ACNS1721 and ACNS1723 Contouring Atlas

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Radiotherapy Planning Scans

- CT Simulation:
  - Non-contrast treatment-planning CT scan of the entire head region.
  - **1.25-1.5mm slice thickness is preferred**.
  - Immobilize patient in supine position using an immobilization device such as an Aquaplast mask over the head.

- MRI-CT Fusion:
  - Register and fuse the relevant MRI sequences to the treatment-planning CT.
  - Suggested imaging type for delineation of organs at risk and target volumes are detailed in the following slides.

OAR General Principles

- Please adhere to use of standard name terminology detailed in Section 17.9.

- The following imaging is suggested for delineation of organs at risk:
  - Cochlea, lens: CT planning scan (bone window)
  - Brainstem, optic n., chiasm: Isovolumetric imaging (MPRAGE or SPGR) T1 or T2
  - Body: CT planning scan
  - Optic Globes: CT planning scan (brain or head and neck window)

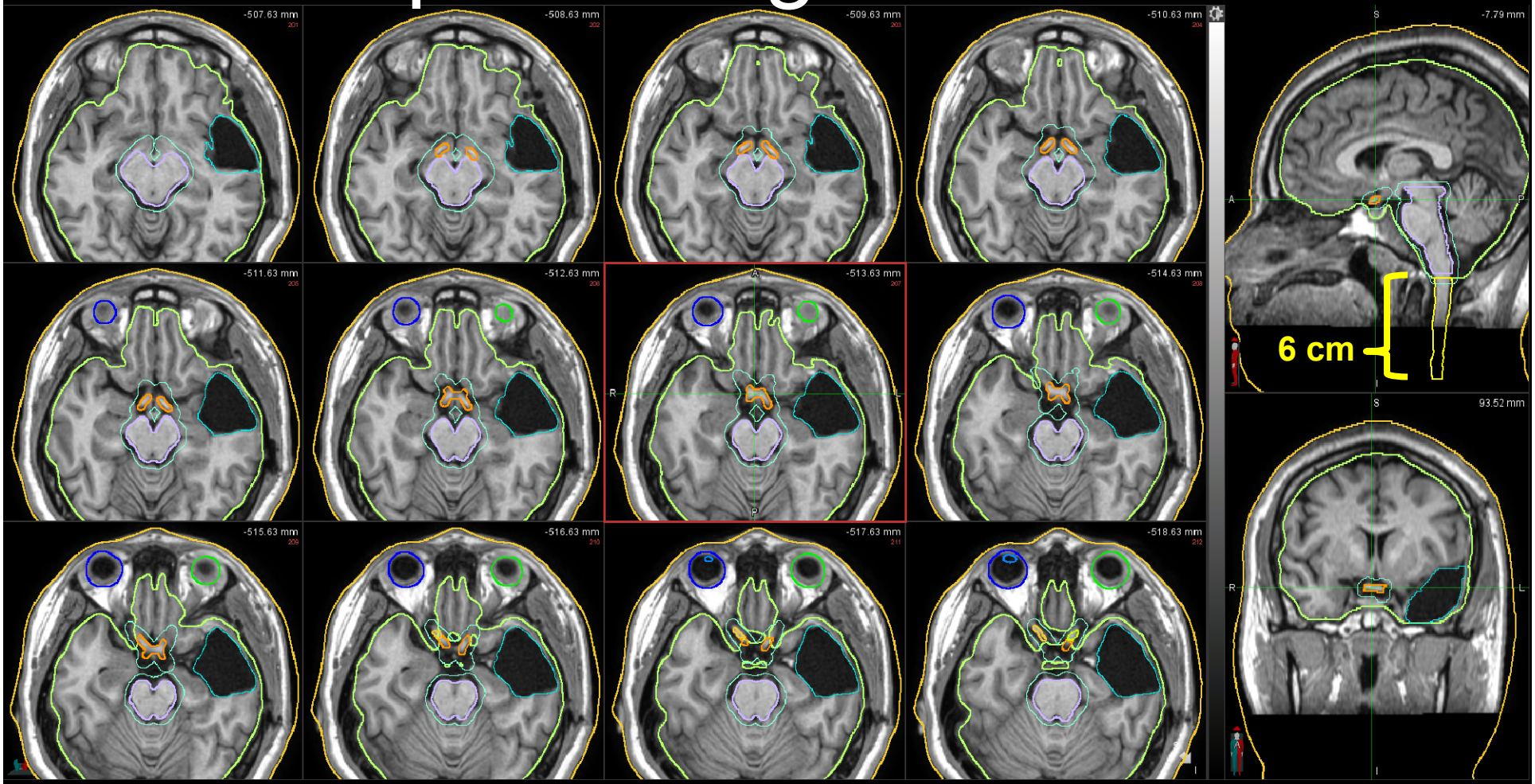
Required Organs at Risk

Description	Standard Name	Goal	Maximum
Right Optic Nerve	OpticNrv_R		D50% < 5400 cGy & D0.1cc < 5600 cGy
Left Optic Nerve	OpticNrv_L		
Optic Chiasm	OpticChiasm		
Optic Nerves & Chiasm PRV			D50% < 5600 cGy & D10% < 5800 cGy – PRV
Brainstem	Brainstem	D50% < 5240 cGy, D10% < 5600 cGy & D0.1cc < 5880 cGy	
Spinal Cord	SpinalCord		D0.1cc < 5400 cGy
Right Cochlea	Cochlea_R	D50% < 3500 cGy (single cochlea) D50% < 2000 cGy – Preferred (single cochlea)	
Left Cochlea	Cochlea_L		
Body	External		
Unspecified Tissue			
Optic Globes		D50% < 1000 cGy & D10% < 3500 cGy	D50% < 2000 cGy & D10% < 5400 cGy

See ACNS1721 Protocol Section 17.8 and 17.9 for structure definitions and further detail regarding constraints.

Figure 1a

Required Organs at Risk



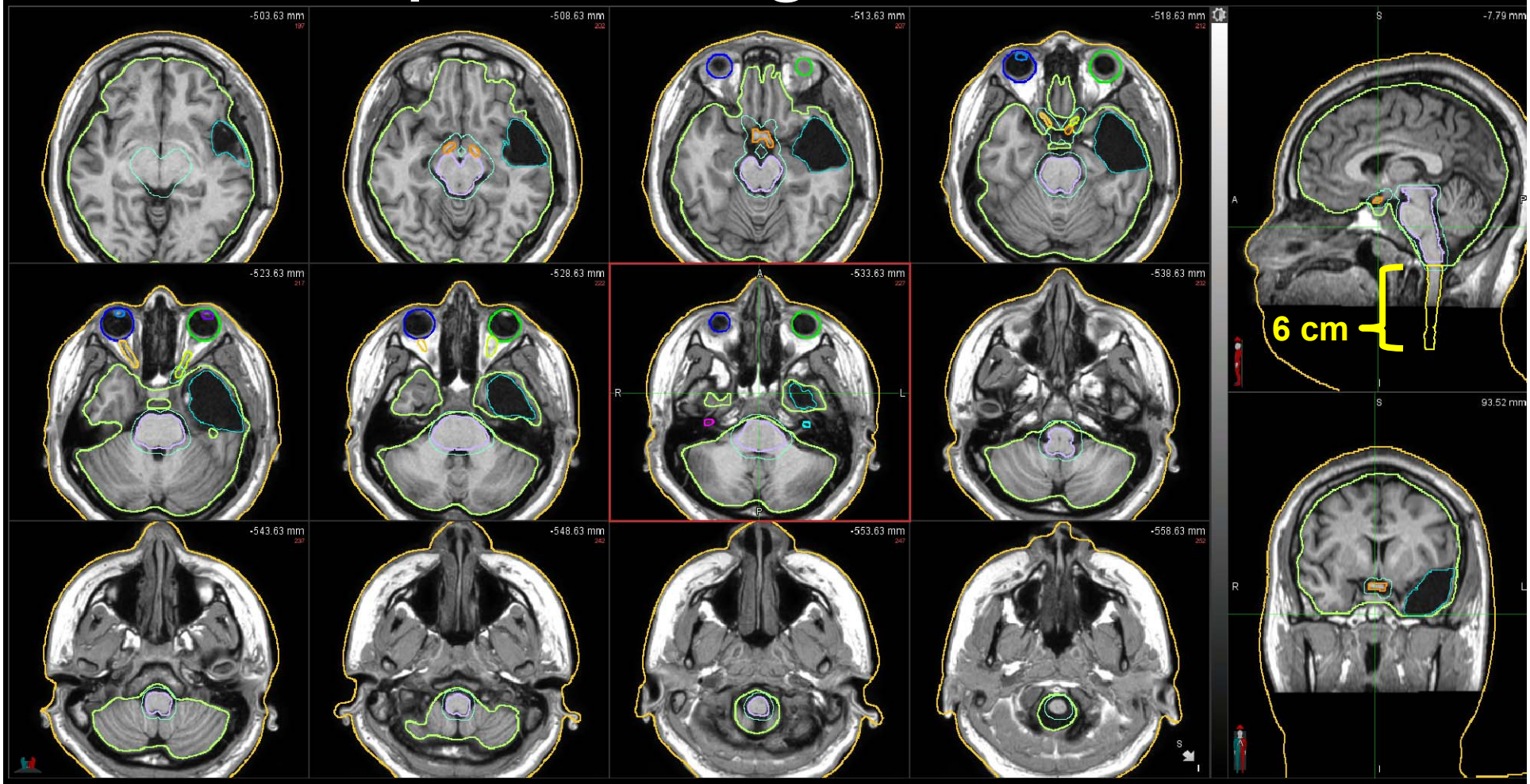
Brain_total
Brainstem
OpticChiasm
Cochlea_L
Cochlea_R

SpinalCord
Optic_Globe_L
Optic_Globe_R
Lens_L
Lens_R

OpticNrv_L
OpticNrv_R
External
Optic_Nerve_Brainstem_PRV

Figure 1b

Required Organs at Risk



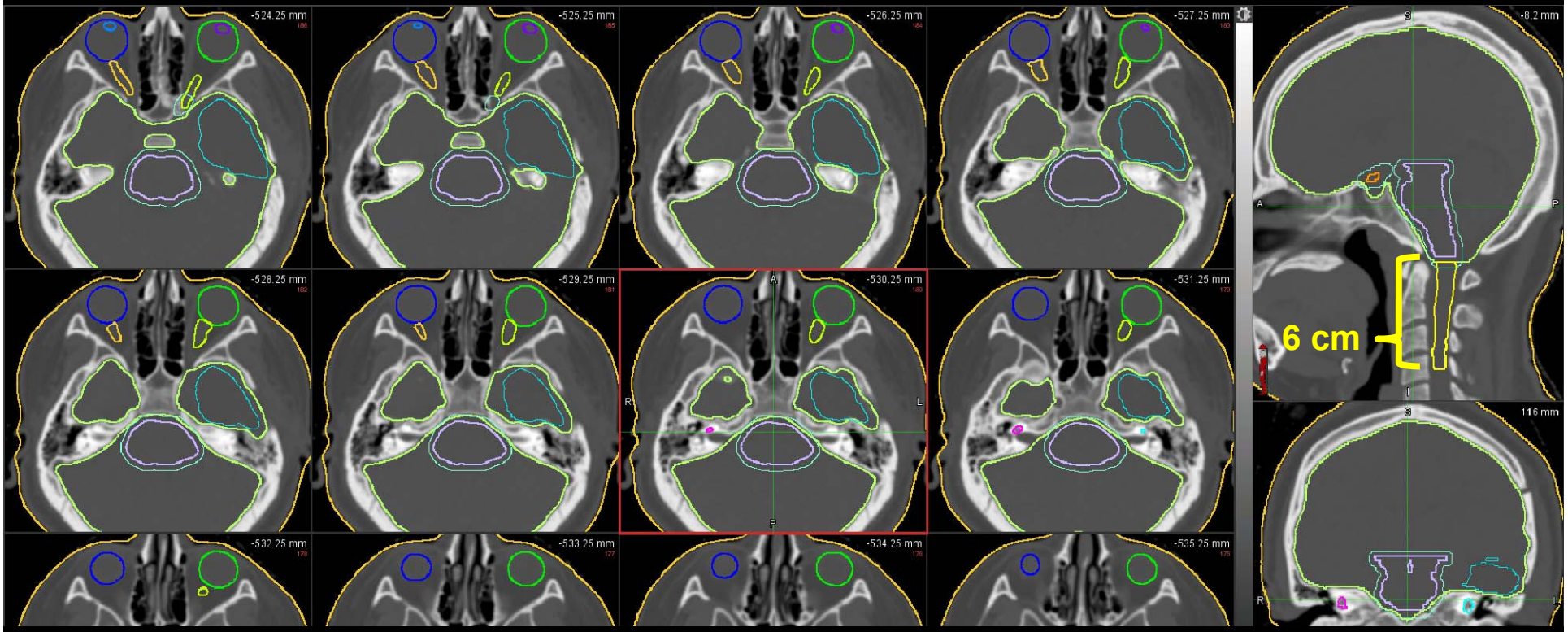
Brain_total
Brainstem
OpticChiasm
Cochlea_L
Cochlea_R

SpinalCord
Optic_Globe_L
Optic_Globe_R
Lens_L
Lens_R

OpticNrv_L
OpticNrv_R
External
Optic_Nerve_Brainstem_PRV

Figure 1c

Required Organs at Risk



Brain_total
Brainstem
OpticChiasm
Cochlea_L
Cochlea_R

SpinalCord
Optic_Globe_L
Optic_Globe_R
Lens_L
Lens_R

OpticNrv_L
OpticNrv_R
External
Optic_Nerve_Brainstem_PRV

Target Prescription Dose Guidelines

- Gross Total Resection: The total dose will be 54.0 Gy if a gross total resection has been performed.

- Incomplete Resection: If the tumor has not been completely resected, the residual disease will be boosted to a total dose of 59.4 Gy.

- Dose to PTV1 and PTV2: All patients receive a total dose of 54.0 Gy to PTV1. Patients with an incomplete resection receive an additional dose of 5.4 Gy to PTV2.

Prescription Coverage Goals

- Radiotherapy Planning:
  - At least 95% of the protocol-specified dose should encompass 100% of the PTV1, and the maximum dose to PTV1 in the absence of PTV2 should be no greater than 110% of the protocol dose for PTV1 as evaluated by DVH.
  - When optic nerve and chiasm constraints are at risk of being exceeded secondary to attempts to cover PTV2 with 5940 cGy, relaxed coverage of PTV2 is permitted such that at least 95% of the protocol specified dose should encompass 95% of PTV2.
  - For protons, the PTV should be used to confirm appropriate coverage regardless of planning technique utilized. Two methods are acceptable for evaluating sufficient coverage according to various treatment delivery uncertainties. The same criteria for coverage will be used for proton and photon plans.

Target Volume Definitions

- GTV_PreOp:
  - This is the full extent of initially involved tissue apparent on review of the CT, and MR imaging prior to resection. This volume is only defined for resected cases (See Figure 3aϒ).
- GTV_Cavity:
  - This is the CSF space that fills the area where parenchymal normal brain resided prior to resection. The resection cavity is best delineated using T2, T2*, and Susceptibility Weighted Imaging (SWI).
  - GTV_Cavity will only be delineated as a target volume in cases where a resection has been performed (See Figure 3d⌂).
- GTV1:
  - GTV1 will include all the tissues initially involved with disease and the entire residual tumor defined by the post-operative MRI scans.
  - Large Resection Cavities:
    - Coverage of the entire surgical cavity may result in excessively large treatment volumes which do not reflect an at risk region for tumor spread. The inclusion of GTV cavity in GTV1 is at the discretion of the treating radiation oncologist (See Figure 3c⌂).
  - Surgical Tract:
    - In deep seated brain tumors where a substantial amount of normal brain parenchyma is traversed in the surgical approach, the treating radiation oncologist may consider the exclusion of the surgical tract if the surgical tract extends beyond the pre-operative tumor volume defined by GTV PreOp delineated on the pre-operative brain MRI.
- GTV2:
  - GTV2 will include only the area of residual disease based on the post-operative MRI scans.
  - Not defined for cases where a GTR is obtained.
  - The GTV2 should exclude regions of residual tumor which are within 5 mm proximal to either the brainstem or optic chiasm (See Figure 2c←).

Target Volume Imaging

- The following sequences are suggested for delineation of the relevant target structures:
  - Residual tumor following resection:
    - Any and all available imaging.
    - ADC, DSC- or DCE-MRI perfusion, T1Gd, T2 & T2 Flair may be especially useful.
  - At risk regions of spread: T1 and DTI for following at risk white matter tracts.
  - Operative bed and cut surfaces of brain parenchyma: SWI, and T1Gd
  - Operative Cavity: T2 and T2 Flair.

Target Volume Definitions

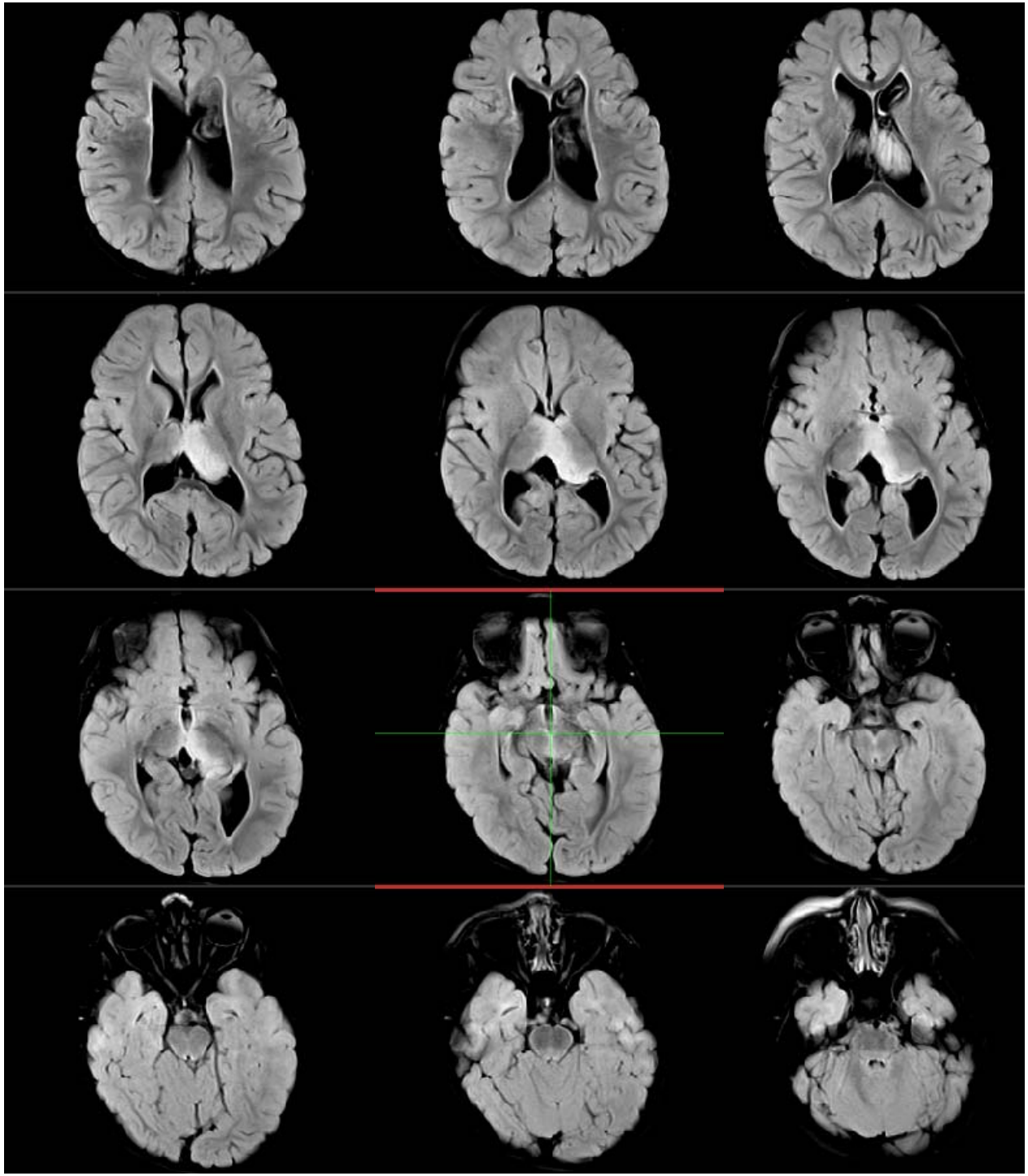
- CTV1:
  - CTV1 = GTV1 + 1-1.5 cm (1 cm is recommended). A 1.5 cm expansion is appropriate when GTV1 is in close proximity to a major white matter tract and this area is at increased risk for tumor spread.
  - i.e. In infratentorial tumors (cerebellar, non-brainstem) this could include extension into the middle cerebellar peduncles.
  - i.e. In temporal lobe tumors, this could include extension along the longitudinal fasiculus See Figure 3d∆).
  - When large resection cavities are resultant following resection, exclusion of a contracted GTV_cavity may be used to limit the size of the target volume when the tentorium or other dural surfaces are not expected to be involved (See Figure 3d←).
  - The CTV need not extend beyond the bony margins of the calvarium, across fissures, or non-contiguous brain regions (See Figure 3f◄).
  - The CTV need not include the extent of the surgical tract going beyond the GTV_Pre-Op in cases of deep seated tumors.
- CTV2:
  - CTV2 = GTV2 + 0.5 cm (1 cm is recommended). A 1.5 cm expansion is appropriate when GTV1 is in close proximity to a major white matter tract and this area is at increased risk for tumor spread.
  - The CVT2 should exclude regions of residual tumor which are within 5 mm proximal to either the brainstem or optic chiasm (See Figure 2d◊).

Target Volumes

Description	Standard Name	Coverage Goals	Maximum	Variation Acceptable	Deviation Unacceptable
GTV_Pre-Op	GTV_Pre-Op				
GTV_Cavity	GTV_Cavity				
GTV1	GTV1				
CTV1	CTV1				
GTV2	GTV2				
CTV2	CTV2				
PTV1	PTV1	95% of the protocol-specified dose should encompass 100% of the PTV1.	in the absence of PTV2 should be no greater than 110% of the protocol dose for PTV1.	Prescribed or computed dose differs from protocol specified dose by 6–10%	Prescribed or computed dose for PTV1 or PTV2 differs from protocol specified dose by > 10%
PTV2	PTV2	95% of the protocol-specified dose should encompass 100% of the PTV2.	When optic nerve & chiasm constraints are at risk of being exceeded secondary to attempts to cover PTV2 with 5940 cGy, relaxed coverage is permitted such that >95% of the protocol specified dose encompasses 95% of PTV2.		

Case 1:

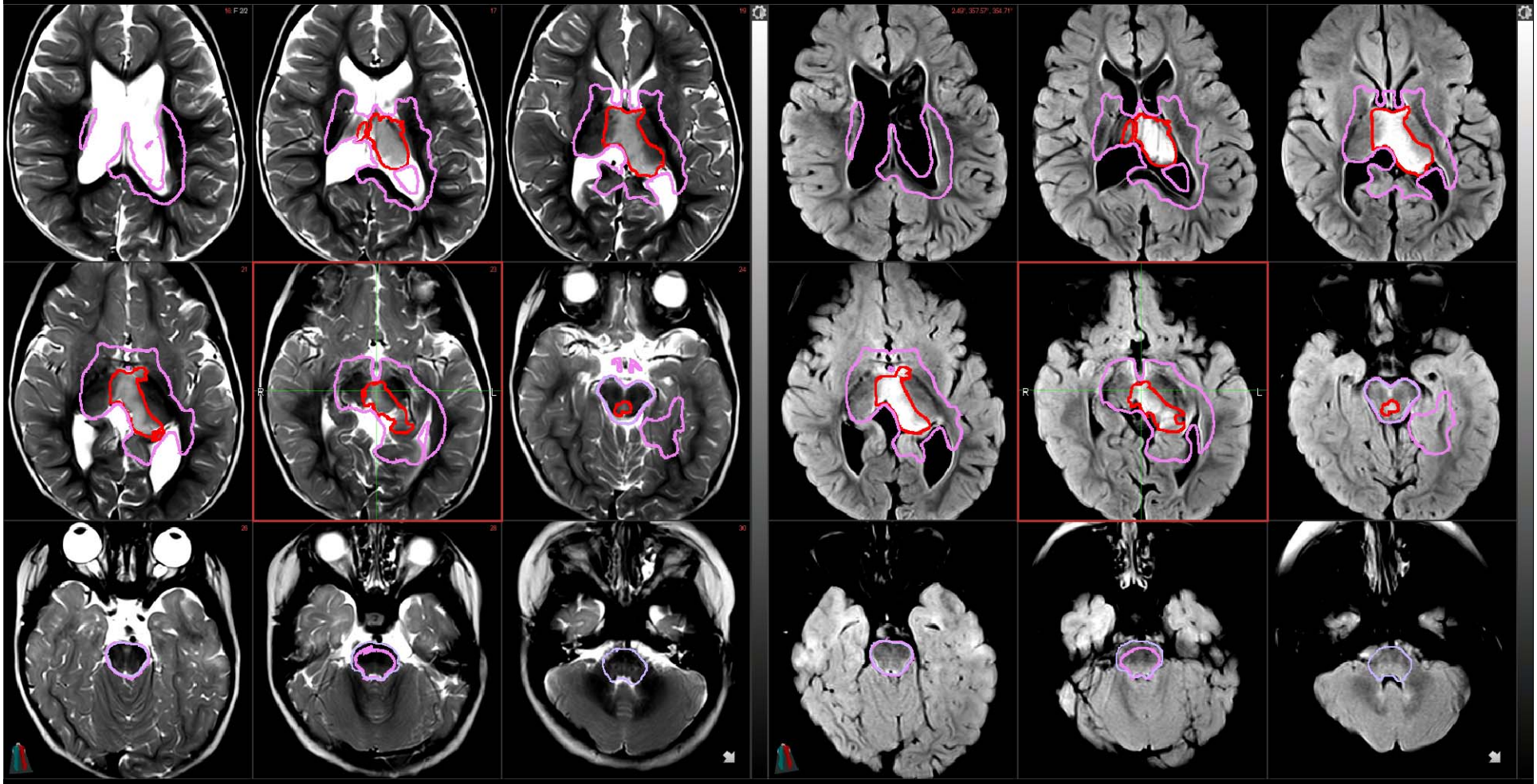
8 year old with a Glioblastoma Multiforme H3.3 K27M(-) BRAFV600E(-), status post biopsy alone.



A scrollable version of this case complete with ancillary imaging sequences is available for download as a companion to the atlas on the IROC website in the form of a Mimviewer executable.

Figure 2a

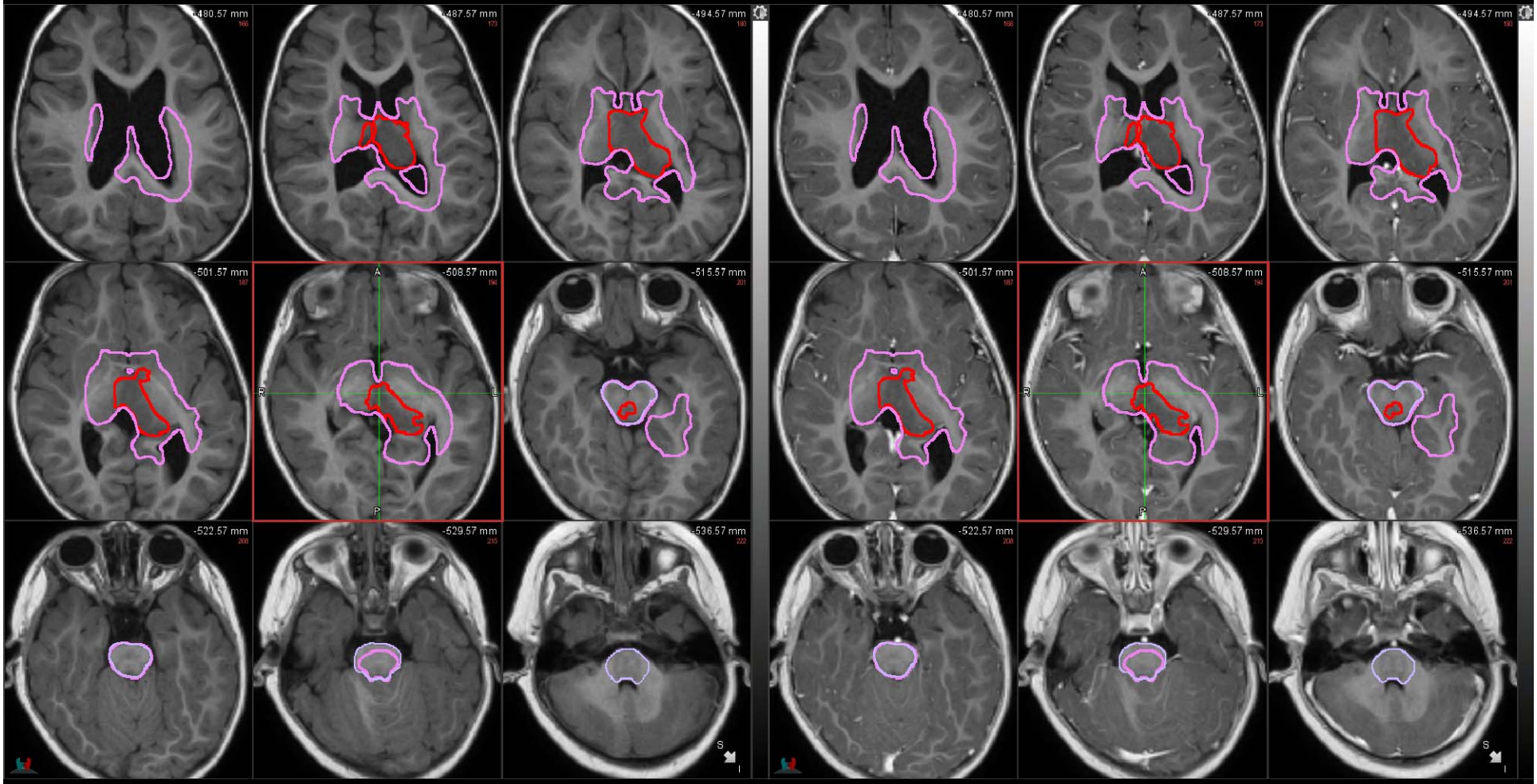
Initial Target Volumes



GTV1 should include all regions at risk for or including residual tumor as defined by post-operative MRI.
CTV1 = GTV1 + 1-1.5 cm, anatomically constrained according to patterns of spread.
Ex. T2 (left) and T2-Flair (right) image from a MRI obtained on a patient with a Midbrain-Thalamic Anaplastic Astrocytoma.

Figure 2b

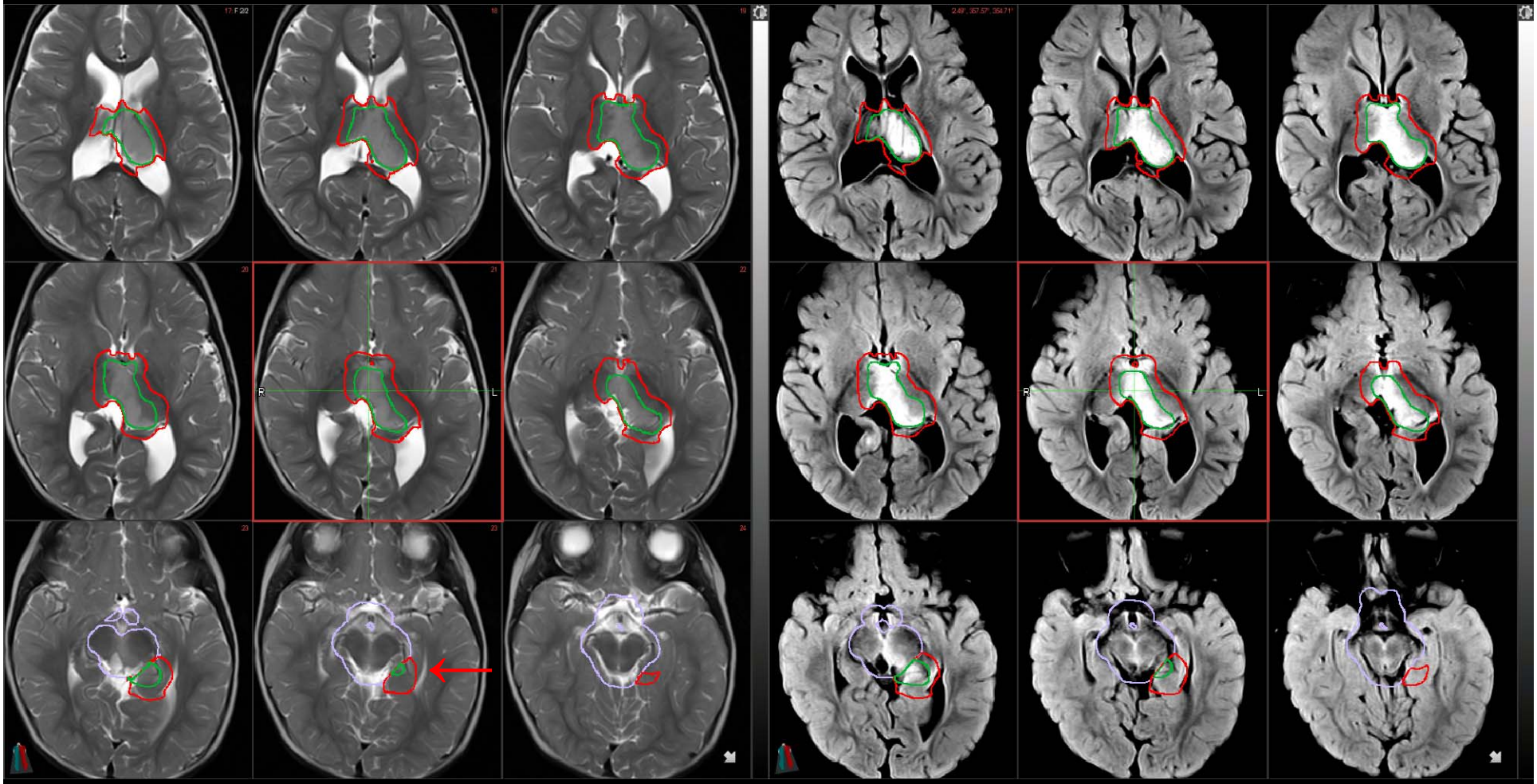
Initial Target Volumes



GTV1 should include all regions at risk for or including residual tumor as defined by post-operative MRI.
CTV1 = GTV1 + 1-1.5 cm, anatomically constrained according to patterns of spread.
Ex. T1 (left) and T1-Gd (right) image from a MRI obtained on a patient with a Midbrain-Thalamic Anaplastic Astrocytoma.

Figure 2c

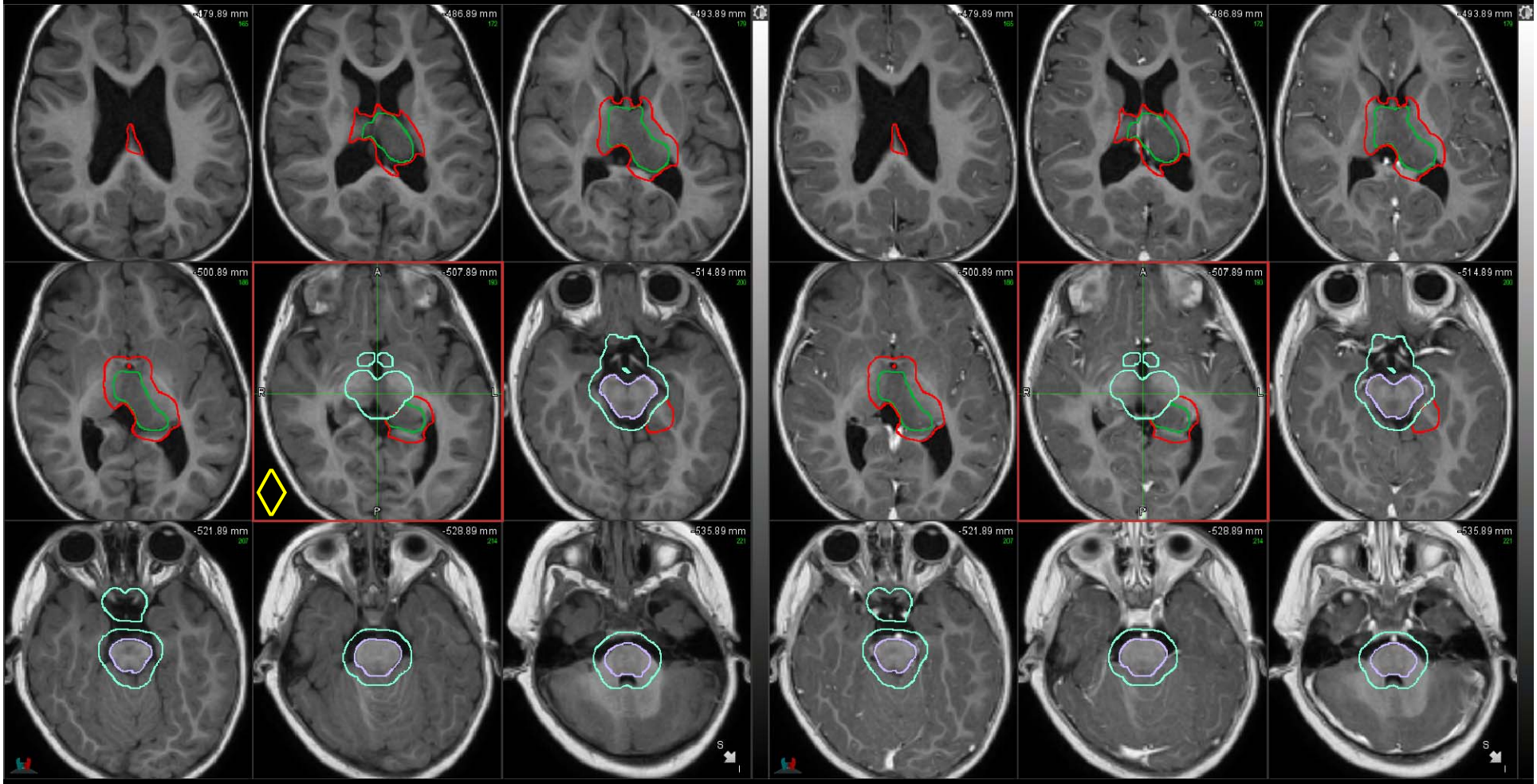
Boost Target Volumes



GTV2 should include all regions of potential residual tumor as defined by post-operative MRI. CTV2 = GTV2 + 0.5 cm anatomically constrained by key OARs (Brainstem & Optic PRV).
Ex. T2 (left) and T2-Flair (right) image from a MRI obtained on a patient with a Midbrain-Thalamic Anaplastic Astrocytoma.

Figure 2d

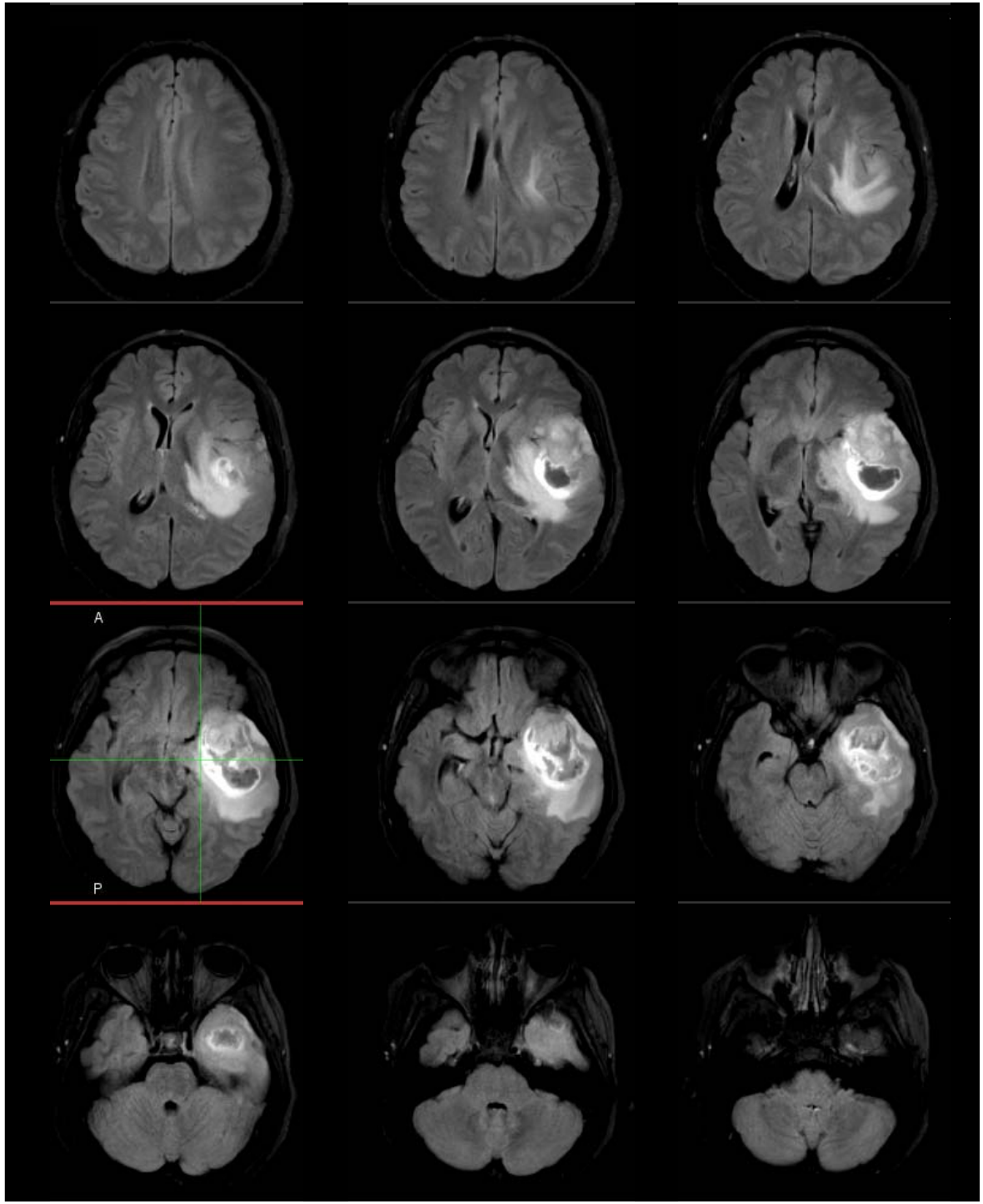
Boost Target Volumes



GTV2 should include all perioperative regions at risk for or including residual tumor as defined by post-operative MRI. CTV2 = GTV2 + 0.5 cm anatomically constrained by key OARs (PRV, Brainstem).
Ex. T1 (left) and T1-Gd (right) image from a MRI obtained on a patient with a Midbrain-Thalamic Anaplastic Astrocytoma.

Case 2:

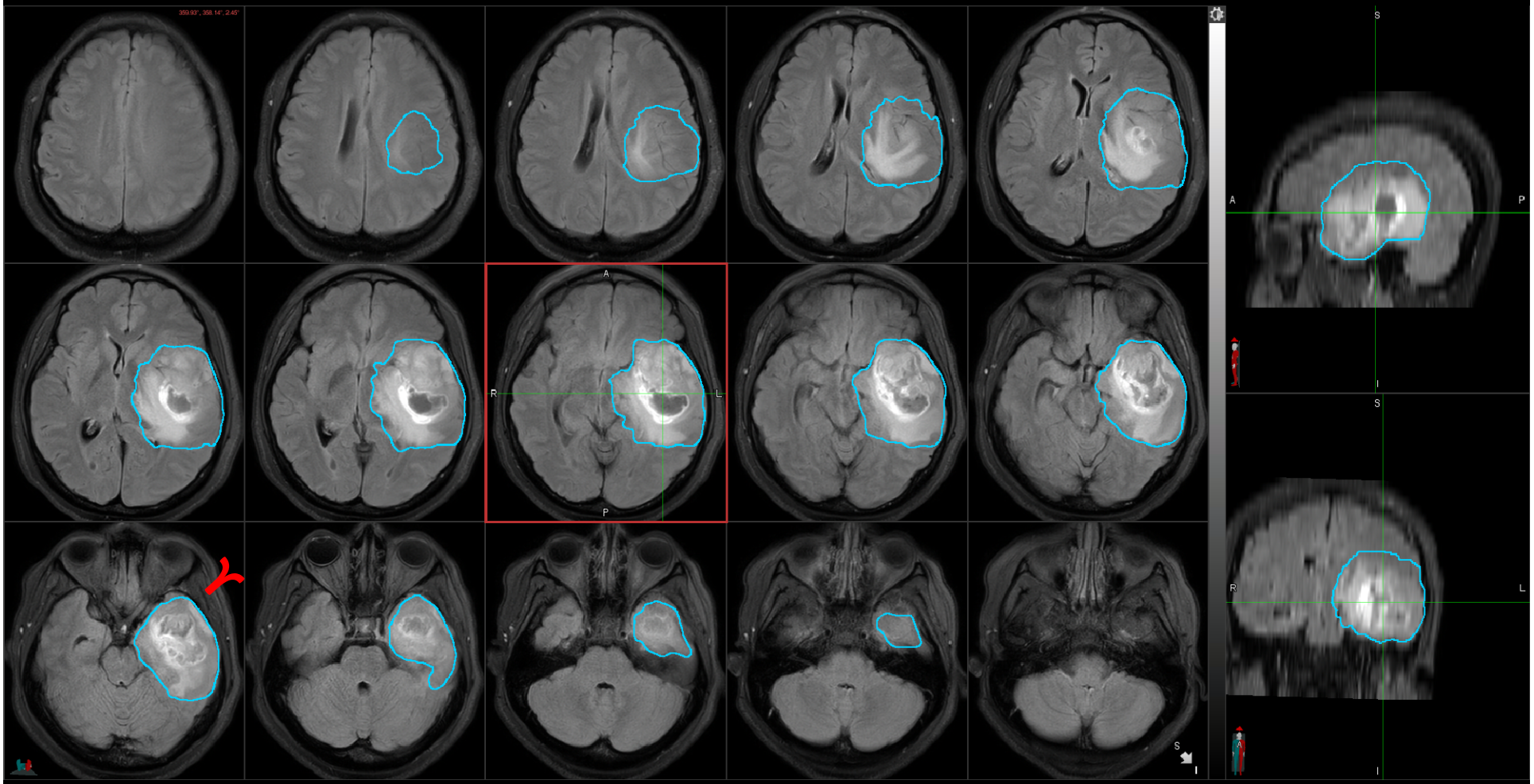
17 year old with a Glioblastoma Multiforme IDH1wt, H3.3wt BRAFwt, status post subtotal resection.



A scrollable version of this case complete with ancillary imaging sequences is available for download as a companion to the atlas on the IROC website in the form of a Mimviewer executable.

Figure 3a

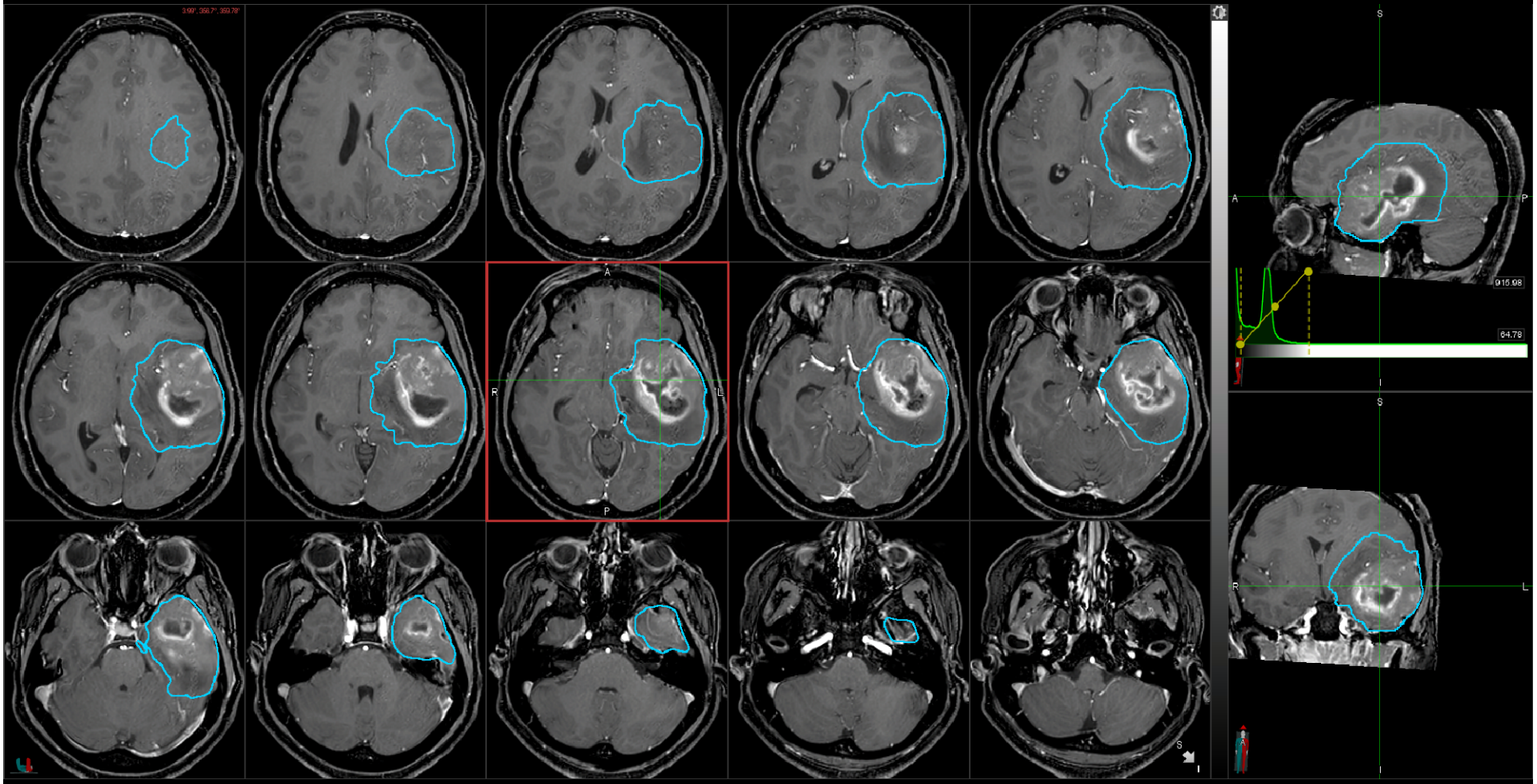
Pre-Operative Target Volumes



Define GTV_Pre-Op when a resection is attempted.
Ex. T2-Flair image from a pre-operative MRI from a patient with a predominately L. Temporal Lobe GBM.

Figure 3b

Pre-Operative Target Volumes



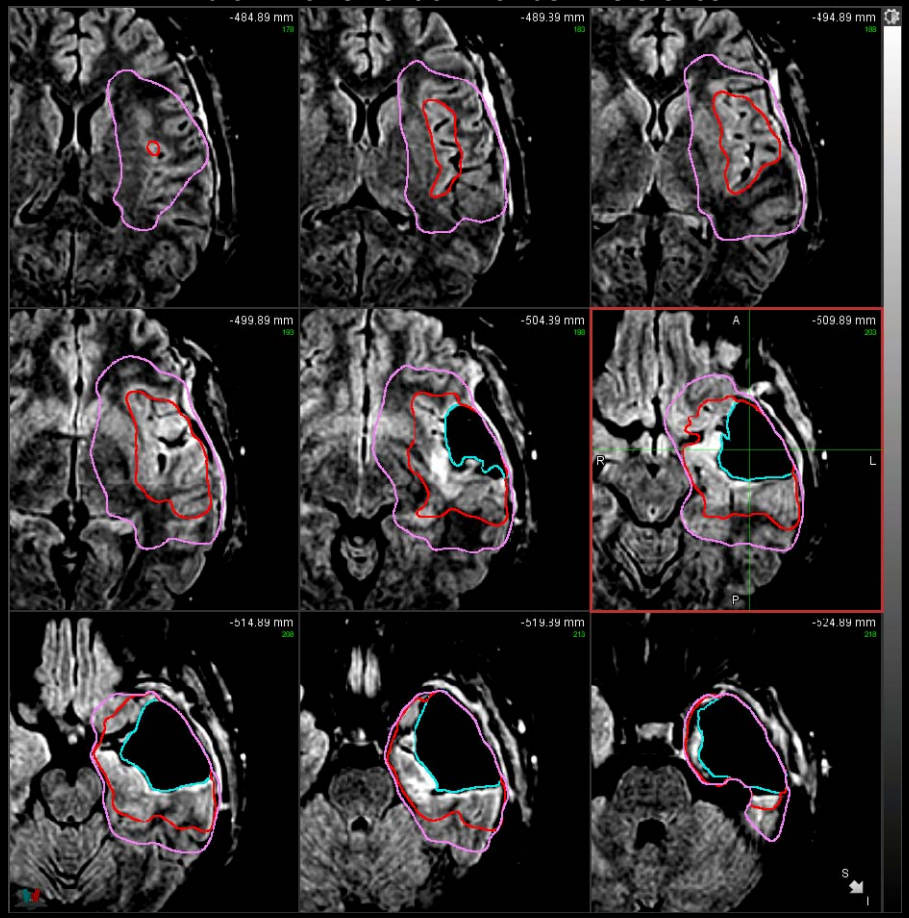
Define GTV_Pre-Op when a resection is attempted.
Ex. T1-Gd image from a pre-operative MRI from a patient with a predominately L. Temporal Lobe GBM.

Figure 3c

Initial Post-Operative Target Volumes

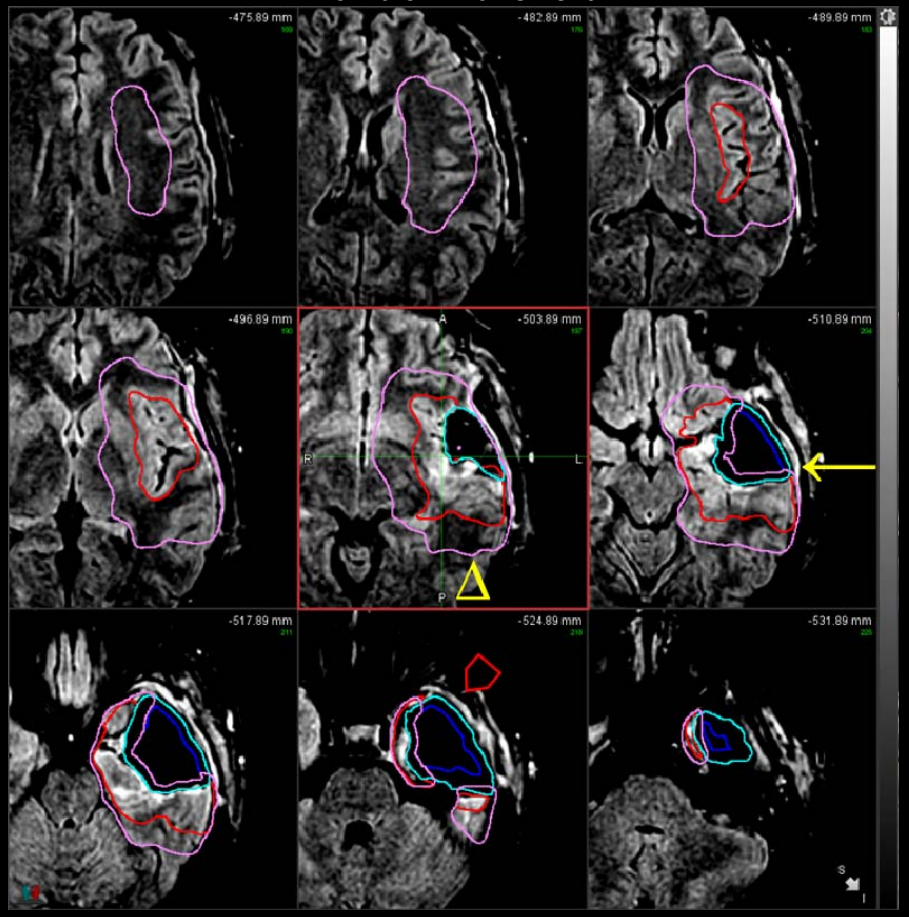
Option #1 – Cavity Included

Dural Involvement or Provider Preference



Option #2 – Cavity Excluded

No Dural Involvement

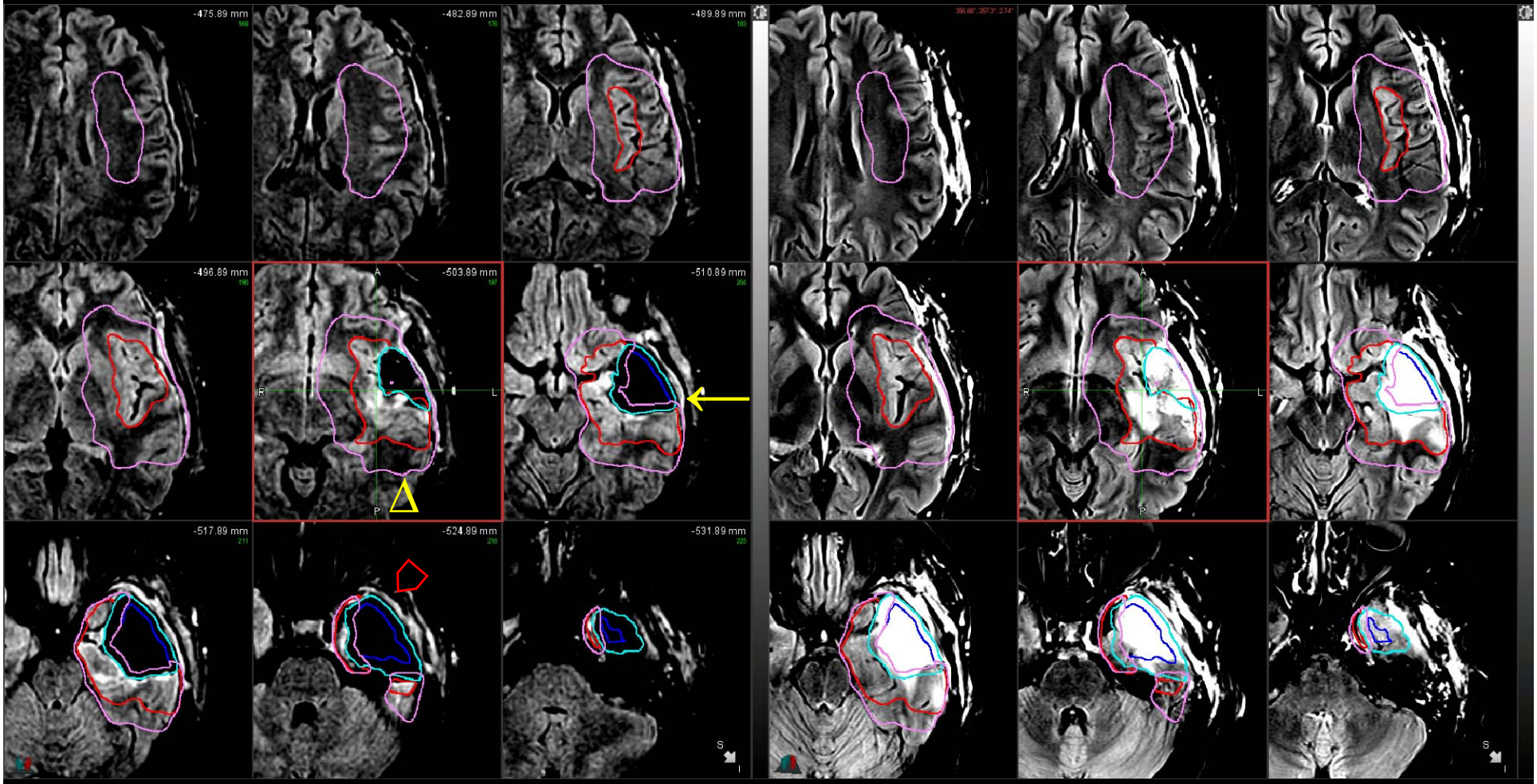


Two options for target volume delineation for post-operative cases are available for treating radiation oncologists. In cases where the tumor did not extend to the L. temporal dural surface, ***option 2 may be preferred*** although option 1 is still protocol compliant. The operative note & pathology report ***should be reviewed*** to confirm the absence of dural involvement if option 2 is chosen. If the involvement of the dural surface is unclear, then ***option 1 is preferred***. The process for delineating option 2 is detailed in Figure 2d-g.

GTV_Cavity, **GTV_Cavity_Contracted**, **GTV1**, **CTV1**

Figure 3d

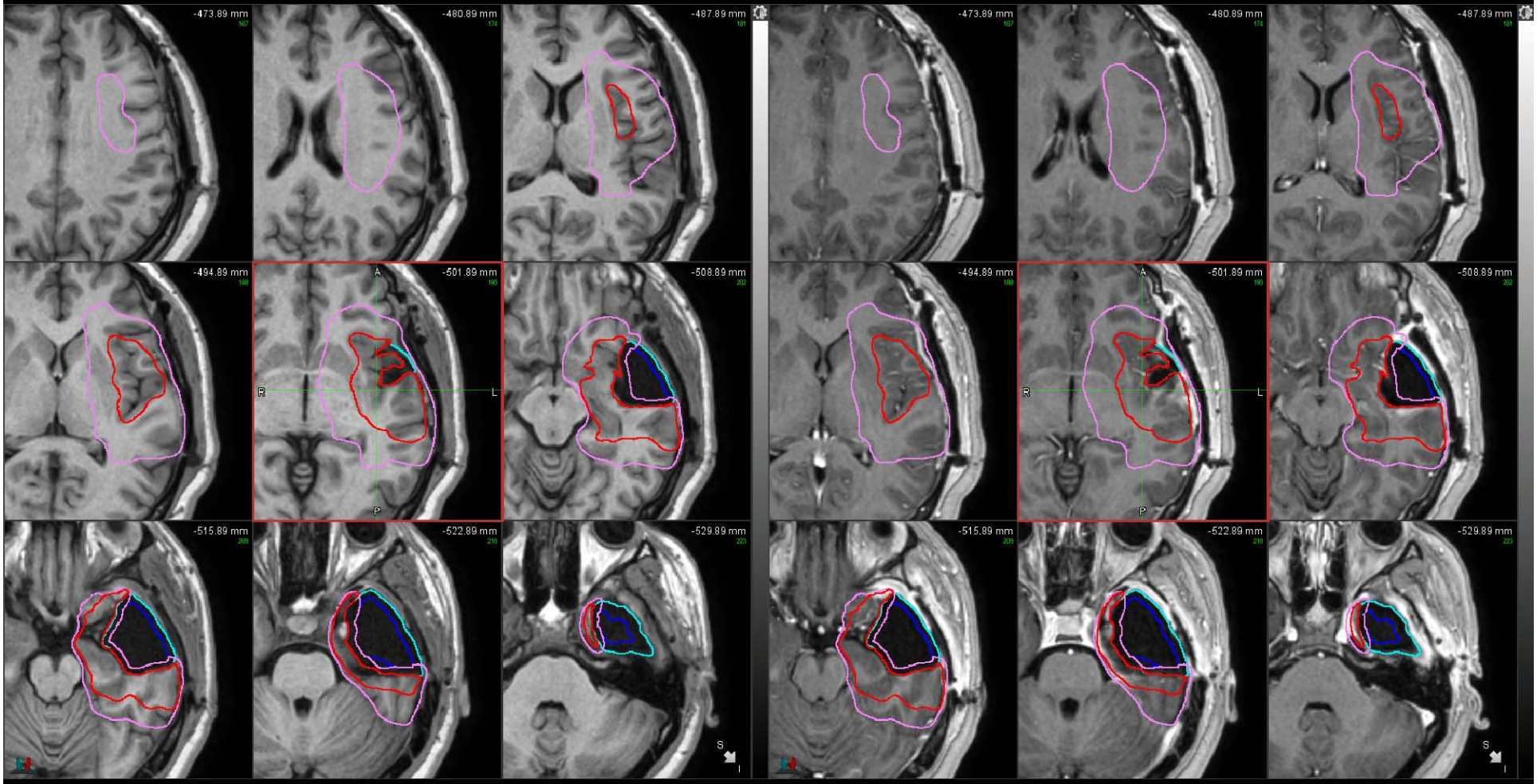
Initial Post-Operative Target Volumes



Defined **GTV_Cavity**, **GTV_Cavity_Contracted** when a resection is attempted.
GTV1 should include all perioperative regions at risk for or including residual tumor as defined by post-operative MRI. CTV1 = GTV1 + 1-1.5 cm, anatomically constrained according to patterns of spread.
Ex. T2-Flair (left) and T2 image (right) from a post-operative MRI from a patient with a predominately L. Temporal Lobe GBM.

Figure 3e

Initial Post-Operative Target Volumes



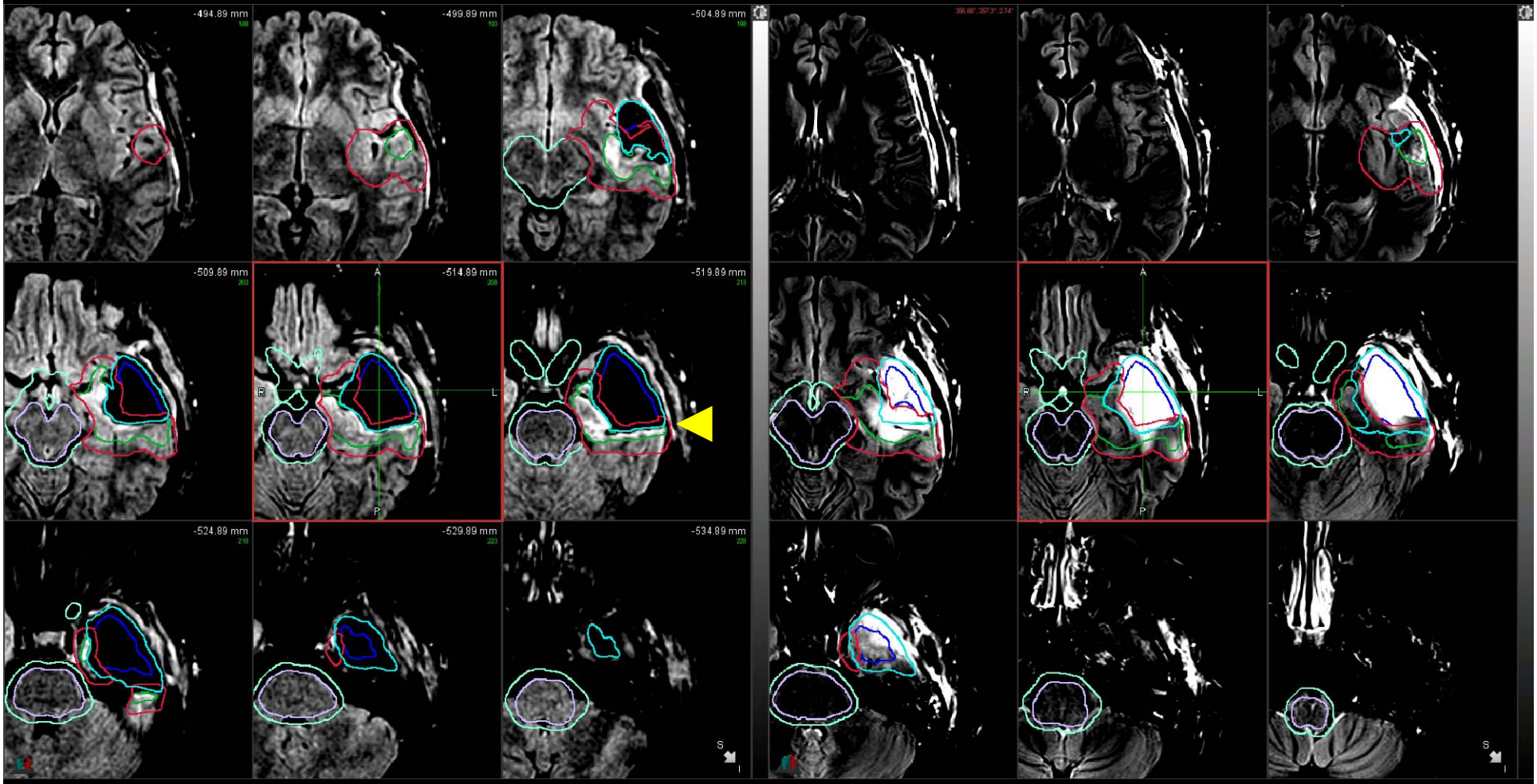
Defined **GTV_Cavity**, **GTV_Cavity_Contracted** when a resection is attempted.

GTV1 should include all perioperative regions at risk for or including residual tumor as defined by post-operative MRI. CTV1 = GTV1 + 1-1.5 cm, anatomically constrained according to patterns of spread.

Ex. T1 (left) and T1-Gd image (right) from a post-operative MRI from a patient with a predominately L. Temporal Lobe GBM.

Figure 3f

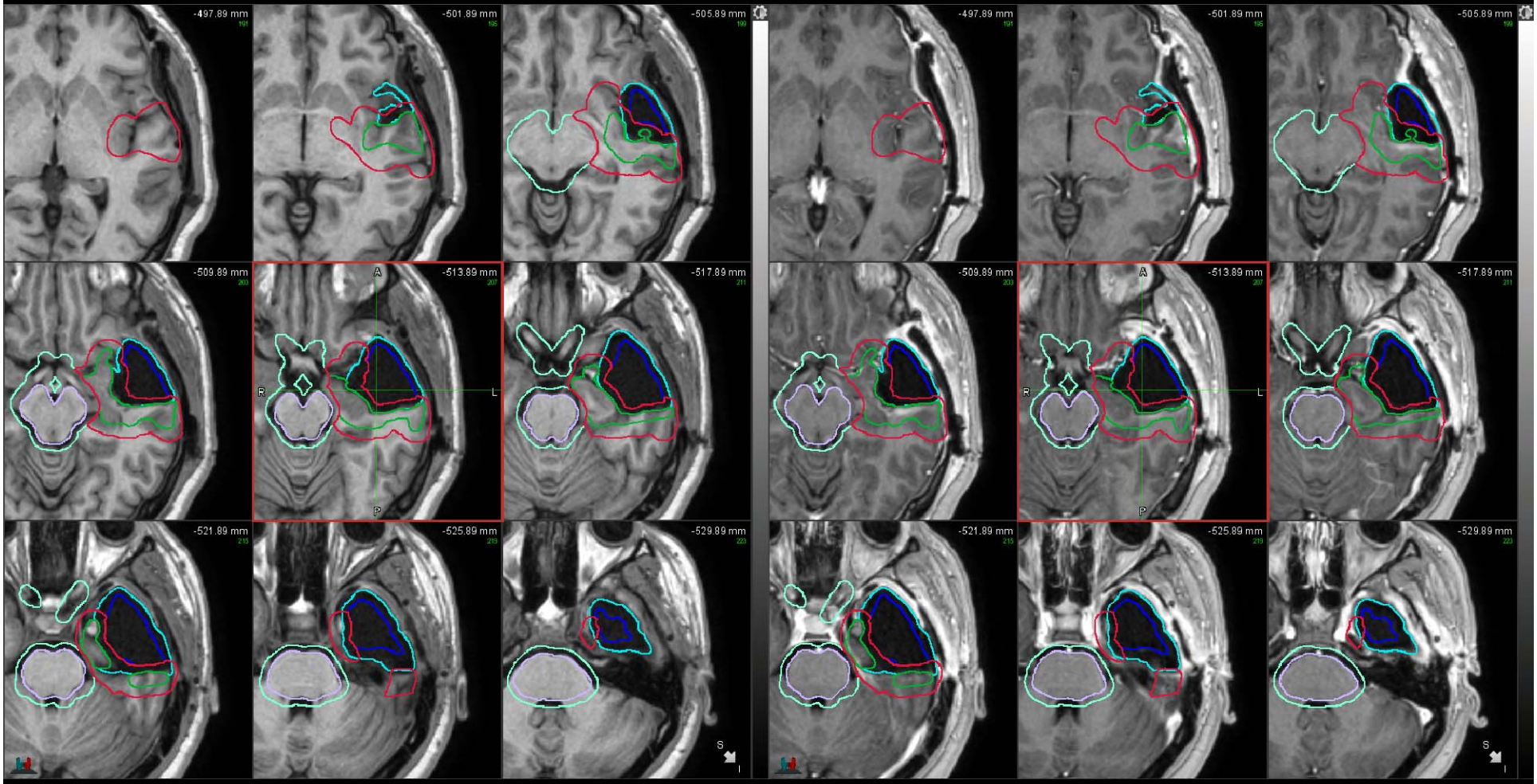
Boost Post-Operative Target Volumes



GTV2 should include all potential regions of residual tumor as defined by post-operative MRI. CTV2 = GTV2 + 0.5 cm anatomically constrained by key OARs (PRV, brainstem).
Ex. T2-Flair (left) and T2 image (right) from a post-operative MRI from a patient with a predominately L. Temporal Lobe GBM.

Figure 3g

Boost Post-Operative Target Volumes



GTV2 should include all potential regions of residual tumor as defined by post-operative MRI. CTV2 = GTV2 + 0.5 cm anatomically constrained by key OARs (PRV, brainstem).
Ex. T1 (left) and T1-Gd image (right) from a post-operative MRI from a patient with a predominately L. Temporal Lobe GBM.