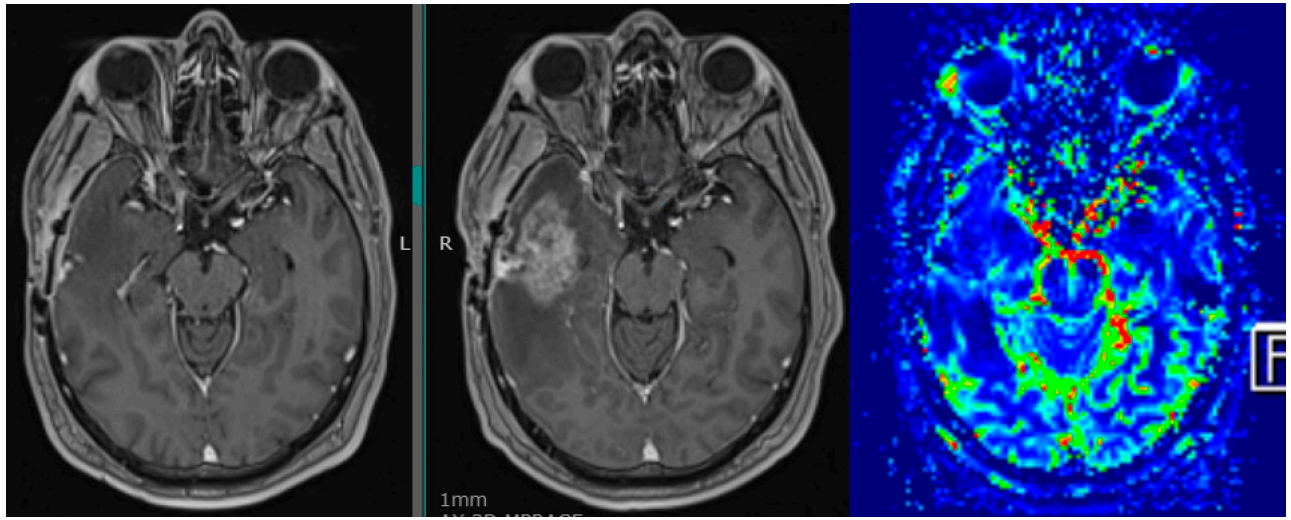
A51 y/o man with a glioblastoma, IDH-wildtype, MGMT-unmethylated presents to the ED with increasing fatigue and left sided weakness, 4/5. He completed chemoradiation 4 months ago and is undergoing adjuvant chemotherapy with temozolomide.

What is the next best course of action?

- Admit the patient for emergent resection of progressive glioblastoma
- Prescribe high-dose dexamethasone for symptomatic radiation necrosis and edema

Radiation necrosis – "pseudoprogression"

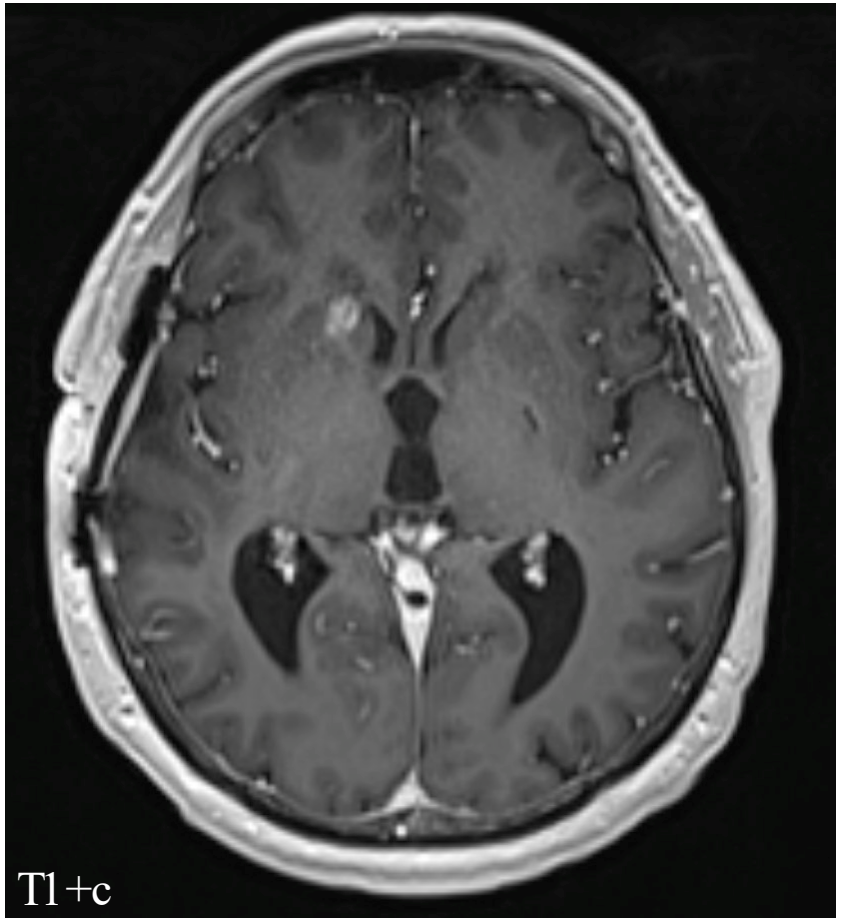
- "Bubbly" vs nodular enhancement
- Less likely to have elevated cerebral blood volume
- More common in MGMT-methylated tumors, but can also occur in MGMT-unmethylated

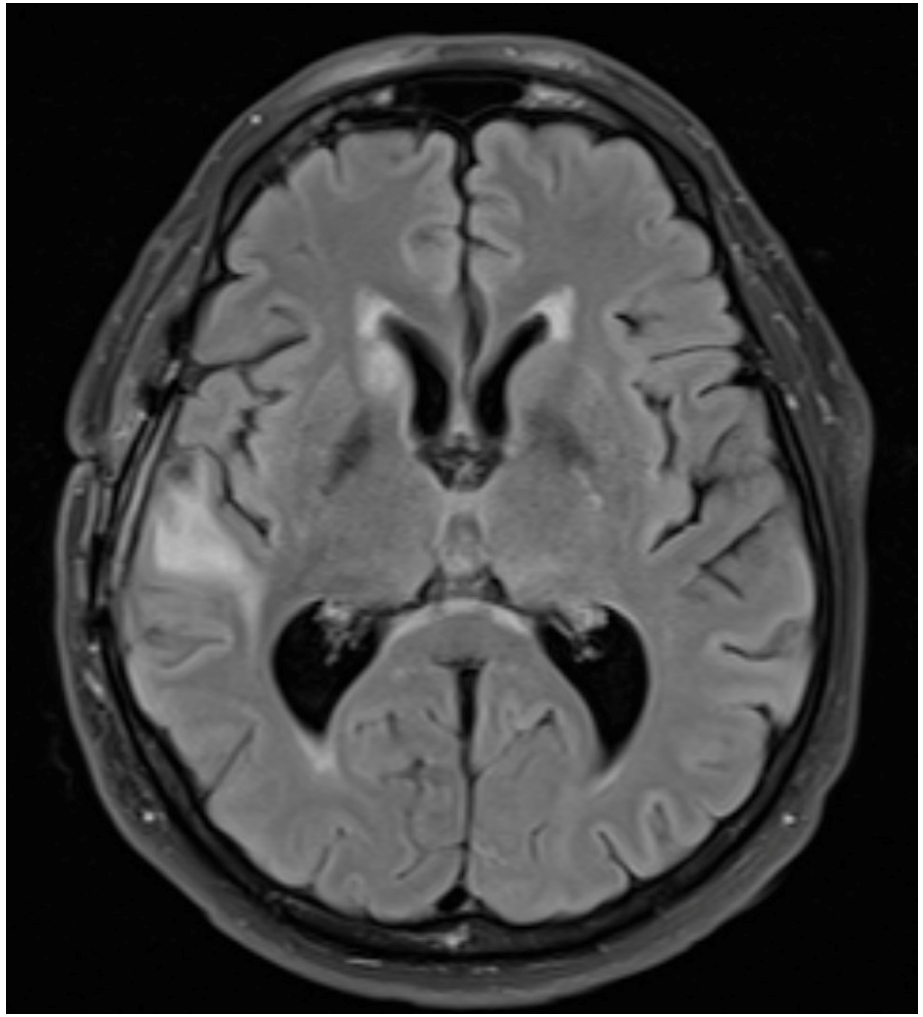


Case 2

A62 yo man presents to clinic after a routine surveillance MRI brain for his right temporal glioblastoma. He has no new symptoms. His imaging shows the following:

Imaging





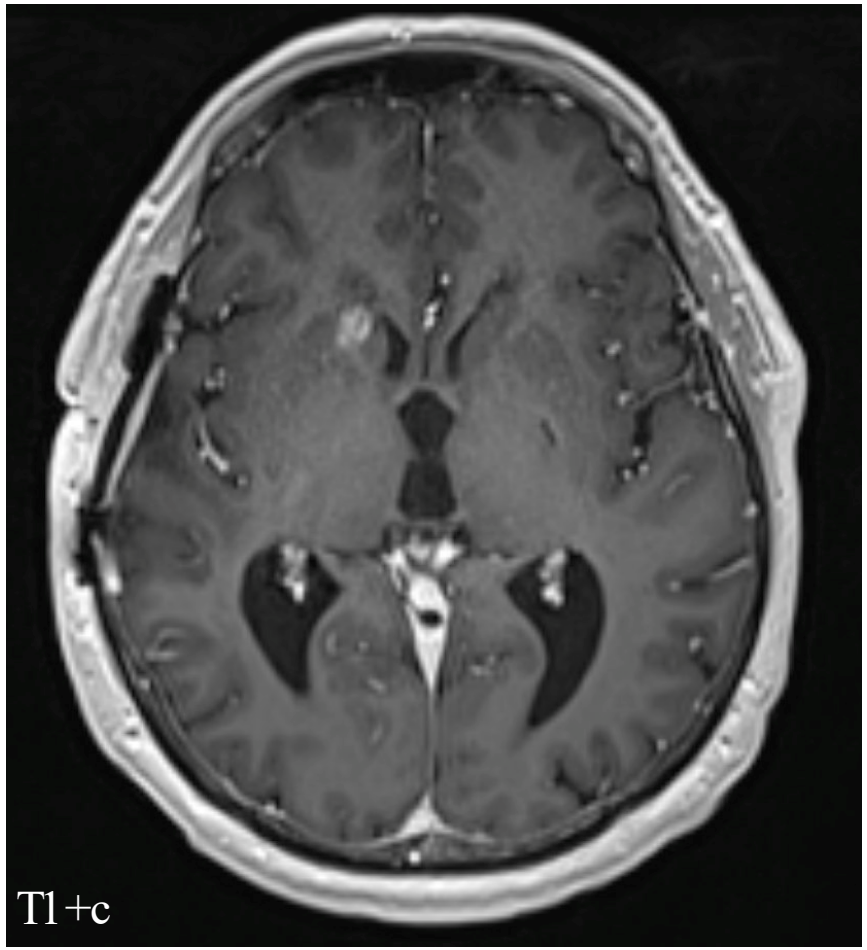
Case 2

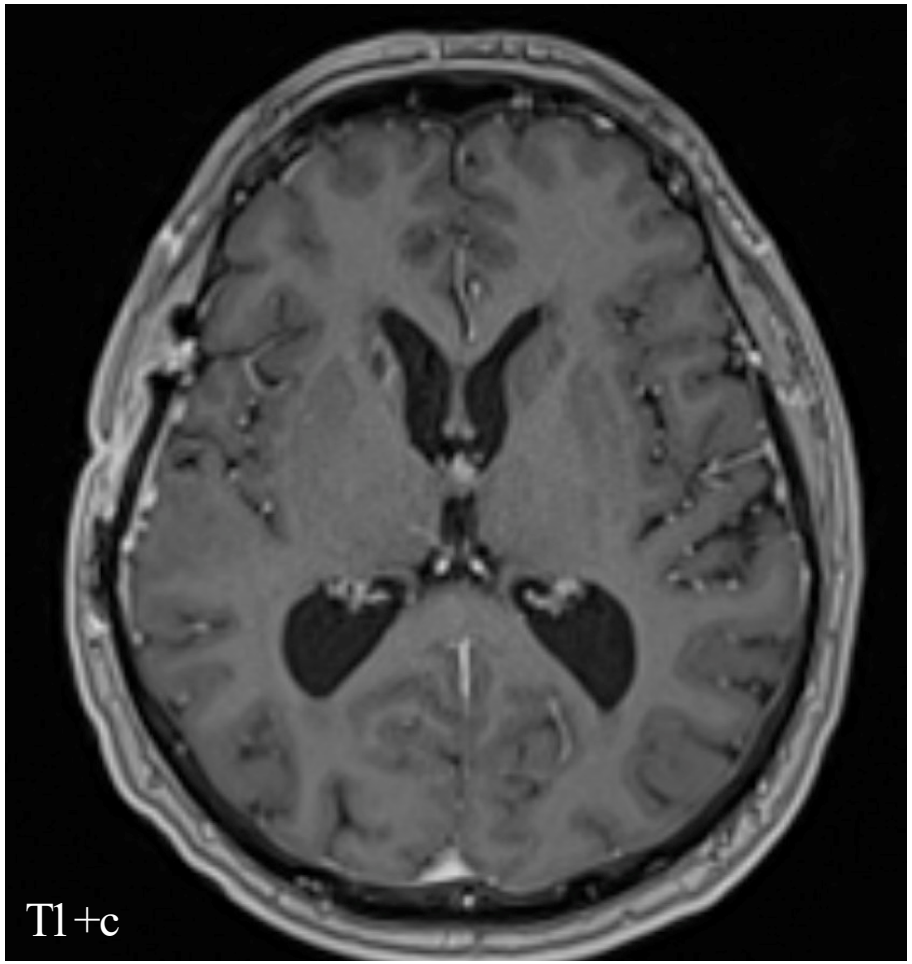
A62 yo man presents to clinic after a routine surveillance MRI brain for his right temporal glioblastoma. He has no new symptoms. His imaging shows the following:

What is the next best step?

- Tell the patient he has recurrent glioblastoma and needs repeat surgical resection
- Order a short-interval surveillance MRI in 4 weeks

Subacute infarction



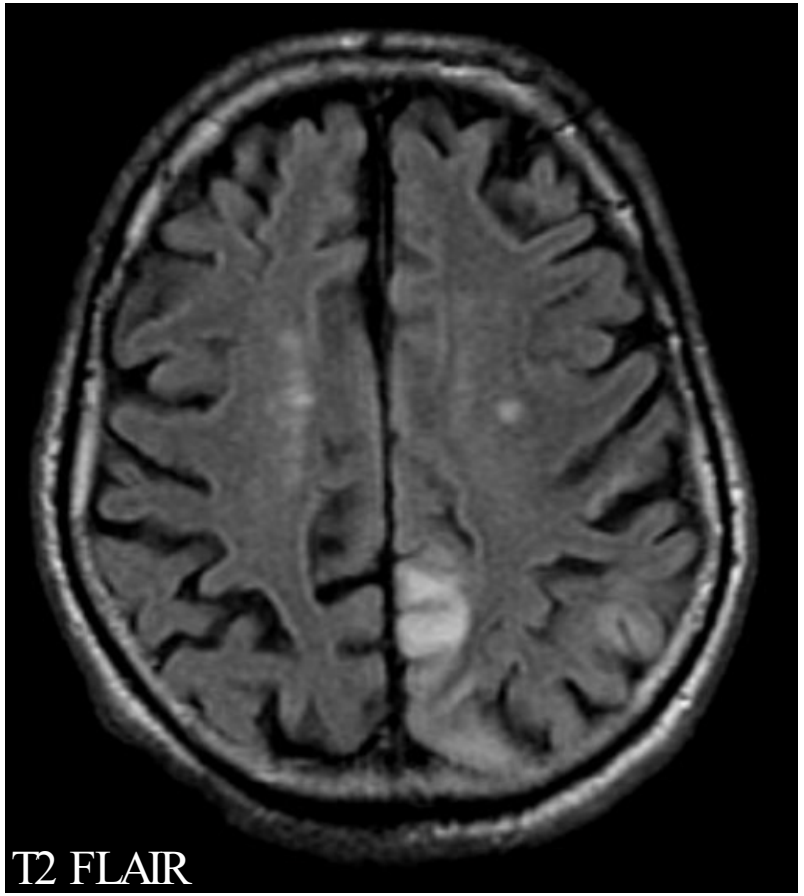


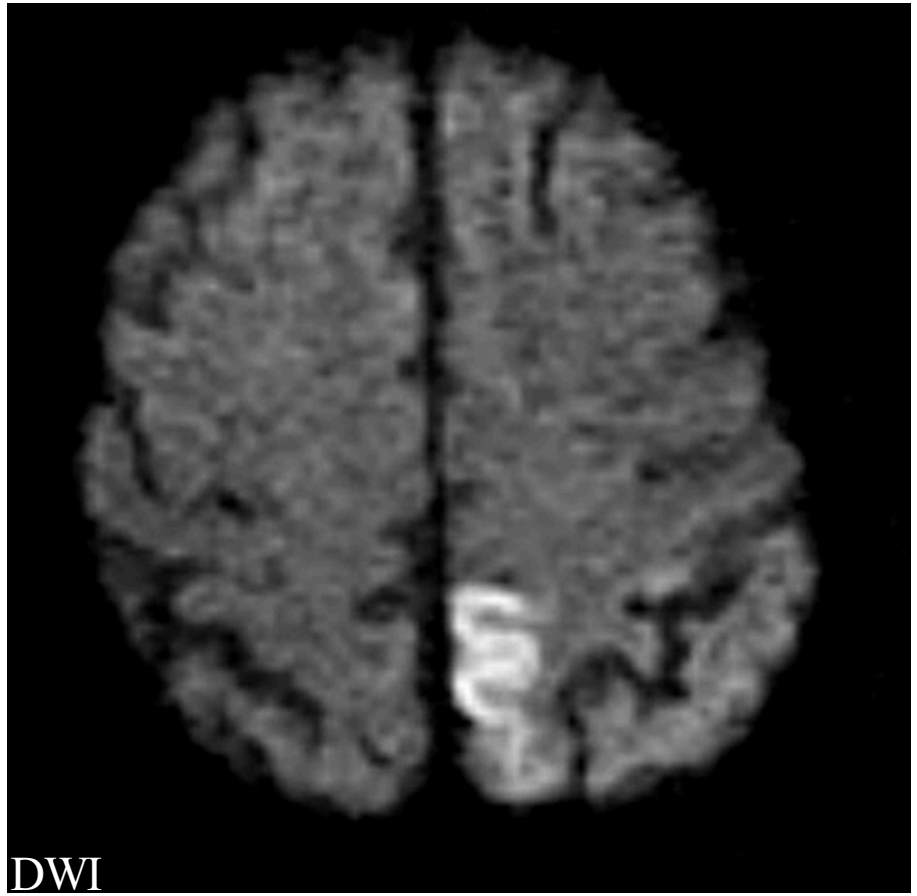
4 weeks later

Case 3

A70 yo woman presents to the ED with a seizure. She requires diazepam for prolonged seizure abortion. Imaging for seizure etiology workup shows the following:

Case 3





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Case 3

A 70 yo woman presents to the ED with a seizure. She requires diazepam for prolonged seizure abortion. Imaging for seizure etiology workup shows the following:

What is the next best step?

- Consult neurosurgery for resection of low-grade glioma
- Treat seizures medically; consider re-imaging in 3-6 months

The End

Non-neoplastic Mimics

- Pseudoprogression
- Enhancing infarct
- Seizure-related changes
- Tumefactive demyelination – incomplete rim enhancement
- Toxoplasmosis vs immunocompromised PCNSL
- Checkpoint inhibitor neurotoxicity vs LGG
- PTLD vs mets
- Abscess
- Dural mets vs meningioma