Reporting Guidelines for Intracranial Patterns of Failure Following Post-Resection Stereotactic Radiosurgery for Brain Metastases

Brandon Turner, Stuart Burri, Roshan Prabhu, Scott Soltys

Stanford MEDICINE | Radiation Oncology

Introduction

- Stereotactic Radiosurgery (SRS) is the standard of care following surgical resection of a brain metastasis, with improved local control compared to gross total resection alone[1] and improved neurocognition compared to whole brain RT[2].

- With post-resection SRS, a dominant pattern of failure is with leptomeningeal disease (LMD)[3].

- However, the reported LMD risk varies widely (from 5%[2] to over 28%[1,3]), possibly due to a lack of reporting standardization in patterns of failure.

1. Mahajan Lancet Oncology July 4, 2017
2. Brown Lancet Oncology July 4, 2017
3. Atalar IJROBP 87, 2013

Introduction

- SRS to the surgical cavity is associated with a unique pattern of intracranial failure, herein termed nodular leptomeningeal disease (nLMD), which is under-recognized, not yet reported, and distinct from classical LMD.

- We hypothesize that a formal training module defining the patterns of intracranial failure following post-resection SRS will improve inter-observer reliability and validity in the diagnosis of LMD.

Background

- Historically, progression within the brain following treatment for brain metastases has been characterized into 3 groups:

1. Local Failure (LF - at the site of the initial brain metastasis)
2. Distant Failure (DF - elsewhere in the brain, distant from the initial site)
3. Leptomeningeal Disease (LMD)

Background

- However, with post-resection cavity SRS, a new pattern of failure has emerged: nodular leptomeningeal disease

1. Local Failure (LF - at the site of the initial brain metastasis)
2. Distant Failure (DF - elsewhere in the brain, distant from the initial site)
3. Classical Leptomeningeal Disease (cLMD)
4. Nodular Leptomeningeal Disease (nLMD)

Radiographic Classification of Patterns of Failure

- **Classical Leptomeningeal Disease (cLMD)[1]:**
  - New clear, thin, linear leptomeningeal enhancement in the brain (in the sulci of the cerebral hemispheres, the subependyma, the cranial nerves, or folia of the cerebellum), spinal cord, or cauda equina.
  - This is the classical 'sugar coating' of enhancement.

- **Nodular Leptomeningeal Disease (nLMD):**
  - New focal nodular enhancement on the dural, pial or meningeal surface.
  - This can appear similar to distant intra-parenchymal failure (DF), but this recurrence is indicative of CSF spread, rather than hematogenous spread.
  - nLMD is distinguished from hematogenously spread, intra-parenchymal distant failure by its location. A new brain metastasis that does not abut the pial surface is scored as a distant failure (DF) rather than nodular LMD.
  - nLMD on the meninges often has a hypervascular dural tail, similar to meningiomas

1. Freilich, DeAngelis, Ann Neuro 38, 1995

Radiographic Classification of Patterns of Failure

- **Local Failure (LF)**:
  - New nodular enhancement within the resection cavity.
  - LF is an in-field failure, within the isodose line representing 80% of the prescribed SRS dose.

- **Distant Failure (DF):**
  - New nodular enhancement within the brain.
  - Parenchymal distant failure can occur near the pial surface and may be difficult to discern from nLMD. The investigator will use their clinical judgement to best determine if the mode is spread is more likely through the CSF (for nLMD) or hematogenous (for DF).

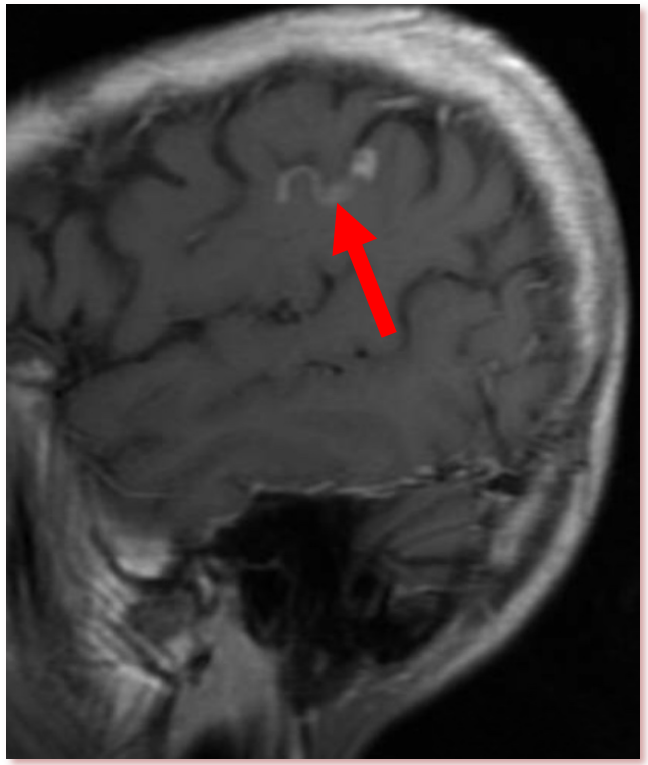
Radiographic Classification of Patterns of Failure

- Note: This guideline does not attempt to discriminate between LF and the common occurrence of post-treatment adverse radiation effect (ARE) or radiation necrosis

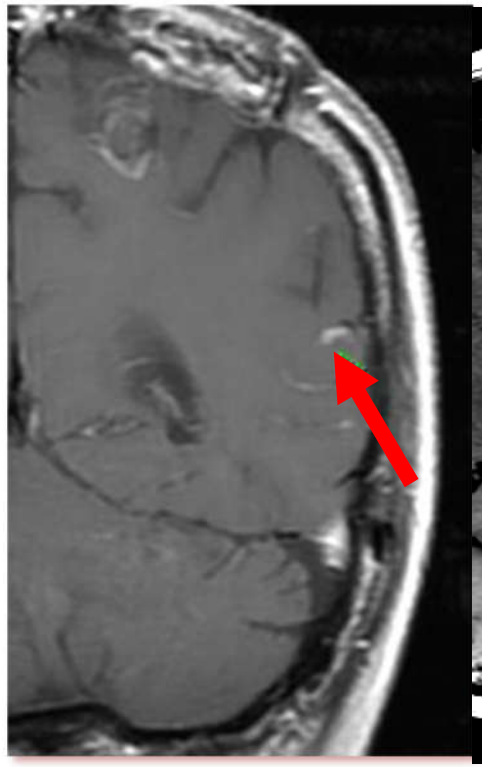
Classical LMD (cLMD)

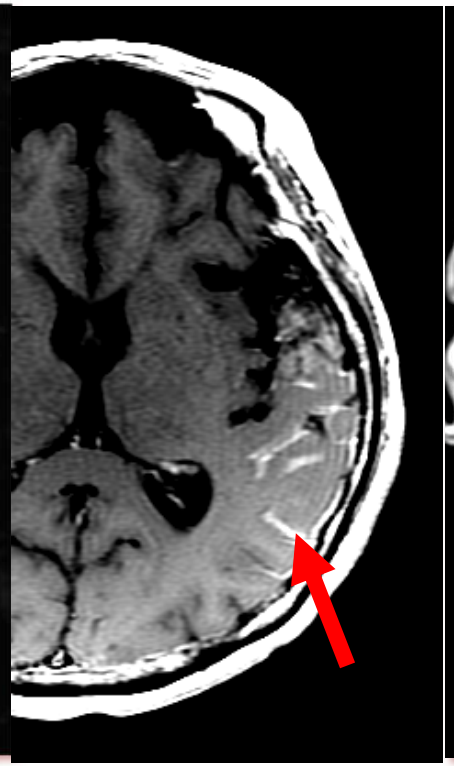
- Thin, linear leptomeningeal enhancement of the sulci, folia, cranial nerves, spinal cord, cauda

Sulcal Enhancement

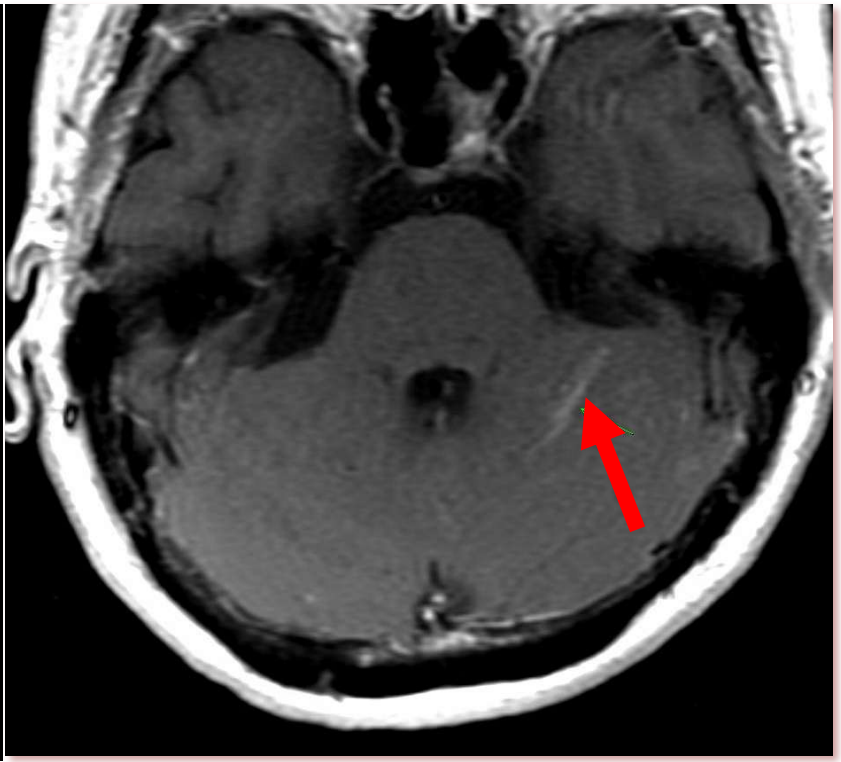


Sulcal Enhancement



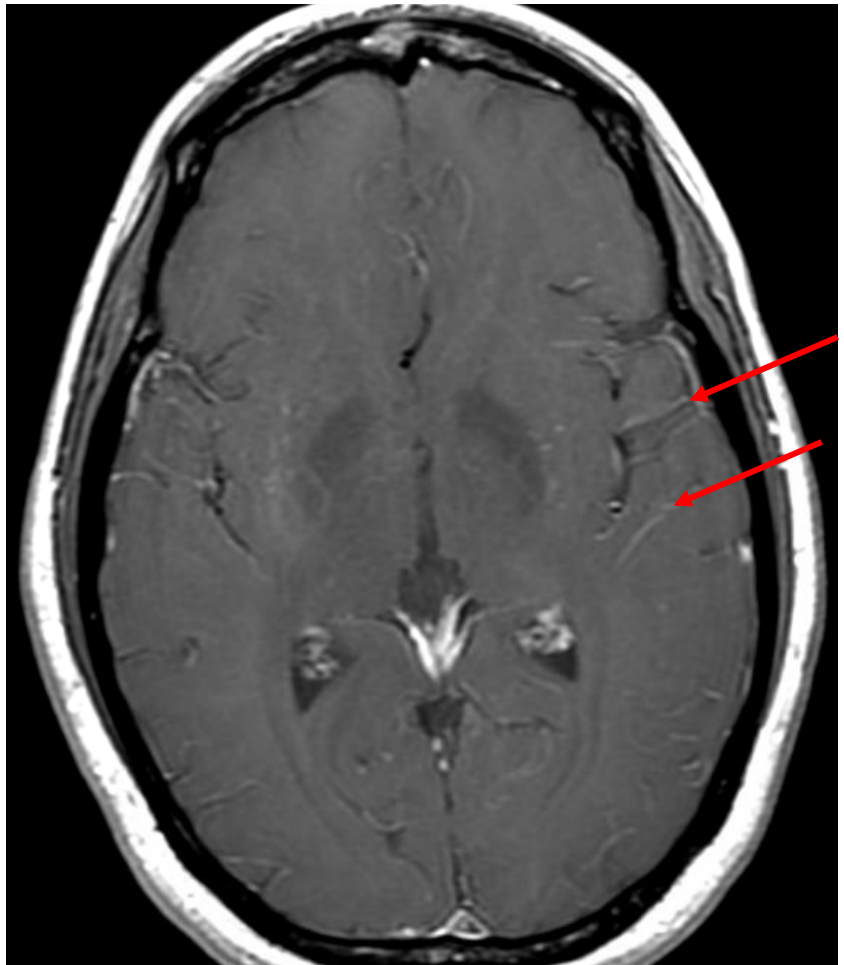


Folia Enhancement



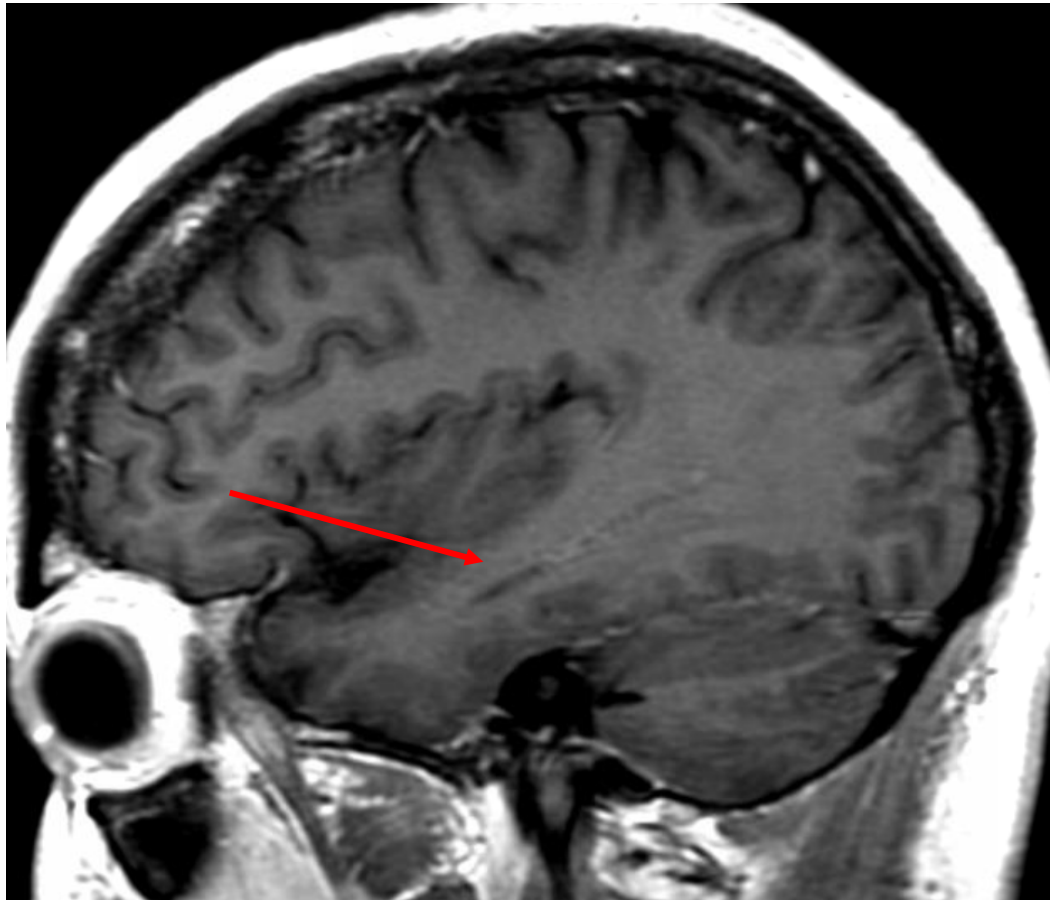
Vascularity can be mistaken for cLMD

- Vascularity can appear linear as well, but is typically absent when looking across multiple series.

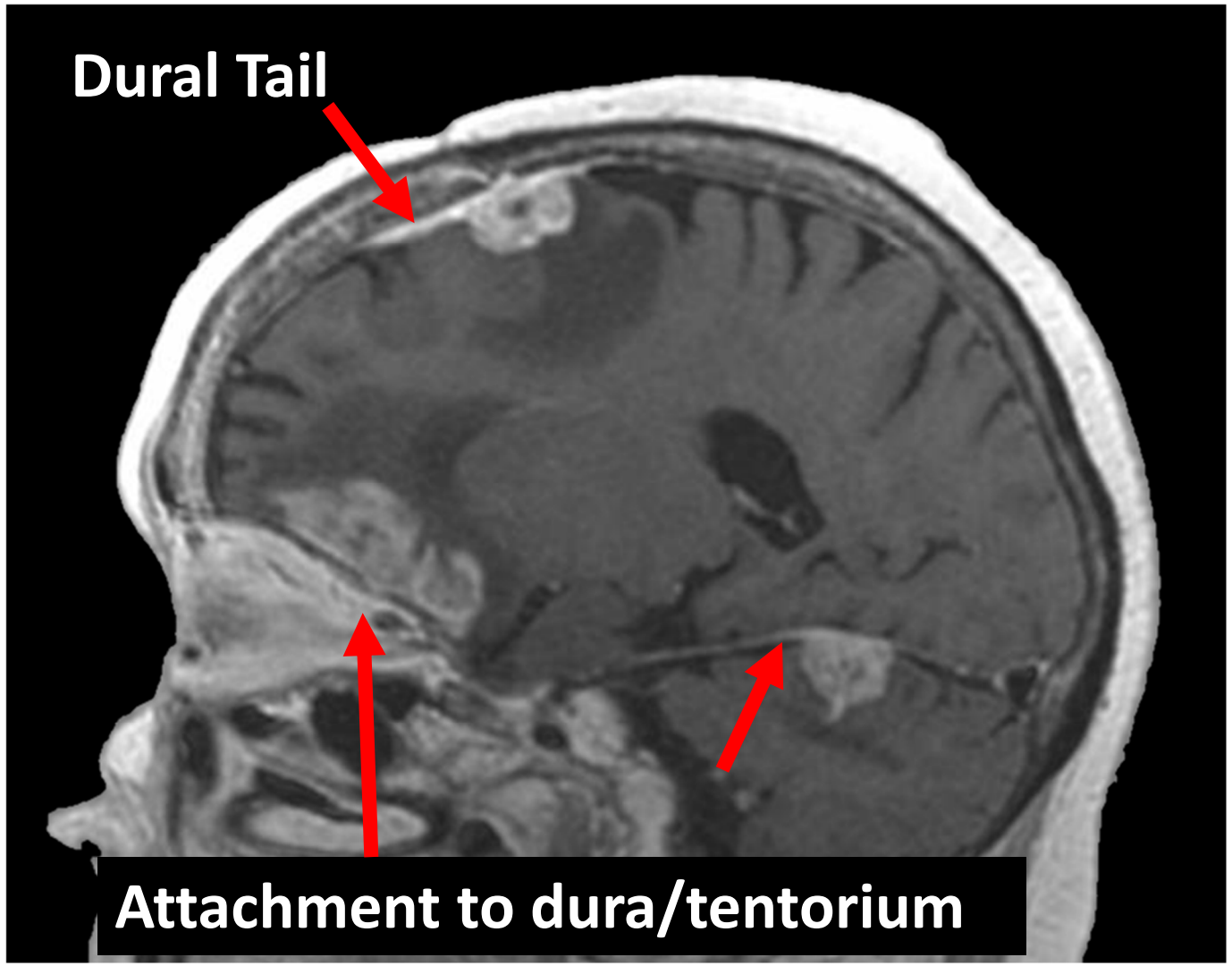


Apparent linear enhancement

Not present in other views

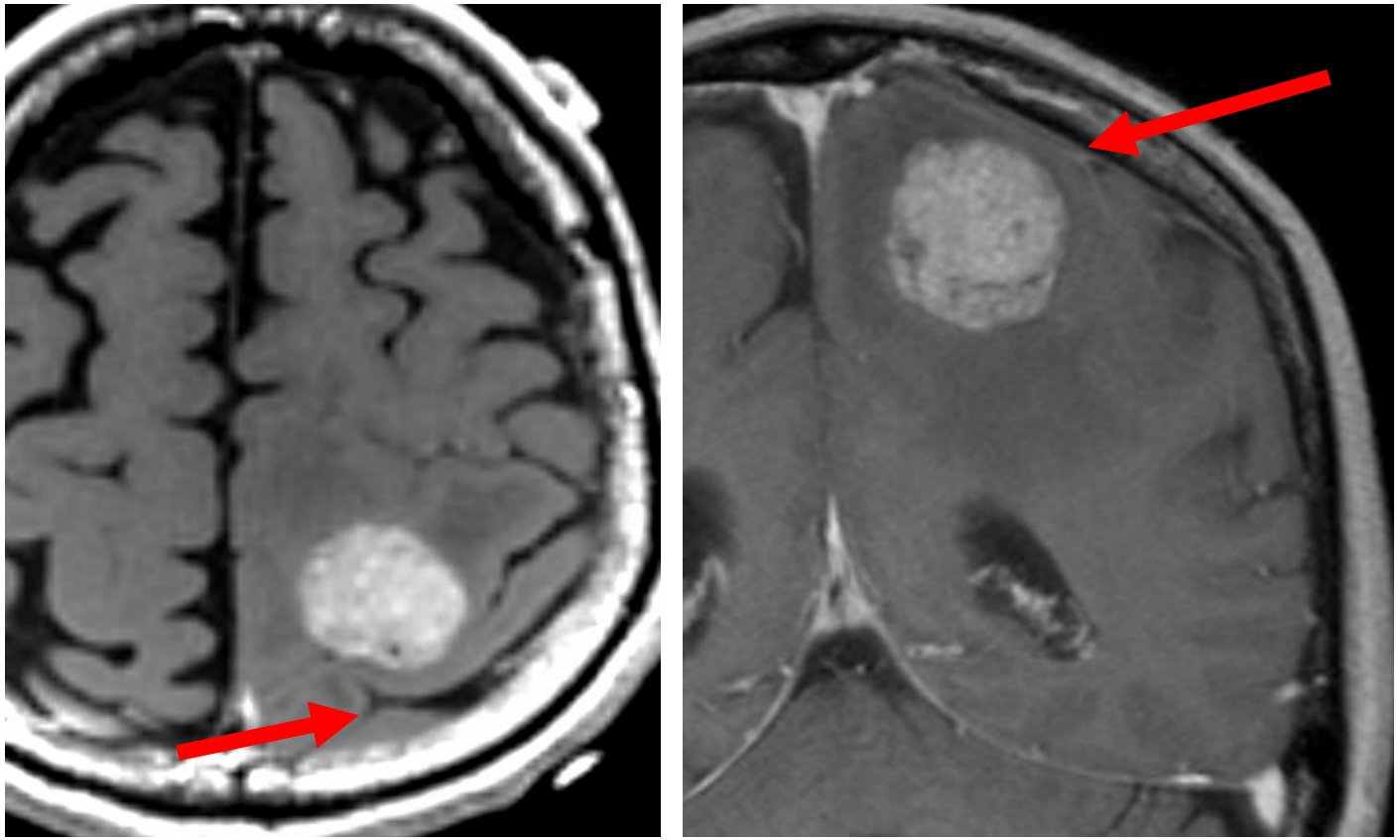


Nodular LMD (nLMD)



- New focal nodular enhancement on the dural, pial or meningeal surface.
- This looks similar to distant intra-parenchymal failure (DF), but this recurrence is indicative of CSF spread, rather than hematogenous spread.
- nLMD is distinguished from hematogenously spread, intra-parenchymal distant failure by its location. A new brain metastasis that does not abut the pial surface is scored as a distant failure (DF) rather than nodular LMD.
- nLMD on the meninges often has a hypervascular dural tail, similar to meningiomas.

Distant Failure (DF)

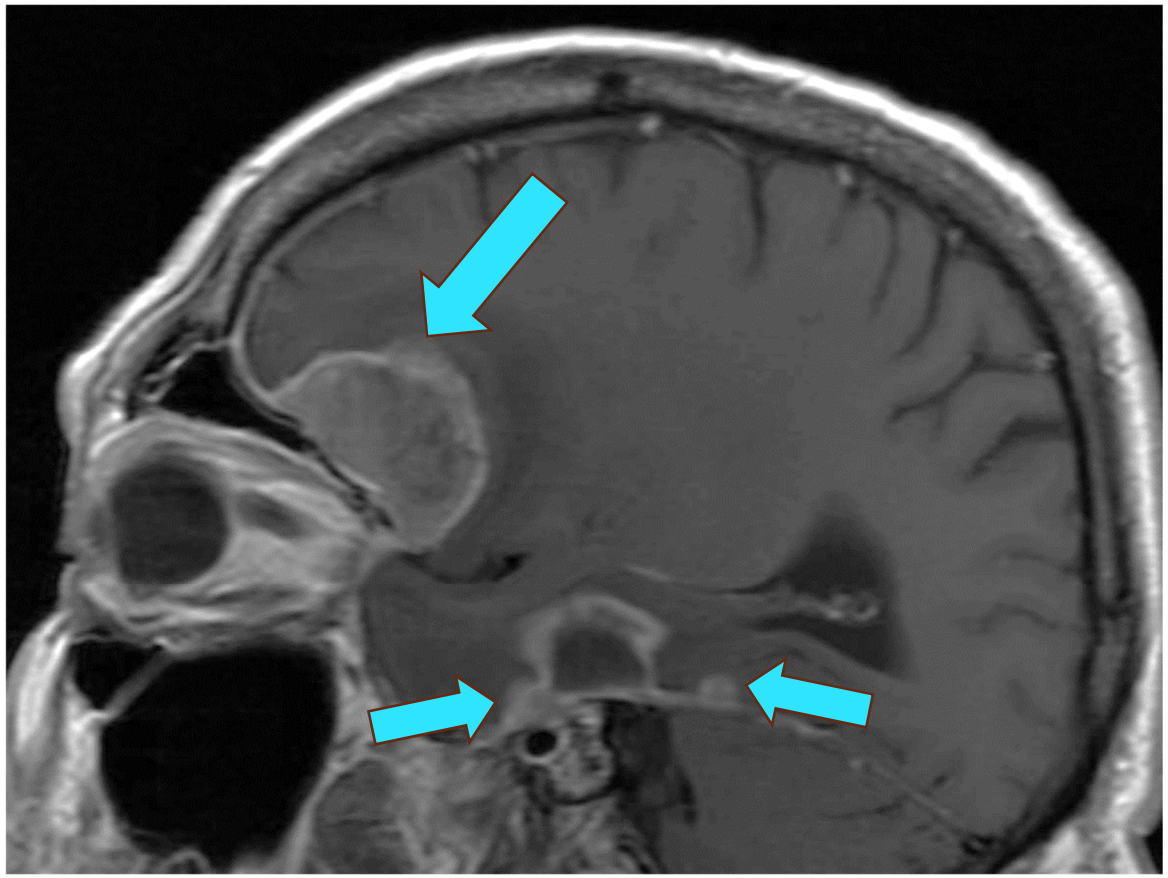


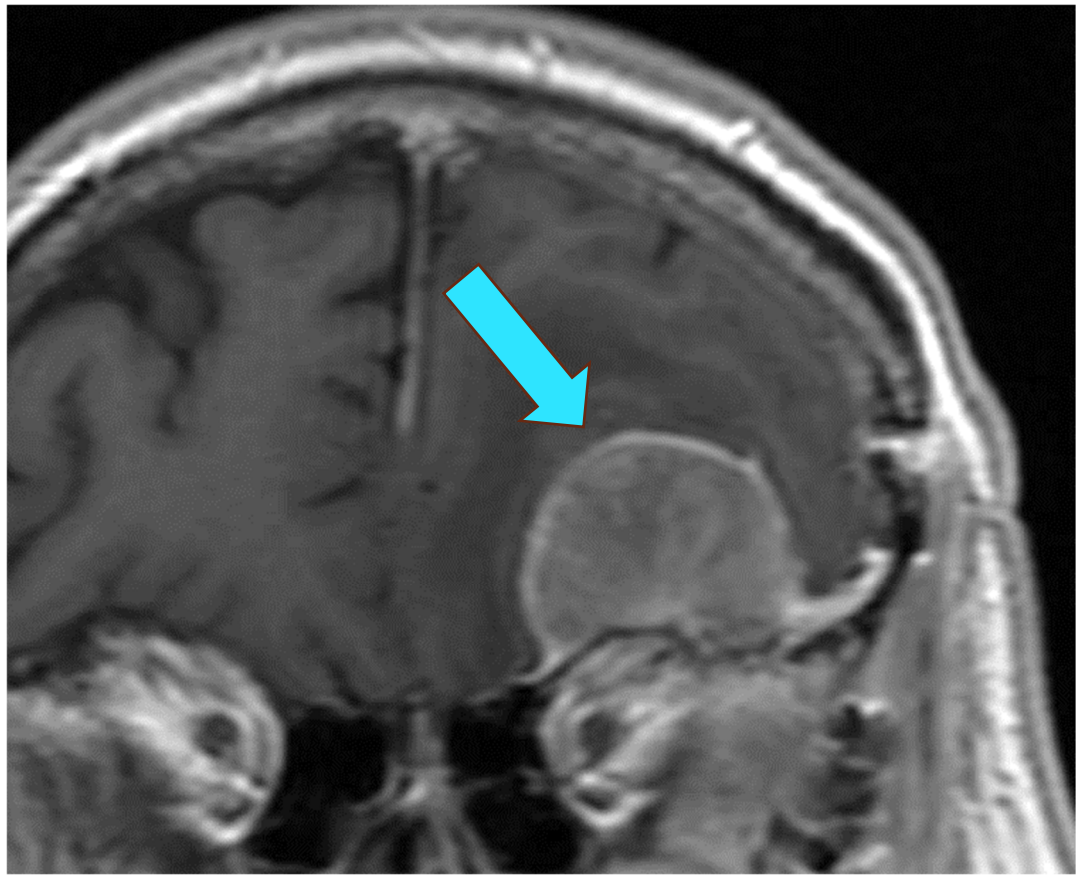
Deep to the pial surface

- New nodular enhancement within the brain.
- Parenchymal distant failure can occur near the pial surface and may be difficult to discern from nLMD. The investigator will use their clinical judgement to best determine if the mode is spread is more likely through the CSF (for nLMD) or hematogenous (for DF).
- A new brain metastasis that does not abut the pial surface is scored as a distant failure (DF) rather than nodular LMD.

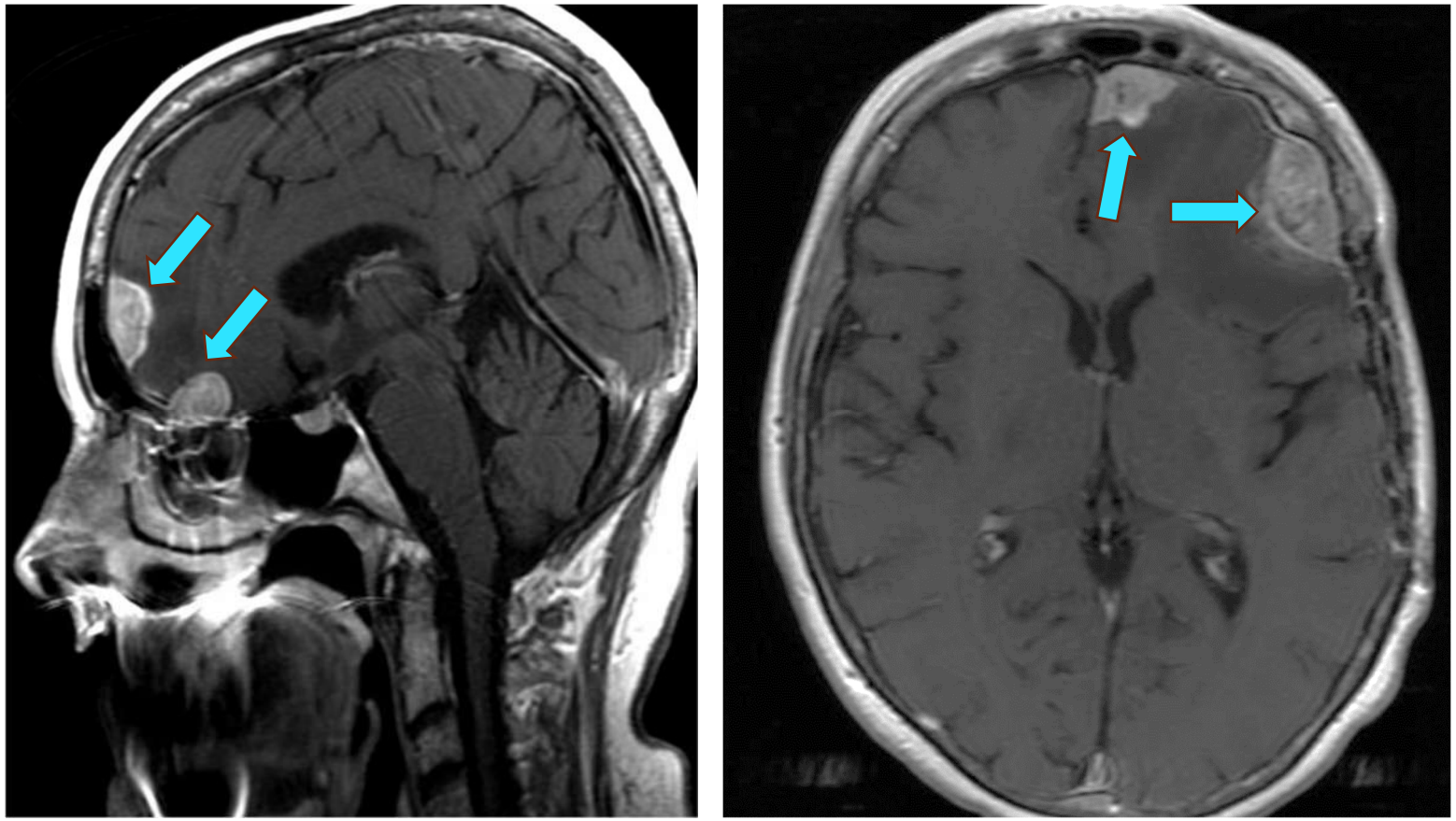
The following images were not provided to raters in the original study. They are included here to provide the reader with additional examples of nodular leptomeningeal disease (nLMD)

Patient 1: Nodular LMD (nLMD)

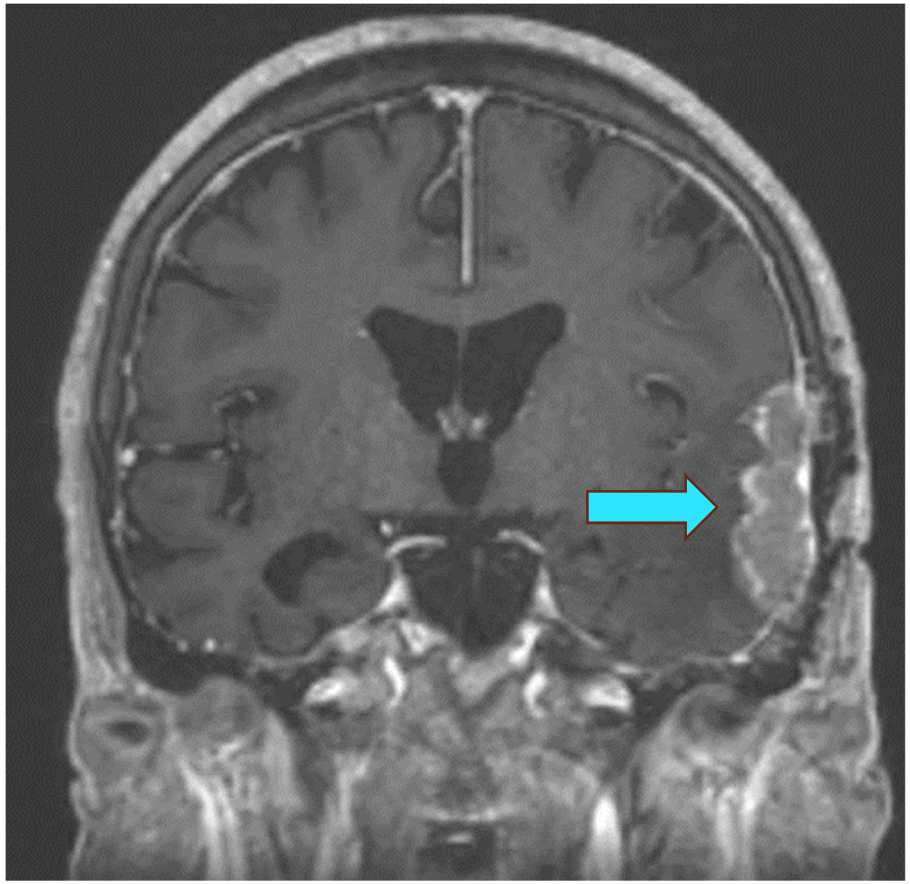


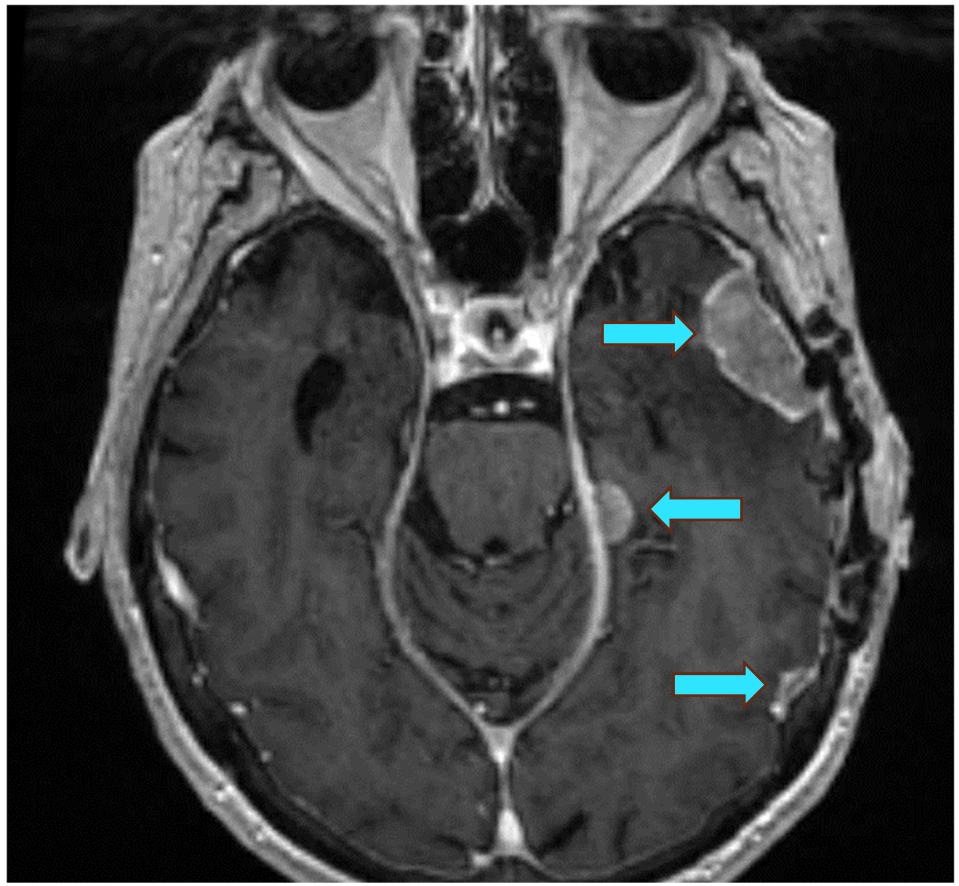


Patient 2: Nodular LMD (nLMD)



Patient 3: Nodular LMD (nLMD)





Patient 4: Nodular LMD (nLMD)